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SPECTRE OF THE COMMONS: A POLITICAL ECONOMY OF RADIO REGULATION IN THE COMMUNISM OF CAPITAL

Rachel O'Dwyer

School of Engineering
Trinity College Dublin

Submitted for the degree of Ph.D

2013

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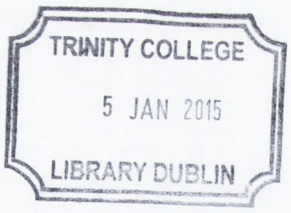

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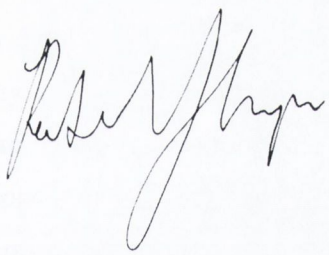

Thesis summary

This thesis performs a critique of the political economy of mobile networks through the theoretical framework of the communism of capital. It identifies the economic centrality of social production to the contemporary economy and analyses how the proprietary enclosure of network resources facilitates the accumulation of value from social production over mobile networks. To perform this analysis, the thesis argues for a theoretical framework that moves from the traditional dichotomy of the commons versus capital toward a critical position that recognises that these oppositions no longer hold and may even be counterproductive to analysis. The thesis addresses three core questions: What conditions bring commons-based peer production over networks to the fore of contemporary capitalism? Through what discursive, material and juridical apparatuses is social production enclosed and how, in turn, is value extracted seemingly beyond the wage relation and the direct command of organised production? Finally, what antagonisms emerge from this system of accumulation and what are their implications for future institutions of the common?

The thesis uses controversies surrounding the regulation of electromagnetic spectrum to provide insight into the communism of capital as it operates in the political economy of mobile networks. First, the historical regulation of an intangible such as spectrum provides a nuanced account of the enclosure of the commons and the extraction of rent from social production. Second, controversies in spectrum regulation between the legacy of exclusive licensing and burgeoning proposals for an expansion of commons spectrum shed light on the antagonisms and future orientations of this system of accumulation. The conclusions drawn from spectrum are broadly generalisable to the operation of rent over digitally networked media.

Chapter two undoes the now false dichotomy between social production and capitalist accumulation. It situates the new hegemony of informational and cultural production alongside the rise of neoliberal tendencies following on a crisis of Fordist accumulation. This is an expansion of the market outwards to the commodification of 'immaterial' capacities that were previously the domain of the commons. Far from being a nonmarket practice, therefore, social production now inheres in the market economy. So too, where this form of accumulation requires a new composition of

labour, we now encounter a continuum of social production over networks emerging in place of the traditional environs of the wage, or the factory.

Chapter three further analyses the system of accumulation that attends to these transformations to labour and identifies rent as the core dynamic of value accumulation in digitally networked media. It explores how, through the interstices of networks, a privileged position is produced that facilitates the extraction of value external to production. This involves the enclosure of communicative capacities that are appropriated, filtered through administrative channels and re-provisioned to labour as part of the tools necessary to the production of the immaterial. Chapter three then introduces electromagnetic spectrum as a lens for the study of the dynamics and antagonisms of rent accumulation as it operates over digital networks.

Chapters four, five and six address the core enquiries of the thesis through the lens of electromagnetic spectrum. Chapter four explores the historical enclosure of spectrum. In wireless communications this involves not only the alienation of the general public from the means of communication, but the production of a topology in which communicative activities can be made productive to capital. As such, this chapter traces how spectrum - an intangible 'capacity'- is conceptually, technically and juridically corralled as a scarce tangible resource comparable to land. This chapter then details the development of a commercial broadcast system that extracts rent from the unremunerated work of the media audience.

Moving on from this critical foundation, chapter five examines the operation of rent over spectrum today, details forms of rent accumulation and identifies antagonisms emerging between the traditional property relations governing the enclosure of spectrum and the economic re-socialisation necessary for the proliferation of mobile networks. This concerns the current controversies surrounding the 'spectrum crunch', which are leading to widespread proposals for a shift from exclusive licensing towards an increase in unlicensed and commons spectrum.

Chapter six analyses burgeoning proposals for a spectrum commons through a critical synthesis of a number of key reports from 2012 that argue for a regulatory reconfiguration of spectrum. Exploring the implications of these proposals, this thesis analyses whether the new communality of network resources suggests a disaccumulation of capital through antagonisms in rent or simply a reconfiguration of the dynamics of enclosure.

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Chapter One: Introduction

Section 1.1: Introduction

In June and July of 2012, I was lead curator of openhere, a four-day festival and conference in Dublin that brought together individuals from engineering, politics, activism and social movements, law, art and design and critical theory to tease out social and technical issues surrounding the digital commons (openhere, 2012). While this was quite an ambitious project, we, the curatorial team, narrowed our focus through recourse to the question 'What does it mean to be open today?'. The answers to this question were as varied as the disciplinary orientations of the many brilliant participants who spoke, facilitated workshops and contributed to discourses throughout openhere: true openness required a common core infrastructure; openness meant rendering transparent the mechanisms of value production or political sovereignty at play in networks; openness required a transparency in digital policy and public data; or openness gestured to the need for transdisciplinary dialogue between the materiality of networks and telecommunications engineering and the philosophical orientation of critical theory and critical art practices. All these conversations and perspectives have, in one way or another, helped to shape the theoretical and conceptual approach taken in this document, but one particular response has really stayed with me while authoring the thesis.

One of the most invigorating panels of the four-day conference concerned the future of 'open spectrum'. Robert Horowitz, the director of the Open Spectrum Foundation, a founding member of the Open Spectrum Alliance and a co-author of a recent European Commission report on the socioeconomic value of shared spectrum access (Forge, Horowitz & Blackman, 2012) spoke very eloquently of his then conflicted emotions as a long time advocate of open spectrum. Horowitz at this point in time had devoted thirty-five years of his life advocating for open spectrum. It was something he ardently supported, believing that access to wireless communications was a common right and not a proprietary resource to be subjected to market or state command. Horowitz's life work so far had included pushing for access and innovation in underutilised ISM bands in the 1980s through to addressing contemporary issues such as expanding license-exempt spectrum for Wi-Fi and

opening 'TV White Space'; closely following technical innovations in dynamic spectrum access that supported shared spectrum; and all the time strongly advocating a radical reconfiguration of radio regulation towards shared and commons access. Speaking in June 2012, in the wake of a spate of government and commercial support for unlicensed spectrum, his long-term goal was slowly becoming a reality. "And yet", Horowitz observed, "I now feel I may have been paving the way to hell".

Horowitz's comment stayed with me after the panel because it points to a critical transformation of the constituent relations governing the political economy of digitally networked media, a condition I was exploring in my own research. Today we might find that we are often confused about how commercial accumulation or sovereign control operates over digital networks and equally confused about how we might go about resisting or struggling against such operations.

This thesis performs a critique of the political economy of mobile networks through the theoretical framework of the 'communism of capital' (Virno, 2004, p.111). In particular it identifies the economic centrality of digitally networked social production to contemporary capitalism, as it emerges alongside the appearance of seemingly collectivist, socialist and communist sentiments in neoliberal policy. This centrality points to a transformation of the relations between labour, value forms and property relations structuring capitalist accumulation in digitally networked media. This condition, its catalysts and inherent antagonisms are analysed in the thesis through the lens of transformations to electromagnetic spectrum regulation.

If we speak of 'the commons' today as a general phenomenon, this has a lot to do with the modes of production, consumption and distribution that have emerged over the past decade around information and communication technologies. Though 'the commons' exists in both material and immaterial spheres, and has a legacy beyond the network, recent technological transformations are identified as a core actor in the hegemony of commons-based peer-production (Benkler, 2006). Moreover, the technical facility to leverage communicative capacities, support non-hierarchical cooperation and enable the circulation of non-proprietary content, has led a number of theorists to posit a kind of 'virtual communism' with broad social and juridical implications for the producers of online culture (Lessig, 2004; Benkler, 2006; Kelly, 2009).

However, such 'virtual communism' is, to quote Virno, 'a communality of generalized intellect without material equality' (Virno, 2004:18). While social production becomes increasingly central to the economy, the possibility of autonomous production continues to be constrained by a variety of institutional, technical and juridical enclosures operating through the network. The digital commons emerges, not as a virtual space unfettered by commercial exploitation, therefore, but as a highly conflictive terrain. The social production of informational and cultural content is situated at the centre of a mode of capitalism that seeks valorisation for the owners of network infrastructure, digital platforms and online content. This system of accumulation is socially and technically diffuse; it blends the essence of 'the commons' with new forms of enclosure.

As such, we require a theoretical framework that moves away from the traditional dichotomy of the commons versus capital towards one that recognises that these oppositions no longer hold and may even be counterproductive where we wish to theorise forms of potential resistance to cognitive capitalism (Fumagalli & Lucarelli, 2007)[1]. Today we encounter conditions in which the core tenets of communism: the socialisation of production, the abolition of wage labour, and the centrality of commons-based peer-production, are remade in the interests of capital (Virno, 2004). These conditions imply a new political economy. This is not to say that the commons has not historically potentiated capitalist accumulation, but that we are witnessing a dramatic intensification of these conditions[2]. We cannot hope to theorise or develop

---

[1] The term 'cognitive capitalism' designates a third form of capitalism following on mercantile and industrial capitalism and concerned with accumulation through the information, cultural and cooperative capacities of labour. The evolution of Marx's theory of knowledge from *Capital* to *Grundrisse* traces a transformation from the atomised intellectual capacities of the industrial worker towards conditions where 'general intellect' – a collective intelligence that is supported by a technical assemblage - acts as a direct force of production. Throughout the industrial age, capitalism exploited human bodies for mechanical labour and energy. Today, it is the numerous higher order acts, decisions, quantitative processes and interpersonal relations that workers constantly perform and enact that constitute the most significant value they produce.

[2] Hardt and Negri (2009) outline two different types of commons: firstly, the naturally occurring, material and finite resources such as common land, agricultural and mineral resources and, secondly, the 'artificial', cultural or socially produced commons, comprising common knowledge, language and shared culture. While this second commons still operates through very material channels, their outputs may not be subject to the same logics of scarcity as a natural resource. Traditionally, the socially produced commons was nonmarket because it was difficult to corral as property. Today, alongside transformations to capitalist accumulation, we encounter an expansion of the market outwards to this form of commons based production.

an autonomous form of online production until we have grasped how this system works and whom it works for.

In turn we are faced with a number of questions. What conditions bring the social production of information, knowledge and culture to the fore of contemporary capitalism? Through what discursive, material and juridical apparatuses is social production enclosed and how, in turn, is value extracted seemingly outside the subjugation of waged labour and the direct command of organised work? Finally, what antagonisms emerge from this system of accumulation and what are their implications for future institutions of the common? On one hand, it can appear as though antagonisms between openness and enclosure in cognitive capitalism represent a crisis in property relations that potentiate possible forms of anti-capitalist 'exploit' (Galloway and Thacker, 2007). On the other, it is also possible that capitalist accumulation is becoming ever more tightly organised through highly fluid and distributed mechanisms that route, not only around a direct intervention in production, but increasingly around the old property regimes.

Section 1.2: Electromagnetic Spectrum

Drawing on a key example from core infrastructure, this thesis will use controversies surrounding the regulation of electromagnetic spectrum to produce insight into the "communism of capital" (Virno, 2004, p. 111) as it operates in mobile networks. First the historical regulation of spectrum provides a nuanced account of the enclosure of the commons and the extraction of rent from social production. Consequently this allows us to unpack the dynamics of this system of accumulation. Secondly, current controversies in spectrum regulation, between the legacy of exclusive licensing and burgeoning proposals for an expansion of commons spectrum, shed light on the antagonisms and future orientations of this system. The conditions we identify and the conclusions we draw are broadly generalisable to the operation of rent over digitally networked media, providing critical insight into how this system works and also how we might struggle against it.

Spectrum describes the electromagnetic frequencies used for all forms of wireless communication. As such it has evolved from the channel that supported point-to-point radio communications, radio and television broadcast networks and cellular networks, through to the mobile Internet and next-generation networks of all scales

and densities, from smart dust to smart grids. Because of its integral role in relation to the continuum of wireless and mobile networks, spectrum is considered to be the most valuable resource in the wireless economy (Greeley, 2013; The Insider, 2013; New America Foundation, 2013). This is increasingly so as the proliferation of mobile data augments demand for mobile bandwidth.

Despite a legacy belief that spectrum is a public good, the majority of spectrum is consolidated in exclusive channel allocations under the control of the state and/or powerful commercial incumbents. This regulatory framework produces spectrum – by nature a 'non-rival' or 'durably rival' good – as a scarce proprietary resource. The basic tenets of this framework have been in place since the early decades of the twentieth century. Through the enclosure of a common communicative capacity and the production of an artificial scarcity with respect to supply, therefore, powerful incumbents have succeeded in extracting rent from the possession of exclusive licenses to electromagnetic spectrum (Smythe, 1987). So too a lack of access to spectrum is a significant constraint for the development of open or community orientated networks. Throughout the history of spectrum, beginning with amateur radio communities and progressing to open source mesh networking and ICT for development communities, individuals and collectives have pushed for an increase in open spectrum with limited success.

More recently, however, the existing regulatory framework has come in for widespread criticism as the proliferation of mobile devices and data streams produce a demand that cannot be accommodated through the current proprietary consolidation. Licensed spectrum facilitates the enclosures necessary for the extraction of rent from wireless networks, but it also constrains the necessary forms of transmission and production taking place over those networks. Many factions now argue that in the face of a 'spectrum crunch' the current regulatory consolidation of spectrum produces an artificial scarcity that conflicts with the demands of the burgeoning mobile economy. This has pushed advocacy for open spectrum beyond communities of digital activism to core regulatory bodies, governments and even commercial interests. There is now a widespread opinion shift away from exclusive licensing towards a substantial increase in shared or commons spectrum. Where the proprietary control of spectrum by powerful incumbents is the operand of accumulation, this suggests something of an impasse. Does a shift towards non-

proprietary and unlicensed network infrastructure represent an antagonistic element in cognitive capitalism? Or if this new communality of network resources is not at odds with capitalist interests, how might an acquisitive logic continue to act?

Electromagnetic spectrum is therefore an ideal lens for an exploration of the shifting relations between the commons and enclosures in cognitive capitalism. This is for a number of reasons.

First, the historical enclosure of spectrum allows us to fully examine the foundations of enclosure of the digital commons. To fully understand how social production in online environments is enclosed and expropriated, it is necessary to look beyond the immediate present and position enclosure as part of a complex historical trajectory. This means analysing how enclosures are initially produced and also how, over time, they intensify, transform and sometimes break down. In analysing the historical enclosure of intangible electromagnetic frequencies as a scarce proprietary resource we can also see what conditions – discursive, technical and juridical – produce a rentier dynamic in online social production.

Second, spectrum's current prominence in the political economy of mobile networks allows us to fully analyse the dynamics of rent accumulation in the current information economy. By attending closely to the operation of rent over mobile networks today, and by attending to the various antagonisms currently arising from this system of accumulation, we can theorise, in a way that is particular to spectrum and generally applicable to information and communication technologies, how this system of accumulation is breaking down or transforming.

Consequently spectrum allows us to attend to the core enquiries of the thesis: analysing how social production is expropriated by capital; detailing a system of accumulation through which this occurs; attending to the various antagonisms that are produced through the operation of rent over the commons; and finally asking if these antagonisms are leading to a disaccumulation of capital or simply pointing towards its reconfiguration towards new species of enclosure. The aims of this study are reflexive. If the burgeoning political vocabulary of the 'communism of capital' offers a critical insight into the enclosure of the digital commons, spectrum management also provides a lens to reflect on the theoretical underpinnings of this vocabulary.

Section 1.3 Theoretical Framework

Today we are witnessing the reconfiguration of pre-capitalist forms of social coordination in the computational-informational space. Traditional economic theories and the new schemes proposed by the advocates of the digital commons provide only a partial understanding of this burgeoning economy. Recent critical activity is in part about developing a new political vocabulary to attend to these conditions. In particular, a new generation of Post-operaismo[3] theorists have sketched an outline of the fundamental transformations underlying this mode of capitalism (Fumagalli & Lucarelli, 2007; Hardt & Negri, 2000, 2005, 2009; Lazzarato, 1996, 2012; Marazzi, 2010; Vercellone, 2008; Virno, 2004). These take in changes to the conditions and products of capitalist accumulation; structural alterations to the property relations under which labour produces and changes to the technical composition of labour (Hardt, 2010). The nature of these will be elaborated in chapters two and three, but as they relate to the digital commons they include:

- A shift from the hegemony of material goods to immaterial and intangible goods such as knowledge, cultural capital and social/affective relations that were previously cast as external to the market
- The emergence of new relations of production: In the context of the network economy, waged labour and capitalist intervention in production is replaced by conditions of precarity and a variety of automated apparatuses for the extraction of surplus that see the network emerge as the cognitive division of labour (Moulier Boutang, 2012)
- Transformations from the productive entrepreneurial capital typical of the industrial era towards the operation of forms of rent accumulation over social production.

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[3] This is situated within a Marxist political economy. Marx's political economy (1876, [1986]) is a critique of 18th and 19th century economic theory such as Malthus (1796, [2013]), Smith (1776, [1937]), Ricardo (1817, [1971]) and so on. It builds and expands on these economic theories but is critical of them also. Following directly on Marx however, the neoclassical economic theory of the 20th century is largely depoliticised in favour of a rational scientific discourse focusing on cooperative economic agents making choices under conditions of scarcity. Marxist theories are once more engaged through Italian workerism (operaismo) in the 1970s to read a history of capitalism through the perspective of labour and cycles of resistance (Negri, 1989). This theoretical framework has been further refined over the past two decades by post-operaismo theories that attend to the operation of neoliberalism and to the recent crisis in the global economy.

From these transformations it should be clear that the key to understanding economic production today lies with the commons. Capitalism needs the commons and consequently a range of systems to regulate and enclose its products. Where once these enclosures operated over land, today they operate over the entirety of human knowledge. Situated within the broader discourses of cognitive capitalism, and developing from the neo-Marxist philosophy of theorists such as De Angelis, Virno (2004); Marazzi (2007); Pasquinelli 2008; Caffentzis (2007); Hardt and Negri (2009) Hardt (2010) and Vercellone, (2010), the 'communism of capital' provides a critical insight into the enclosure of social production.

Post-operaismo theories involve features such as 'cognitive capitalism' (Fumagalli & Lucarelli, 2007) 'immaterial labour' (Lazzarato, 1996) and the 'becoming-rent of profit' (Vercellone, 2008) that are central to the thesis framework. However, when it comes to an analysis of the communism of capitalism, this framework evolves not only through post-operaismo theory but also other neo-Marxist theories that treat of the centrality of the commons to capital. For example, a burgeoning perspective on the communism of capital (Ephemera, 2013) includes post-operaismo theorists who identify something optimistic in the "proximity between the idea of communism and contemporary capitalist production" (Hardt 2010, p.143) where a form of production reliant on the commons is thought to usher forth the "conditions and weapons necessary for a communist project" (ibid). Consequently, post-operaismo theory not only acknowledges correspondences between forms of the common with capitalist accumulation, it also identifies a number of antagonisms in such an alliance, whether through the growing socialisation of production (Hardt and Negri, 2009) or through the imminent crisis of an underlying proprietary logic (Berardi, 2009b, Negri, 2010). An analysis of the communism of capital also considers the perspective of commons theorists working in a Marxist tradition such as De Angelis (2013) and Caffentzis (2013), who understand this 'communist project' as a strategic response to an impasse of neoliberalism. This couches the communism of capital in terms of capitalist appropriation rather than radical change, a crude communality designed to save neoliberalism from itself. This is the introduction of a theoretical framework that will allow an analysis of the political economy of contemporary mobile networks.

Section 1.4 Proposed Contributions to Knowledge

This thesis aims to:

- Bridge the theoretical gap between the theoretical literature on cognitive capitalism and telecommunications;
- Expand understandings of the communism of capital through the lens of electromagnetic spectrum and its regulation;
- In turn apply theoretical frameworks from post-operaismo theory and in particular theories of rent accumulation to an analysis of current transformations to spectrum regulation, speculating about the future implications of these regulatory transformations for the future development of open networks.

Section 1.5: Thesis Outline

The thesis begins by demonstrating the centrality of social production[4] to capitalist accumulation. To do this, chapter two unpicks a now false dichotomy between social

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[4] Social production describes the relational processes that produce the commons. It details forms of collective production undertaken on a voluntary basis; it is not subject to price-based forms of matching or financial remuneration and as such is thought to be nonmarket and non-proprietary. Structurally, social production takes the form of decentralised and non-hierarchical forms of organization in contrast with the hierarchical organisation of the firm (Benkler, 2006, p.7). Social production is traditionally associated with pre-capitalist relations of production such as those associated with barter, gift and sharing economies and with local forms of resource management and allocation separate to state or market-based management such as the commons. However, today we arguably see a resurgence of forms of social production emerging in online environments. As such the term social production now has currency within economic theories of online production alongside terms such as commons-based peer production (Bauwens 2005, Benkler, 2006), collaborative consumption (Botsman & Rogers, 2011) and free culture (Lessig, 2004). Social production is frequently identified as a potential third way of governing and managing resources beyond the private/public dichotomy (Benkler, 2006, Botsman & Rogers, 2011). It is here that its application within critical theory becomes problematic, as while anti-capitalist movements frequently identify social production in terms of existing and ongoing forms of collective material reproduction existing *outside* of the subjugation of capitalist accumulation, contemporary neoliberal economic theorists now identify social production as relations of production that support and counteracts many of the failures of the market, providing a workaround solution to the impasse of neoliberal capitalist accumulation. This application is well illustrated by Yochai Benkler's use of the term in his 2002 paper on open software development versus the firm and later in his book *The Wealth of Networks: How Social Production Transforms Markets and Freedom* (2006). This relates to the more established economic idea of 'social capital', which casts lights on the forms of trust and cooperation necessary for the production process but still sees these intangibles as essentially external to the formal production process. Social production, in contrast understands these relations - solidarity, care for others, creating community, and cooperating in common projects - to be inimical to new relations of capitalist production. The possibilities of the social within this context are therefore limited by their definition both within and against a competitive market logic. In the context social production is used here, this critique is acknowledged and indeed central to the core enquiry of the thesis. However, social

production through digitally networked media and capitalist accumulation. In the context of the enquiry this means discrediting an 'ideology of free culture' (Lessig, 2004; Pasquinelli, 2010a) that understands the collective production of information, knowledge and culture as nonmarket. Contrary to this ideology, we demonstrate that the social production of information, knowledge and culture is now central to capital and trace the origin of this system of accumulation. Rather than thinking of this as a condition that progresses and advances alongside the rise of information and communication technologies, we situate it as part of a broader series of transformations to the relations of production that emerge from an impasse of Fordism and the development of Post-Fordist (Lipeitz, 1997) and neoliberal financial policies (Harvey, 2007). Following on falling rates of profit, this is an expansion of the market further outwards to the expropriation of 'immaterial' capacities that were previously the domain of the commons. Far from being a nonmarket practice, therefore, social production now inheres in the market economy. So too, this system of accumulation requires a new composition of labour. Instead of labour organised through a wage relation, through strong technical divisions and through the external administration of institutions such as the factory, the union or the corporation, we now encounter a hypertrophy of production in which the network emerges as a cognitive division of a fluidly organised labour (Moulier Boutang, 2012, p.66).

Chapter three builds on the theoretical foundations of chapter two to analyse the systems of accumulation that attend to these transformations to labour. This draws from a theory of value put forward by post-operaismo theorists and adopts rent as the key operand of contemporary capitalist accumulation. Due to the hegemony of immaterial production, capital moves from the production of profit and a labour theory of value that characterised industrial capitalism towards conditions in which rent, previously understood as a pre-capitalist legacy (Hardt, 2010) and cast in opposition to profit, becomes central to accumulation. This chapter argues that rent allows us to describe the systems of accumulation that operate over the commons, producing a privileged position with respect to autonomous forms of sociality that are now made productive for capital.

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production refers not only to its own enclosure within neoliberal economic but to the power of social relations to produce and reproduce the commons in ways that may or may not be subsequently inured to the market.

While rent operates in a variety of spaces today, we specifically identify its operation in digital networks, where the technical dispositif facilitates a recursive accumulation of forms of attention, informational and cultural content, and sociality between cooperative individuals in order to produce value. Secondly, we analyse how a rentier relation is produced and maintained through the enclosure of the digital commons and the substitution of command over labour for command over markets. Through the enclosure of networks, a privileged position is produced that facilitates the extraction of value from a position external to production. In the operation of rent over digitally networked media, this involves the enclosure of communicative and cooperative capacities, which are appropriated, filtered through administrative channels and once again distributed to labour as part of the tools necessary for production of the immaterial. Chapter three then introduces spectrum as the lens for the study of the dynamics and antagonisms of rent accumulation as it operates over digital networks.

As such, chapter two and three are a broad overview of how social production is central to capital and how value is accumulated through such a system. Chapters four, five and six then explore the core enquiries of the thesis through the lens of electromagnetic spectrum. The thesis distinguishes three stages for the purposes of discussion. The first concerns the primitive accumulation of the socially produced commons and includes the historical regulation and enclosure of communications networks alongside the emergence of new forms of cultural industry. The second stage corresponds to an advanced capitalist society in which information, knowledge and cultural production are now hegemonic. This second stage, which details the operation of rent today, identifies fragile and sometimes conflictive alliances between the enclosures necessary for the extraction of rent and the forms of autonomy necessary for social production. Finally, these conflicts are arguably leading to a third stage in the development of this mode of accumulation, the outcomes of which are as yet unclear. These three stages correspond to the analyses performed in chapters four, five and six respectively.

Chapter four analyses the historical conditions necessary for the enclosure of spectrum. In wireless communications this involves not only detailing the alienation of the general public from the means of communication in the early decades of the twentieth century, but also analysing how this separation proceeds alongside the

wilful production of a topology in which these communicative activities can circulate and be productively organised. Consequently, chapter four argues that the enclosure of the socially produced commons is as much an inventive act as an act of separation. As such, we trace how a relational capacity for communications between radio devices is conceptually, technically and juridically *produced* as a scarce material resource similar to land or some finite natural reserve. This capacity has to be made to appear as a rival tangible resource subject to use, degradation and scarcity in order that it can be commodified, codified and enclosed. Once these conditions have been explored, the chapter then analyses how forms of general access to spectrum were historically marginalised, conferring access instead to powerful commercial incumbents. This marks the development of a commercial broadcast system that extracts rent from the unremunerated labour of the broadcast audience and is such is a foundation of the contemporary system of accumulation.

Moving on from this foundation, Chapter five looks closely at the operation of different forms of rent over spectrum today and identifies antagonisms emerging between the traditional property relations governing the enclosure of spectrum and the economic re-socialisation necessary to social production in mobile networks. Specifically it identifies how conditions underpinning the operation of rent, such as the production of exclusive licenses and the rarification of resources for the purposes of market command, are manifesting as a 'spectrum crunch', where current demand for the resource is outpacing supply in its current regulatory consolidation. This in turn is leading to proposals for a shift from exclusive licensing towards shared and unlicensed spectrum 'commons'.

In light of these antagonisms, chapter six identifies burgeoning proposals for a spectrum commons. This synthesises a number of key government commissioned reports from 2012 that argue for a reconfiguration of spectrum in favour of shared, unlicensed or license-exempt spectrum. Exploring the implications of these proposals, the thesis analyses whether the new communality of network resources is suggestive of a disaccumulation of capital through antagonisms in rent or simply a reconfiguration of the dynamics of enclosure. The conclusions drawn from spectrum are broadly generalisable to those operating over other forms of networked media.

Chapter Two: Social Production is Central to Capital

Section 2.1: Introduction

> [T]he central event of the 20th Century is the overthrow of matter…the powers of mind are everywhere ascendant over the brute force of things….today, wealth comes not to the rulers of slave labour but to the liberators of human creativity, not to the conquerors of land but to the emancipators of mind. (George Gilder, 1998)

In this brief quotation from a speech entitled 'The Soul of Silicon', republican politician George Gilder describes the significant transformations to capital in the late twentieth century. Although it is heavily couched in neoliberal rhetoric, two ideological trends are significant in Gilder's claim. First we have the recognition that collective intelligence succeeds the material commodity as the core driver of economic wealth, and secondly, the recognition that this immaterial value can only be realised through an approach that subverts the standard economic logics of industrial capital, whereby 'openness' as opposed to enclosure and 'freedom' as opposed to direct subjugation, now characterise the relations of production.

This chapter has two main points of focus that resonate with Gilder's soul of silicon. The first point of focus seeks to demonstrate that, despite all rhetoric to the contrary, the social production of information, knowledge and culture is now central to capital, and does not necessarily produce opposition with the market. The second point of focus is to analyse how this new centrality produces significant transformations to the organisation of labour that see the network emerging, not as some autonomous space, but as a sociotechnical assemblage for organising and corralling free culture in ways that are ultimately productive to capital.

Section 2.2 begins with an outline of what is sometimes termed the 'ideology of free culture' (Pasquinelli, 2010a), referring to a belief that understands social production through digitally networked media as a social and political force that emerges in opposition to capitalist accumulation and capitalist relations of production. Here, various technological affordances are thought to precipitate the rise of forms and expressions of value that operate outside of the market. However, by exploring various transformations in the 20th century economy following on falling rates of profit, we identify a shift towards the monetisation of 'immaterial' aspects of human

innovation and sociality in processes directly connected with the financialisation of the global economy. These bring intangible goods such as information and culture to the fore of capital. These transformations are discussed in section 2.3.

It should not be surprising that such a radical shift in terms of where value resides in the market is also accompanied by significant transformations to the organisation of labour and the relations of production. These are discussed in section 2.4. In contemporary capitalism, we encounter transformations that see the nature of work associated in a much more direct way with the production of subjectivity, dissolving the boundaries between work and non-work, waged and unwaged time. What was previously a relation between the social and the economic becomes a pure conflation; distinctions between these dissolve and this in turn situates labour at the very heart of the production of the commons. Activities such as paying attention and responding to messages, expressing tastes and communicating with others are now part of a continuum of labour.

As the nature of work changes so does its organisation. We also encounter new divisions of labour that bring not only communicative and cooperative capacities, but forms of peer-production and non-reciprocal exchange to the fore of work. Where these relations are antagonistic to the traditional organisation of work, we see the network come to the fore as a sociotechnical model of organisation in place of the corporation or the factory. Rather than simply ushering forth a new equality, therefore, information and communication technologies re-compose labour in ways that are productive to capital and provide powerful intermediaries in the extraction of value from communicative and cooperative work.

Section 2.2: The Ideology of Free Culture

2.2.1 Introduction: What is the Ideology of Free Culture

In an article entitled 'The New Socialism: Global Collectivist Society is Coming Online', editor of Wired magazine Kevin Kelly (2009) argues that the collaborative cultures emerging around web 2.0 platforms cultivate a "digital socialism" with broad political and economic implications for the producers of online culture. Kelly, alongside others, sees digitally networked media as an environment in which nonmarket forms of collectivism can occur and in time come to influence material circuits of production. Tracing a smooth trajectory from the publication of More's

Utopia in 1516 through to the monopoly of the YouTube platform at the time of publication, Kelly defines the core principles of digital collectivism.

Instead of collective farms or land, Kelly posits the 'desktop factory' as the locus of commons-based activity in the digital age. This is a digitally networked workforce composed of voluntary agents, operating through a "decentralized gift or barter economy where there is no property and where technological architecture defines the political space" (ibid). Instead of sharing manual tools and resources, in digital socialism, shared codes, applications and APIs will take precedence in the peer-production of informational and cultural outputs. These activities are in turn premised on a decentralized and non-discriminatory architecture with the supposed potential to scale social production from the collective distribution of ideas and resources through to cooperation, collaboration and collectivized production on a global scale.

Kelly's article is a classic example of the extreme techno-ideology that continues to surround the voluntary production of information, knowledge and culture over digitally networked media, an analytical position often associated with the 'Californian Ideology' (Barbrook & Cameron, 1996) or the 'ideology of free culture' (Lessig, 2004; Pasquinelli, 2010a). Where the Californian Ideology described the conflation of "free market economics and counter-culture libertarianism" in the dot com era (Barbrook and Cameron, 1996, p.41), the term 'free culture' can be traced to Lawrence Lessig's eponymous publication (2004) and an 'ideology of free culture' located in Matteo Pasquinelli's critique of similar attitudes promulgating in Web 2.0 (2010a). The term 'free culture' is used here to describe the broad range of utopian ideologies surrounding open source; the 'networked information economy'; 'commons-based peer-production' (Benkler, 2006); 'social production' and various nonmarket and non-proprietary practices emerging around the production and circulation of information, knowledge and culture through digitally networked media. This ideology of free culture has many advocates in both the communities of digital activism and the core apparatuses of neoliberal power.

Progressing alongside countercultural and hacker movements in the 1980s right up to the hegemony of social production in web 2.0, 'free culture' emerges as a counter-capitalist ideology. This set of beliefs progresses and advances alongside the work of

a new generation of network theorists (Bauwens, 2005; Benkler[5], 2006; Bruns, 2005; Dyson, 1996; Gauntlett 2011; Kelly, 2009; Lessig, 2004; Varnelis et al., 2008). Like Kelly, its advocates argue that the technological affordances of ICT networks facilitate the emergence of a non-proprietary 'information economy'. Contrary to the regulations structuring the production, market exchange and property relations of material goods, therefore, recent social and technological transformations are thought to alter the way we make and exchange information, knowledge and culture, both as individuals and in collaboration with others (Benkler, 2006, p.2).

Free culture is premised on a number of key transformations in terms of what social production over digitally networked media specifically generates, who is said to produce it and through what motivations, social relations, and property relations. Three claims are significant: first that digitally networked media have facilitated a more active and engaged relationship with content production (Bruns, 2005); second that they have allowed for the connection and coordination of these individual acts of production, commentary and distribution across time and space in a variety of loosely and tightly woven relations (Benkler, 2006; Sheller, 2004); and third that the relations of production and organisation of labour through digital networks have increased the role of nonmarket and non-proprietary production in ways that can inflect a material economy (Benkler, 2006). Free culture, therefore, speaks to transformations in the relations of production emerging alongside digitally networked media and espouses their broader social, juridical and economic impact. Both these changes and their promised effects require some elaboration.

Free culture involves the individual or collaborative production of information, knowledge and culture through digitally networked media channels. Advocates argue that recent technological affordances have transformed the individual's relationship to media from the passive stance of audience, user or consumer to that of the media 'prosumer' (Toffler, 1981) or 'produser' (Bruns, 2005) as an active and engaged

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[5] While Yochai Benkler, makes strong arguments for the social and juridical benefits of commons-based peer production, and as such is an advocate of free culture, he also acknowledges the significant constraints produced by the proprietary consolidation of core infrastructure. As such he does not claim that the operations of free culture are enough to transform the relations of production without concurrent transformations to material network infrastructure.

creator of information and cultural content[6]. Today, the sphere of production has expanded to the point where the consumer has become an active producer of media content and the user is now an active contributor to the design and evolution of future tools for production. Examples of these practices include user-generated content in a variety of rich media forms such as text, software, image, audio and video; multiplayer and collaborative game production; DIY cultures and Maker communities; and forms of co-design, co-creation and collaborative production across a variety of cultural platforms and outputs (Gauntlett, 2011). Affordable digital production tools, consumer electronics, sophisticated networked media and a range of online platforms for production, circulation and distribution are a significant factor in this culture (Benkler, 2006). So are topological shifts in media from the hegemony of one-to-many broadcast towards forms of many-to-many and multicast communications that allow contributions from a broader public (Bauwens, 2005; Varnelis, 2008).

Global telematic networks (and the spatial dedifferentiation afforded by mobile and wireless networks in particular) enable a variety of fluid or concentrated interactions between individuals, bridging previous diffuse forms of cooperation (Sheller, 2004). Social production in online environments is depicted as a distributed form of organisation where autonomous agents freely determine their behaviours and relations with others outside of the subjugation of the wage relation and without the hierarchical organisation of centralised authorities or obligatory hubs. As such, cooperative production is premised on distributed power and distributed access to resources, but also on distributed models of intelligence, where value, knowledge and consensus are produced through collective intelligence -the 'wisdom of crowds' - as opposed to any sovereign chain of command (Surowiecki, 2005).

These freedoms are in turn associated with broad social, economic and juridical

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[6] These terms are nomenclatures for the conflation of traditional roles of 'consumer' or 'user' with that of the producer. Alvin Toffler (1980) was the first to speak of the emergence of a 'prosumer' within the information society, describing the conflation of traditionally discrete positions of consumption and production in the production cycle. Axel Bruns (2005) coined a similar portmanteau with the term 'produser'. Both terms describe twin conditions: a shift from the passive figure of the consumer or audience towards active engagement especially in digital content and production and the rise of open innovation and collaborative design models in the innovation and production process. Toffler and Bruns both frame prosumption in terms of social and juridical benefits: an increase in personal and collective autonomy; the rise of a critical culture, a participatory political framework; and the rise of liberal democracies.

implications: producing greater personal and collective autonomy, potentially democratic forms of political and civic engagement, a more critical and self-reflective culture; and possibilities to improve human development globally (Benkler, 2006, p.2, Varnelis et al., 2008). Taken as a whole, free culture is also thought to represent an antidote to globalizing capitalist forces, especially in the interstices of media and communications where it is believed to pose a significant threat to powerful incumbents and media conglomerates (Barbrook, 1997; 1998, Benkler, 2006, Rheingold, 2002). Situated at the core of a global economy that places increasing importance on the circulation of knowledge, images and affects, the voluntary production of information and cultural content is thought to emerge in a favourable position to transform the economy of material production. The pervasiveness of open source software, user-generated content and collaborative knowledge production, DIY cultures and the peer-to-peer trafficking of rich media content over networks driven primarily by an economy of 'the gift' or social capital, suggest for some a networked space emerging as a counterforce to capitalist accumulation (Barbrook, 1997, 1998; Benkler, 2006: Lessig, 2004). In such a framework, the digital commons is traditionally presented as a space unfettered by the constraints and exploitations that govern material production, conversely capable of exerting material influence through the economic centrality of immaterial production and the growing conflation of 'real' and 'virtual' spaces wrought by mobile and pervasive media.

2.2.2 Why is Free Culture Thought to be Nonmarket?

But why exactly does 'free culture' lend itself to nonmarket or 'commons-based' peer-production? First of all, the kinds of outputs commonly produced through digitally networked media are classified as 'immaterial' or 'intangible'[7]. While the use of the term 'immaterial' in cognitive capitalism and the political economy of communications is nuanced, an 'immaterial good' designates a good whose use and/or exchange value resides in the informational and cultural content rather than in a tangible or mediated form (Lazzarato; 1996; Moulier Boutang, 2012). An intangible, similarly, refers to a non-physical good (IFRS, 2012). Digital files, images, music and information are all examples.

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[7] With perhaps the exception of recent innovations in 3D additive printing over networks.

Immaterial goods such as information, knowledge and cultural outputs are by nature 'non-rival', meaning that their consumption by one individual does not inhibit their consumption by another (Benkler, 2006, p.36). Once such a good is produced, no more significant investment of resources is required to circulate it to other individuals. In fact it is the case that such goods are frequently 'anti-rival'; their utility and value actually increases with consumption. As a result such goods are socially provisioned and equally they are not easily absorbed into the market or corralled as private property (Bauwens, 2003; Boyle, 2003; Benkler, 2006; Kleiner, 2010). Material and tangible goods, on the other hand, are rival; the consumption of a rival good by one individual prevents or inhibits consumption by others. Their marginal production costs are greater than zero. Where such goods are in demand they are typically consolidated in property relations and thought to be best provisioned by a pricing system[89].

It should be immediately obvious that information is non-rival. Information supports almost cost-free *reproduction* (aside from the costs associated with the means of distribution themselves: paper, network infrastructure, storage and processing capacities etc.). The informational content itself is only created once, and after that redistribution is generally inexpensive. Secondly, its use value generally increases precisely through forms of sharing, circulation and redistribution; shared language, as a fundamental example of an informational good, is something that is naturally produced and held in common, has a value that grows exponentially with use and defies privatization or enclosure (Bauwens, Mendoza & Iacomella, 2012). Economists call such goods "public" because "a market will not produce them if priced at their marginal cost – zero" (Benkler, 2006, p.36). In order to make them profitable within a market, various forms of artificial scarcity in the shape of

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[8] As Benkler explains:

> If I eat this apple, you cannot eat it. If you nonetheless want to eat an apple, more resources (trees, labor) need to be diverted from, say, building chairs, to growing apples, to satisfy you. The social cost of your consuming the second apple is the cost of not using the resources needed to grow the second apple (the wood from the tree) in their next best use. In other words, it is the cost to society of not having the additional chairs that could have been made from the tree (2004, p.36).

[9] Within the category of rival goods we encounter a further category distinguishing rival goods as durable or non-durable. A durable rival good produces constraints on multiple uses at a particular moment in time. For example, only one person can use a hammer at a particular moment, but that use should not significantly impede future use by somebody else. A non-durable good on the other hand, is something like food, which is depleted or degraded through use (Hess & Ostrom, 2006).

intellectual property or licensing have to be produced to effect economic competition. It is frequently argued therefore, that the markets developed around the proprietary control of information are as a result inefficient. As Kenneth Arrow put it in 1962 "precisely to the extent that [intellectual property] is effective, there is underutilization of the information" (cited in Benkler, 2006, p. 36). Because of fundamental difficulties to their inclusion in the market, therefore, immaterial commodities such as those produced through 'free culture' are candidates for substantial nonmarket production.

Not only are these goods not easily corralled as private property but the 'work' required in their production - creative, communicative and collaborative acts - aren't easily enclosed within the traditional composition of labour. Instead, free culture generally describes forms of production exterior to the traditional subjugation of the wage relation, as outputs that are voluntarily produced outside of work hours and often given away for free without the expectation of future economic returns. Advocates present collaborative culture as a digitised gift economy (Barbrook. 1997, 1998) where goods are produced and circulated without an explicit agreement regarding future or immediate remuneration. Social relations and self-realisation rather than financial remuneration are thought to govern the principles of exchange. So too, the 'work' required to produce immaterial goods also requires the purest expression of the self; it primarily stems from passion, enthusiasm, a desire for social connection and a hedonistic pursuit of knowledge (Moulier Boutang, 2012, pp.88-89). These things escape organization in the typical composition of labour, because, while innovation is valuable, it is very difficult to organise, quantify and control.

2.2.3 The Technological Affordances of Distributed Networks

These social, economic and cultural changes are thought to be based on various technological affordances. First, they progress and advance alongside capitalist investment in global telematic networks and a variety of information and communication technologies (Benkler, 2006; Varnelis et al., 2008). As these capacities extend across the globe and into a variety of different everyday contexts through wireless and mobile media, they are thought to facilitate new forms of expression, cooperation and communication. Similarly, free culture is also premised on a consumer electronics culture that places the means of digital production in the

hands of the majority. 'Moore's law'[10], describing the rising levels of processing capacity in computers and other electronic devices, has meant that sophisticated devices such as personal computers and mobile devices are now affordable and accessible to the majority of the developed world.

However, not only the ubiquity of these communications media, but their technical organization is significant to fostering the concatenations of free culture. There are topological and legislative dimensions to cooperation outside of market signals or managerial command and the decentralized and non-hierarchical organization of digital networks is thought to facilitate these. As peer-to-peer foundation leader Michel Bauwens argues:

> The Internet, as a point[-]to[-]point network, was specifically designed for participation by the edges (computer users) without the use of obligatory hubs.... [It] is controlled through distributed governance, and outside the complete hegemony of particular private or state actors. The Internet's hierarchical elements (such as the stacked IP protocols, the decentralized Domain Name System, etc) do not deter participation (Bauwens, 2005).

One of the defining characteristics of the Internet is the end-to-end principle, in which the intelligence of the network (discriminating and processing functions) exists primarily at the periphery, while the communicative pathways remain neutral, handling all data traffic identically (Flannigan, 2010, p.182). This architecture prioritises the free flow of content from the ends, rather than being selective about the type of content or where it has travelled. As the internet has scaled up and as networking applications have become more sophisticated, this end-to-end architecture, it is argued, has helped support cultures of peer-to-peer media distribution and many-to-many forms of communication, shifting communications from typical broadcasting topologies with their attendant one-to-many relations towards distributed and decentralised modes of communication and exchange (Bar, Baer, Ghandeharizadeh & Ordonez, 2008). The utility of these networks is also thought to scale exponentially[11] (Reed, 2001).

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[10] According to Moore's law, the processing capacity of electronic devices is thought to double every 18-24 months (Werbach, 2003).

[11] Network engineer David Reed, one of the original authors of the end-to-end principle, maintains that this topology drove the growth of the Internet beyond communities of engineers to support

In the past decade, computation has shifted from the traditional desktop framework consolidated in a wireline network to mobile and pervasive platforms that overlay everyday spaces (Greenfield, 2010; Weiser, 1991, 1994). In turn this is thought to transform social production from a strong dichotomy between real world and virtual practices towards spatial hybrids (de Souza e Silva, 2006; Kluitenberg, 2006) in which the commons-based activities cultivated through digital networks now inflect not only social and juridical processes, but material economies (Kelly, 2009).

2.2.4 What's Wrong with the Ideology of Free Culture?

This thesis identifies a number of issues with this theoretical position. The ideology of free culture actively helps to obscure the very real forms of constraint and enclosure that continue to operate over the common production of information, knowledge and culture. Firstly, this position fails to understand that, far from being external to the market, free culture is becoming increasingly central to capitalist accumulation and logics that place 'commoning'[12] (Linebaugh, 2004) at the centre of production and 'the commons' at the centre of commodity exchange. Secondly, the ideology of free culture relies on an immaterial rhetoric that tends to obfuscate the direct forms of material enclosures still at play; the very reason that these systems can be expropriated by capital is that a variety of technical, material and juridical enclosures inhere within the so-called 'open' spaces of peer production (Galloway, 2004; Kleiner, 2010; Pasquinelli, 2008). The socialisation of production is not mirrored by an equivalent socialisation of capital. Instead, we have strong regimes of enclosure that operate in tandem with seemingly open networks. In emphasising the primacy of immaterial culture, the advocates of a digital commons gloss over its symbiosis with and subsumption into material capital. Free culture is not external,

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diverse interest groups and broader publics. This is because the utility of such sociotechnical networks is thought to scale exponentially (Reed, 2001). This law of exponential network growth, known as Reed's Law, attempts to mathematically model the cultural and economic shifts facilitated by decentralised networks. This is the fullest expression of a network law, developing on Sarnoff's law, which applies to broadcast topologies and states that the value of the network is proportional to the number of viewers and Metcalfe's law, which states that the value of a communications network is proportional to the square of the number of connected users of the system. Put simply, when a network is aimed at broadcasting information to individuals, the value of services is linear, corresponding to Sarnoff's law. When the network enables transactions between individual nodes, the value is squared, corresponding to Metcalfe's law. And when the same network facilitates the formation of self-organising individual groups, as is the case today, the value is exponential.

[12] A verb used by historian Peter Linebaugh to describe the social practices used by commoners in the course of managing or reclaiming shared access to resources.

but central to the mechanics of a capitalist regime that seeks new forms of valorisation for the owners of the Internet's core resources and infrastructure. As such, the presumed conflict between the commons and capital at work in this ideology is a false opposition, one that is potentially harmful to anti-capitalist resistance, just as it is potentially useful for neoliberal institutions looking to smooth or reduce resistance to their reproduction.

Recently a growing political vocabulary, including 'post-Fordism' (Liepitz, 1997); 'cognitive capitalism' (Fumagalli & Lucarelli, 2007); 'immaterial labour' (Lazzarato, 1996); 'biopolitical production' (Hardt and Negri, 2000, 2009); and the 'communism of capital' (Virno, 2004) address these shifting relations between labour, property and capital. However, the organisation of labour described by free culture corresponds to the 'general intellect', a force of production identified in Marx's *Grundrisse* (1993 [1858]). This is understood as a conflation of technical agency and collective intelligence (machines and knowledge) that points to a new composition of labour (Virno, 2007).[13]

From the vantage of such perspectives, the 'network' ceases as a trope for counter-economic production and becomes an exemplar of neoliberal philosophy made visible through the re-composition of labour-capital relations around the unremunerated labour of online individuals and collectives (Terranova, 2000). This marks a shift away from the labour-wage relations of the industrial economy towards precarious and pervasive models of production coupled to a variety of automated apparatuses for the aggregation and extraction of surplus value (Virno, 2004; Marazzi, 2011). Similarly, it embodies transformations to the composition of productive capital towards a parasitic extraction of rent over common resources that

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> Nature builds no machines, no locomotives, railways, electric telegraphs, self-acting mules etc. These are products of human industry; natural material transformed into organs of the human will over nature, or of human participation in nature. They are organs of the human brain, created by the human hand; the power of knowledge, objectified. The development of fixed capital indicates to what degree general social knowledge has become a direct force of production, and to what degree, hence, the conditions of the process of social life itself have come under the control of the *general intellect* and been transformed in accordance with it; to what degree the powers of social production have been produced, not only in the form of knowledge, but also as immediate organs of social practice, of the real life process (Marx, 1858 [1993] p.706).

were previously cast as external to the market, a condition that will be discussed in further detail in chapter 3 (Pasquinelli, 2008; Vercellone, 2008). In the network economy, exemplified by web 2.0, value resides not only in the value of communications resources and services as elements of production, but also in their extension through a common space of cognitive production. This includes surplus voluntarily produced on social networks, open platforms and cloud architectures and through the sifting, adjudication and dissemination of data by an underlying assemblage of decision engines, algorithms and network hyperlinks. These modes of immaterial surplus are channelled generously through a proprietary infrastructure. Indeed, it is largely through the exclusive control of such network resources that a profitable position can be established external to commons-based peer production. These practices are subject to commercial constraints, the mechanisms of which can only be grasped through an engagement with the property relations underpinning the network[14].

2.2.5 Summary

Social production now inheres in the market economy. The collective production of information, knowledge and culture (particularly, but not exclusively as it is performed through digital networks) is tightly coupled to contemporary capitalism. This relationship between free culture and capital is part and parcel of a broader system of accumulation that brings the commons to the fore. But specifically what conditions – social, political and economic – bring free culture to the fore of capitalism? And what forms of production, labour, cooperation and property relations attend to such a shift? The rest of this chapter will address these questions,

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[14] For example: OpenBts is a software based GSM access point that allows standard GSM compatible phones to place calls outside of an existing telecommunications network (Burgess & Samra, 2008). Using software and inexpensive Universal Software Radio Peripheral devices (USRPs) to replace the costly core infrastructure of the average mobile network, the developers have implemented a communications interface with a number of social and politically beneficial applications. These include not only the provision of universal service in rural and indigenous areas where the cost of infrastructure is prohibitive, but furthermore, the provision of a decentralised communications infrastructure, deployable in disaster relief, or in political situations where the existing network is under sovereign jurisdiction (Grammatis, 2011).[14] As a model for commons-based peer production, OpenBTS seems fairly ideal in that it not only allows users to produce and share information, but also much of the physical underlying infrastructure also acts as common-property; it is owned and maintained by users. This openness still only goes so far: because of current proprietary spectrum licensing, the operation of an OpenBTS system anywhere in the GSM band is prohibited (Song, 2011).

analysing the changes to labour, production and value that bring free culture to the fore of the market economy.

Section 2.3: The Rise of the Super Symbolic Economy

2.3.1 Introduction

A common discourse in political economy locates the origins of cognitive capitalism alongside the rise of cybernetics and the expansive development of information and communication technology (ICT) in the final decades of the twentieth century. In this analysis, the proliferation of digitally networked media in the form of a global Internet and mobile communications ushers forth a new era in capitalist accumulation and new relations under which labour produces. But this is a small part of what we need to examine; if ICTs play a significant role in the facilitation of this system, the composition of cognitive capitalism also extends well beyond the development of a particular communications protocol or integrated chip. Before we discuss how the ownership and consolidation of communications media plays a significant role in accumulation, therefore, we need to pursue a broader outline of the origins of this political economy. This section explores how the social production of information, knowledge and culture comes to the fore alongside a crisis of value that sees a significant reorganisation of work, value and accumulation.

Alongside twentieth century autonomist Marxists and critics of Neoliberalism, we can coherently trace a number of origins in the cultivation and crisis of a Fordist mode of production and its attendant financial and economic policies (Adler, 1988; Foster, 2007, 2010; Harvey, 2007, Holmes, 2012; Marazzi, 2010, 2011). The shift from a Fordist welfare state to a neoliberal state produces significant transformations. Among these are transformations to value from a material economy based on sales minus production costs to a 'super symbolic economy' (Toffler, 1990) premised on financial expansion, and transformations in work from a system of Taylorist scientific management[15] and Smithian divisions of labour to flexible, cooperative and entrepreneurial forms of networked production.

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[15] Taylorism is a scientific theory of labour management concerned with economic efficiency and labour productivity that was developed by Frederick Winslow Taylor in the 1880s.

2.3.2 The Fordist Economy

Before discussing the nature of these transformations, however, it is necessary to briefly sketch the principles that governed the previous economy and to show how these break down. The Fordist economy, indicating global monetary and fiscal policy from post World War Two through to the mid 1970s, was a particularly "conscious blend of state, market and democratic institutions" (Harvey, 2007, p. 10). Alongside mass production and consumption, it was founded on a number of key principles: affordable energy, resources and raw materials; inexpensive foreign labour; virtual full employment; negative real estate rates; fixed exchange rates; and wage and inflation increases that followed closely on increases in productivity (Harvey, 2007).

Economic decisions were founded in Keynesian policy (1936), which argued that market and private sector activities required some degree of external regulation by centralised and state-governed authorities in order to ensure an efficient macroeconomic outcome and helped to counteract the tendency of profit-rates to fall. As a result, a new global order was constructed through the Bretton Woods agreement[16] and various institutions such as the United Nations; the World Bank; The International Monetary Fund (IMF); and the Bank of International Settlements in Basle were established to help to stabilise international political and economic relations. Free-trade in goods was developed under a system of fixed exchange rates and this in turn was stabilised by the US dollar's convertibility into gold at a fixed price. Alongside these international conditions, strong state intervention was implemented to ensure the conditions of full employment, economic production and the maintenance and reproduction of the workforce within a coherent system of welfare.

Alongside these measures, Fordist economies also recognised the centrality of the working class to production. First, this appears as a recognition of the labour force as an 'autonomous moment' within capital, bringing an understanding of equilibrium

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[16] The Bretton Woods system, established in 1944, was a system of rules, institutions and procedures to regulate the international monetary system in the mid 20th century. The architects of Bretton Woods established the International Monetary Fund (IMF) and the International Bank for Reconstruction and Development (IBRD), which today is part of the World Bank Group. The main principles of the system were an obligation for each country to adopt a monetary policy that maintained the exchange rate by tying its currency to the US dollar and the ability of the IMF to bridge temporary imbalances of payments (Harvey, 2007).

/disequilibrium operating between classes in struggle into economic theory (Holmes, 2012). This in turn leads to the production of systems to absorb and contain that instability. Recognising the autonomy of labour, therefore, means recognising the potential refusal of labour and the ways in which work can be excessive to production, while paradoxically working to develop techniques that contain and absorb that excess within a productive equilibrium. Second, this appears as a recognition of the need to invest in the reproduction of the labour force (Marazzi, 2011). Consequently, Fordism is characterised by the introduction of social income, and the period from 1945-1975 saw the initiation of welfare systems to set standards for the social wage including healthcare, education and social housing (Harvey, 2007). The result was a rise in general levels of education and training within the workforce - the cultivation of a "diffuse intellectuality" among the general population (Vercellone, 2010, p.101). Third, it appears as a recognition of the role of the working class in mass consumption, where higher wages and potentially shorter working hours for the labour force could cultivate markets for mass produced goods (Streeter, 1996). Where durable commodities were outside the purchasing power of wages, this also presumed a socialisation of finance (Holmes, 2012).

This is a necessarily reductive outline of a complex history. It is rehearsed here because several aspects are significant to the genesis of an economic modality centred on the immaterial production of knowledge goods.

Firstly, investing in the material and social reproduction of labour, and recognising an autonomous or unstable element in the bios of production - these are the building blocks for a new technical composition of labour. Social provisions in the form of healthcare, education and culture cultivated ideal conditions for the future monetisation of human innovation, knowledge, social relations and forms of life itself. If the development of welfare allowed for the socialisation of knowledge work, neoliberal economic policies lay the foundations for their employment in ways that are ultimately productive to capital. So too, recognising labour as necessarily autonomous produces a measure of freedom in the conditions of employment, emerging as the possibility of refusal or demonstration, but this also advances alongside the cultivation of techniques that, while recognising that this unstable arrangement is potentially excessive to capitalist accumulation, also attempt to compose it in ways that optimise productivity.

Secondly, following the crisis of Fordism, the introduction of a financial economy where profits are produced, not through an excess of sales minus production costs, but though an expansion of the market ever further outwards until the immaterial or symbolic dimension of a good presides over its material reality, marks a new system of accumulation that brings social production to the fore of value accumulation (Marazzi, 2011).

2.3.3 A Crisis of Fordism

From the mid 1970s onwards the pace of economic growth in developed countries began to decline, falling by at least half until growth rates were commensurate with those before 1945 (Foster, 2007). This falling rate of profit indicated an exhaustion of the technological and economic foundations of Fordism, played out through a rise in the cost of raw materials, energy and labour power; a market saturation of mass consumption goods; "downwardly rigid" wages; and the constraints of often rigid and insular regimes of production operating in a global market context (Marazzi, 2010, p.30). Some theorists also argue that the provisioning of social income and welfare services that came about as a result of workers struggles in the post-war era were incompatible with the Fordist regulation mode; they raised the costs of labour power and reproduction to an unsustainable degree (Vercellone, 2010). The effects of these conditions were experienced as a combination of rising unemployment and accelerating inflation (Harvey, 2007, p.14).

As Gorz (2010) describes it "capitalism has reached a frontier in the development of productive forces which it cannot reproduce [...] without superseding itself into another economy" (p.84). What followed from 1975 onwards were various attempts by capitalist entities to bring the falling profit rate back up to the levels of twenty years prior, through the reduction and increasing contingency of wage relations; attacks on unions; the privatisation of welfare provisions; the automation of entire labour processes; and a diversification of consumption models (Marazzi, 2010, p.27-29). However, this crisis of capitalist accumulation did not result in a generalised economic crisis; 'prices' did not collapse. Instead we encounter the association of new modes of production and forms of accumulation to counteract falling rates of profit (Foster, 2007, 2010; Harvey, 2007; Lucarelli, 2010; Marazzi, 2010; Vercellone, 2008, 2010). These included the substitution of the state for market command and a general relaxation of market restrictions in favour of free enterprise;

an anti-Keynesian revolution in fiscal and monetary policy; and of course the new precedence of financialisation: a substitution of Fordist production models with financial systems to "enhance capital's profitability *outside* immediately productive processes" (Marazzi, 2010, p.29, emphasis in original). While the exact mechanisms of this system will be discussed in chapter 3, here we concentrate on how these conditions bring social production to the fore.

Post-Fordism

Following a crisis of Fordism, deregulation, privatisation of public goods and withdrawal of the state from many areas of social provision were common[17]. Forms of welfare such as social housing, education and healthcare were instead replaced by private property, debt, individual culpability and free enterprise (Harvey, 2007, Observatorio Metropolitano, 2011). Labour becomes increasingly fragmented and precarious (Berardi, 2009a; Hardt & Negri, 2000; Lazzarato, 1996). Instead of public sector intervention, the new economic policies forged alliances between private property and free enterprise, relaxing restrictions over trade while at the same time producing the conditions in which capital might become concentrated in the hands of large private sector entities such as corporations, trusts and banks (Foster, 2007). Most significantly, the transformation to Post-Fordism was marked by a progressive expansion of the financial economy as a strategy crucial to the re-composition of capital in the face of a crisis of value (Foster, 2007, 2010; Lazzarato, 2012; Lucarelli, 2010, 2012; Marazzi, 2007, 2010; Vercellone, 2010).

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[17] In the Fordist economy, the state played a central role in the control and regulation of the economy, focusing on full employment, progressive growth and the welfare of society. From the period of economic expansion 1945-1975, Keynesian fiscal and monetary policies were widely deployed to dampen business cycles and ensure reasonably full employment. The mid seventies, however, saw a shift from Keynesian policy towards the neoliberal economic policies enacted by the governments of Regan and Thatcher. In contrast, Post-Fordism is characterised by minimal intervention by the public sector; the role of the state in such an economy is to produce an institutional framework appropriate to the market and to act as guarantor over the quality and integrity of money. Post-Fordism was synonymous with the rolling back of the commitments of the welfare state and the privatisation of certain public enterprises such as social housing, healthcare and education. Thatcher would famously state that there was "no such thing as society, only individual men and women". Harvey argues that this is as much an ideological assault as a material-juridical one: "Economies are the method", Thatcher famously stated, "but the object is to change the soul" (Thatcher, cited in Harvey, 2007, p.23)[17].

2.3.4 Rise of the Symbolic Economy

Deleuze has suggested that the treatment of money expresses the difference between the two systems of capitalist accumulation, where industrial capitalism was structured around fixed currencies containing gold as a numerical standard, while neoliberalism was characterised by floating exchange rates (1992, p.3). As such, Shaviro (2011) argues that we can potentially locate the transition to the neoliberal society in the dissolution of the Bretton Woods agreement in August 1971, when president Nixon ended the convertibility of US dollars to gold, ushering in a system of floating exchange rates that characterises today's financial economy. Several commentators frame the financialisation of the economy in terms of a process of recovering capital's profitability after the period of profit margin decreases. It describes an economic rationale in which money – theoretically a neutral symbol in a barter economy that stands in for the relation between real things – comes to be operative in and of itself. For the owners of capital, a solution to the dearth of investment opportunities and falling profit margins from the 1970s onwards was to utilise financial products as a means of maintaining and expanding monetary assets, placing these resources in financial activities remote from the production of material goods and services. In turn, financial institutions come to the fore with an array of new financial instruments: futures, options, derivatives, hedge funds and so on. The result was "skyrocketing financial speculation" that persists today (Foster, 2007, p.80).

The shift from production to finance has materialised in every aspect of the economy, including an increase in financial profits relative to real profits; the growth of FIRE economies (Finance, Insurance, Real Estate) as a share of national income; rising debt relative to GDP; the proliferation of increasingly exotic financial instruments; and the expanding role of rapid financial bubbles (Foster, 2010; Lucarelli, 2012; Marazzi, 2010). Financial markets have come to dominate over material economies (industrial, agricultural etc.), just as forms of financial leverage now overrides equity. Simply put, financialisation attempts to reduce tangible, intangible, actually present or anticipated forms of assets into exchangeable financial instruments or derivatives. Mortgages, for example, come about when a wage earner leverages their promise of future employment through a financial instrument. Forms of insurance, too, involve the financialisation of risk sharing facilities of all forms

(Foster, 2007; Harvey, 2010). Capital today attempts to reduce all forms of value (tangible, intangible, present or anticipated) into an exchangeable financial instrument or derivative.

So too, ownership of real capital assets has become secondary to the ownership of paper shares or assets (Foster, 2010, p.5). Previously, economic traditions sought to analytically separate the role of the real economy and that of a virtual or financial actant. In the former, accumulation is characterised by direct interventions into production that increase overall profit, while the latter concerns the appreciation of financial assets. But today there is arguably no distinction between the two (Foster, 2010; Vercellone, 2010); 'real' capital is increasingly overtaken by finance and this happens at exactly the moment when capitalist accumulation is based on social production in the commons (Marazzi, 2010). What we start to see, therefore, is that capital acts not through a direct intervention in material forms of production, but through the conversion of strategic positions over every aspect of life into tradable assets in conditions that conflate profit with rent (Marazzi, 2010; Vercellone, 2008, 2010). The mechanics of this will be discussed in detail in chapter three, but for now it is sufficient to point out that the financialisation of the economy and its attendant processes seems to enclose and monetise every aspect of human life that can potentially be turned into revenue. Those reproductive forces that were previously the domain of the commons or under the protection of the state – health, education, culture - now inhere in financial operations. The process of accumulation extends outside the traditional domain of the market to those things that were previously considered to be nonmarket or held in common.

IAS #38

A good examples of this can be illustrated with the introduction of the accounting standard IAS #38 (IFRS, 2012). The IFRS' International accounting standards are a consequence of international shareholding and trade, designed as a common global language for business affairs and used to maintain company books and to calculate the value of shares. Alongside expected standards for property, leases, revenue, investments and earnings, there now exists a standard for intangible assets: IAS #38. An 'intangible asset' is defined as an identifiable non-monetary asset without physical substance (IFRS, 2012). An 'asset' refers to something controlled by an entity as a result of past events from which future economic benefits are expected to

flow. These are priced according to their risk level and expected rate of return. 'Non-monetary' distinguishes the asset from monetary benefits such as money held, or fixed and easily determinable returns. Finally the assets described by IAS #38 do not have a 'physical substance'; they are things we cannot see or touch. Examples include research and development potential; trademarks, licenses and forms of intellectual property rights; intellectual capital; immaterial aspects of software, servers and PCs; image, reputation and trust confidence; quality of interactions; and forms of goodwill (IFRS, 2012, Moulier Boutang, 2012, p.199).

IAS #38 seems to encompass many of the key conditions of cognitive capitalism. It points to the predominance of the immaterial dimension of products over their material reality, where the inherent value of images, knowledge, information and codes are coming to outweigh the material aspects of commodities in the valorisation process (Gorz, 2010, p.35). The formal introduction of such an accounting standard, therefore, is just one symptom of the growing centrality of collectively produced information, knowledge and culture to capital, and subsequently the introduction of a range of techniques to regulate and enclose these products. The introduction of an accounting standard for intangibles does not just point to a growing preoccupation with free culture, but also the new forms of accumulation that attend this preoccupation. In other words, the introduction of the standard represents a concerted effort to quantify and monetise precisely those things – symbolic, aesthetic and social – that typically resist market enclosure, that are by nature 'common' immaterial goods. It is part of an expansion of the market outwards to immaterial processes.

The Immaterial

The role of the immaterial, therefore, is one of the defining features of the post-Fordist economy (Gorz, 2010). In finance and therefore in the contemporary economy, the commodities that are now central are those that escape direct measurement and are not reducible to a given product or service; their value is contingent on the subjective expectation of future profits enabled by financial markets and networked systems of trading and exchange (Marazzi, 2010, 2011). The immaterial includes elements such as the quality of a given population, interactions between agents, the quality of these relations (trust cooperation), the quality of organisations, implicit and tacit forms of knowledge, know-how and culture (Moulier

Boutang, 2012, p. 199, *supra* note 11). This category includes things that are difficult to abstract from their social and biological contexts, things that are not actually present but are anticipated, that are difficult to corral as a market entity or whose value escapes objective forms of measurement[18].

Symbolic, aesthetic and social value is coming to outweigh the material aspects of commodities in the valorisation process. This does not mean that industrial production disappears; rather, the value of such material goods is increasingly subordinate to these immaterial factors. Alvin Toffler, for example, writes of a 'super symbolic economy' (1990), describing "a new system of accelerated wealth creation" dependent on the exchange of symbolic knowledge that can posit substitutes for material commodities, where "technological and organisational innovation are at a premium" (Toffler, cited in Dyer-Witheford, 1999, p. 43), where mass production is replaced by cognitive markets and where cognitive skills become crucial attributes of the workforce.

So what does it mean when the immaterial becomes a crucial driver of wealth? For Žižek, this condition is best illustrated by appeal to another question: What makes Bill Gates one of the wealthiest men in the world? (2012) As Žižek explains, it is not that for Microsoft the cost of producing software as a commodity is somehow less than their competitors, not that the company produces a superior product for lower prices, or indeed that we encounter higher levels of exploitation of the Microsoft labour force. Instead, millions of people purchase Microsoft software because the company has succeeded in imposing its products as a global standard (2012). To elaborate on Žižek's analysis we can say that the consumer in this case is required to relate to the product in some way in order to communicate or cooperate with other entities. The added value derives from a social externality and not from any material or energetic expenditure for which Microsoft could be said to effectively *pay* (excepting the kinds of investment required to produce such a monopoly position in form of speculation, distribution and market manipulation). Here, we encounter a wealth that arguably accumulates out of all proportion to the labour and resources that were expended in the material side of production.

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[18] An immaterial good can be all of these things at once.

The concept of externalities involves taking into account a phenomenon that is generally excluded in neoclassical economics (Moulier Boutang, 2012, pp.22-29). The externality is, as its name suggests, a traditionally non-market entity; it underpins the complex systems of financialisation involving multiple interactions between non-market effects. And yet, as the examples of IAS #38 and Microsoft demonstrate, we are seeing a rise of both positive and negative externalities with the rise of cognitive capitalism. Positive externalities represent unpaid for wealth: resources and benefits for which the capitalist does not pay. These might include the advantages conferred by proximity to natural resources; increased mass education of a national or localised workforce; the knowledge spill-over produced by proximity to a university or through a geographic density of expertise as in the case of technical hubs such as Silicon Valley; or through network externalities that result from a demand-side return to scale, where the value of a good grows exponentially with its market adoption (such as is found with Žižek's example of powerful software or social media conglomerates). It should at this stage be clear that the extraction of positive externalities, and consequently issues of value accumulation and production today, converge on the privatisation of collective intelligence, knowledge and culture that is produced (if not held) in common[19].

The market proceeds outwards not only in terms of finding possible spaces and subjectivities for exploitation, but also in terms of the enclosure of possible temporalities beyond the conditions of the present.[20] The value of the immaterial may also gesture towards the perceived future value of some resource. Writing about the new relations between wages, rent and profit, Vercellone argues that the value of collective intelligence is never a quantitative figure but the expression of an expectation of future profits produced by financial markets (2008). The value of the

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[19] Negative externalities, by contrast, represent unpaid for damage, such as the ecological exhaustion and pollution of the biosphere, the systemic risk inherent in the banking system or the socialisation of forms of debt.

[20] As an example, the market capitalisation of social networks is often considerably higher than their turnovers or balance sheet totals. An investor's decision to purchase shares is heavily influenced by the intangible assets of the social network (a high density of attention, a strong diffusion rate and trust) and by future expectations of the value of these same intangible assets to advertising and sales (BV4, 2012). The production of value is now based on sociotechnical advantages that confer speed, such as being the first to acquire significant information, having the ability to effectively speculate or forecast the future or being in a favourable position to establish fragile and temporary micro-monopolies within a dynamic system.

immaterial, therefore, is something more than the current equivalent of the present, and, according to Moulier Boutang, it is also something quite different from 'potential', which is a non-real future (2012: p. 200 *supra* note 11). Instead, the immaterial is a present potential and so it is a future, an estimate, "a value of the future that modifies the present" (op. cit, p.199). Or, as Marazzi explains, financialisation in essence refers to profit increases that emerge not from an excess of sales over production costs, but as an excess of value in the stock market "at the time T2 with respect to T1 – where the gap between T1 and T2 can be several days" (2010, p.29). If previous modalities of enclosure and accumulation were largely spatial in nature, therefore, Post-Fordism and the financialisation of the economy introduces a strong temporal dimension to the processes of accumulation. Time becomes significant in two ways. For one it is about enclosing or operating over a future productivity (Lazzarato, 2012). But it is also about using temporal advantages (such as those conferred by speed) to leverage value – being the 'first' to colonise a particular space or acquire advantageous information etc (Pasquinelli, 2008).

2.3.5 Summary

This section identified transformations to the locus of value accumulation from material to immaterial goods. Following a crisis of Fordism, we encounter attempts to counteract falling rates of profit through the commodification of things that were previously the domain of the commons. This proceeds alongside the expansion of financial operatives in the global economy, rendering the symbolic, aesthetic, social and affective qualities and processes that were previously external internal to the market.

Section 2.4: Immaterial Labour

2.4.1 Introduction

Given the nature of its outputs, the conditions under which the immaterial can be produced involve a radical re-composition of labour. This fundamentally transforms the relations of production and the conditions under which labour produces, expanding the limits of production, the organisation of labour, and the ways in which it is subsumed by capital. These aspects require further analysis. We attend to these transformations because they demonstrate how the fluid relations of production associated with free culture are now central to the economy. And this centrality

emerges not just because of what free culture produces, but also because of its sociotechnical composition. In the new order, the network emerges as an organisational diagram in place of the industrial institutions and spaces organising work – the factory, the firm, the union and so on.

2.4.2 An Outline of Immaterial Labour

What conditions today characterise the production of the immaterial? What part(s) of the individual or collective is made to produce, and under what conditions? A key text to begin with is Lazzarato's 'Immaterial Labour' (1996), which details transformations to what labour can be said to produce and to the socialities and activities that are codified as work[21]. Here, Lazzarato defines immaterial labour as "the labour that produces the informational and cultural content of the commodity" (1996, p.134). This characterisation is broken into two distinct aspects of labour:

> On the one hand, as regards the "informational content" of the commodity, it refers directly to the changes taking place in workers' labor processes in big companies in the industrial and tertiary sectors, where the skills involved in direct labor are increasingly skills involving cybernetics and computer control (and horizontal and vertical communication). On the other hand, as regards the activity that produces the "cultural content" of the commodity, immaterial labor involves a series of activities that are not normally recognized as "work"—in other words, the kinds of activities

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[21] Knowledge work and immaterial labour are different things, but the history of knowledge work should be reproduced. Throughout Fordism we encounter the gradual socialisation of knowledge and education. The rise of knowledge work is arguably a consequence of the constitution of a diffuse intellectuality generated by the development of mass education and rising average levels of training in developed countries. In turn a highly educated workforce produces a shift in occupational distribution from manual towards professional and technical work (Dyer Witheford, 1999). Running through these strands are the proliferation of information and communication technologies in the post-war era.

Developing alongside the early origins of post-Fordism were speculations about the role of technoscientific knowledge and human innovation to future economic models. The common thread of these theories is that a new economy would emerge from the convulsions of the industrial society in which immaterial goods such as information, knowledge and culture took economic precedence over the production of material goods. Significant among these were the 'Knowledge worker' (1959) and 'Knowledge Society' (1968) outlined by Peter Drucker; and most significantly, Daniel Bell's 'Post-Industrial Society' (1978). Bell argued that in post-industrial society, knowledge would replace labour as the main factor of production and that between the opposition of capitalist and worker a new class would emerge based not on *intellectual* as opposed to *physical* capital " a professional class, based on knowledge rather than property" (p.374). This form of production was premised on a systemic relationship between technological research and commercial application. As such, it situated wealth at the coincidence of technoscientific knowledge and social forms of coordination.

> involved in defining and fixing cultural and artistic standards, fashions, tastes, consumer norms, and, more strategically, public opinion (p.133).

In the first proposition, Lazzarato appears to suggest that the locus of production shifts from the manipulation of matter towards the management of Information and Communication Technologies, a shift, he is careful to qualify, that also occurs within sectors of work that are not fundamentally informational. If previously capital required manual labour to operate thermodynamic machines, nowadays it requires human intellect to operate and supplement the work of digital machines. Digitally networked media can circulate new streams of information; however, knowledge and innovation reside with human subjects. Not only the development and operation of ICTs, but higher-level decision making, affective skills, and the management of fuzzy language and semantic nuances all prove strategic resources in today's economy.

This is one part of the picture, as it is not only the case that the skills required by a labour force increasingly revolve around information processing, but that 'work' itself has a higher informational or cultural content that expands production. Workers are no longer mere Taylorist cogs in the machine, exploited for their energetic or material productivity. Instead, the 'soul of silicon' (Gilder, 1998) is now the spirit of the worker, obliged down onto the factory floor. Artistic and cultural production; the formation of norms and public opinion; the cultivation of relations of trust and reputation; the fixing of tastes; the circulation of attention and the concentration of desire are also part and parcel of this composition[22]. As Terranova argues, "[n]urtured by the consumption of earlier cultural moments, subcultures have provided the look, style and sounds that sell clothes, CDs, video games, films and advertising slots on television" (2004, p.80).

We don't need to look very far for examples of this in free culture. The proliferation of social media and forms of online 'produsage' associated with web 2.0 environments are an obvious case in point (Bruns, 2005, 2009), as are forms of taste making and cultural consumption and production that are channelled into cities,

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[22] Secondly, though there is a geographic and economic distribution to knowledge work, immaterial labour is by no means a condition that is limited to a particular class or to highly skilled workers. Lazzarato (1996) argues that immaterial labour is not confined to a particular class composition, but describes a pervasive feature of productive activity in the post-industrial society.

tourism and real estate (Florida, 2004). We might also point to the occupation of street style bloggers and 'trend spotters' whose sensibility for current fashions and consumerism is channelled through major brand affiliations such as Apple and American Apparel (Rushkoff & Goodman, 2001).

It is important to emphasise that though it involves the production of immaterial aspects of the commodity, immaterial labour does not refer to work that has somehow succeeded its material dimension. Immaterial labour still requires material energies and physical forms of work; however, the product of this labour is immaterial, referring to intangibles such as those discussed in IAS# 38 that are subsequently channelled through the exchange value of marketable commodities. It might also appear as though we are making a simple distinction here between manual and intellectual labour, but the situation is more nuanced. It is more accurate to frame this as a shift from the measurable production of commodities to the ongoing production of and investment in the labouring self, which is also to indicate a shift from a repetitive labour that is subject to external command towards a form of labour that operates with a degree of autonomy (Berardi, 2009a).

In this way, immaterial labour appears to overthrow the paradigm of work itself, moving away from an understanding of the worker as a subjugated figure – work as alienating, dull, repetitive – towards a model of work that demands the fullest expression of the self. In fact, as Moulier Boutang argues, if we had to point towards an archetype of this new worker, we might point to the artist or the academic, a figure whose work is associated, not with open forms of subjugation, or servitude, but with freedom, play and the hedonistic acquisition of knowledge (2012, p.88). Today, "even the greater power to enjoy is always on the verge of being turned into a labouring task" (Virno, 2001, p.4).

As a further example, software companies such as Google and IBM now incorporate a percentage of time into every working day in which their staff may pursue 'free activity'. Google employees are encouraged to use this time to engage in personal projects and pursuits they are passionate about (Alex, 2006). This is, of course, accompanied by tighter intellectual property coupled with a rapid commercialisation of research activity. As things stood in 2009, 50% of Google's products, including

Gmail, had emerged from this 'free time' (Janson, 2009)[23]. But where exactly does this free time begin and end? When a worker leaves Google headquarters in the evening and travels to their home? Not really; under the conditions of employment Google might just as easily lay claim to an idea a worker had while drawing a bath on a Sunday evening as something produced in 'office' time. Work leaks out into the everyday, moving progressively from non-typical forms of labour, to secondary labour, to outsourcing, to situations today where the consumer becomes a veritable producer of value, a condition redolent of the web 2.0 economy, and lauded by certain FLOSS idealists for the freedom and agency it confers to 'the people formerly known as the audience' (Rosen, 2006).

2.4.3 Pervasive Production

In immaterial labour, therefore, we encounter pervasive forms of production. Here we will explore how this manifests in two interrelated ways. First, production is pervasive because in the new field of work, the *whole individual* is now called on to produce, to invest in and to express the self, expanding labour to the production not only of 'things' but also of subjectivity. And secondly, where this ongoing social production naturally overflows the traditional enclaves of work, production is ubiquitous because its relations are excessive to the wage relation or the factory, flourishing in the commons.

The Production of the Self

Let us start by looking at the first condition. While modes of production under industrial capitalism are characterised in terms of the production of commodities by means of commodities, cognitive capitalism is thought to produce knowledge by means of knowledge (Lazzarato, 2012, p.33 *supra* note 40). What we are speaking about here is a higher level of work, operating at the heart of the production and reproduction of the self. Labour operates at the heart of the social as an imperative to express oneself, to communicate, to cooperate and to consume. As Lazzarato claims, the production of subjectivity now ceases to be an instrument of control, and instead becomes directly productive, because the goal of this form of accumulation is not to construct the material commodity, so much as to construct the consumer/producer as

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[23] There does not appear to be a more recent audit of the economic productivity of free time at the time of writing.

an active subject, and in turn, to cultivate the kinds of productive environments in which material and social reproduction can occur (1996). Today, in other words, the worker experiences an imperative to produce economic value and subjectivity at one and the same time. Neoliberalism no longer conceives of the worker as the subject of exchange and the market, but as an 'entrepreneur of the self' (Lazzarato, 2012, p.24). In this way the worker is now supposed to guarantee the formation, growth, accumulation and valorisation of the self as human capital (op. cit., p.46).

A Marxist analysis of capital understands social relations to lie at the heart of commodity exchange (1986). Lazzarato argues that this situation is laid bare because immaterial labour is at its most basic level the production of a social relation. In other words, the informational content of commodities today is not just 'content' produced such as the auditory content of a music file, images or software. Instead, what is ultimately produced is the social relation itself. And as such, for Lazzarato it follows that the "raw material" of this labouring form is subjectivity itself and the environments in which this subjectivity is produced and reproduced (Lazzarato, 1996, p.139). This is what is meant when we say that the primary forms of labour today involve the production of the commons.

Beyond the Wage Relation

This naturally brings us to our second condition. Because of what it produces, labour now overflows the traditional relations of production. It cannot be managed or corralled within the wage relation for example, or be captured within traditional organisations such as the factory, the firm or the union. This has significant implications for the ways in which labour is subsumed and organised.

To understand how labour now produces outside of a wage relation it is necessary to briefly turn to a Marxist labour theory of value (1976, pp. 38-46)[24]. Marx's labour

[24] Marx's labour theory of value is a political economic critique of the value form in industrial capitalism; the forms that value takes and the practices and ideologies that emerge around this form are brought into question. In Marxian theory, the cell form of capital is the commodity: goods that are exchanged in a certain quantitative relationship with symbolic currency such that x amount of commodity a = y units of money b. In societies that are based on the economic principle of such an exchange, all goods have a use value and an exchange value. The use value is the qualitative aspect of the good, a utility that satisfies certain human needs. In exchange-based societies, humans acquire the goods they need through exchanging other goods with those needed in various quantitative relationships. 'Goods' are not just material but include money and physical labour power. In the accumulation of capital, capitalists purchase labour power and the means of production (raw

theory of value asserts that the value of a good is proportional to the labour time required in its production. The higher the value of a good, the longer its production takes. This can be observed where labour-intensive goods are generally more expensive than those with low labour intensity. The value form of labour is variable capital, which can be observed as wages. The value form of the means of production is constant capital. It consists in turn of two parts: circulating constant capital – the value of utilised raw materials, auxiliary materials and operating supply materials and fixed constant capital – capital that remains fixed in the production process.

Today, a number of theorists argue that we encounter a crisis of the Marxist labour theory of value, where the value of goods accumulates out of all proportion with the time taken to produce them (Vercellone, 2008, 2010; Žižek, 2012). A smaller and smaller percentage of value is thought to be derived from social wages and more and more is derived from the general intellect (Fuchs, 2009, 2010a; Terranova, 2004). As an example, Google 'free time', discussed in section 2.4.2, is an example of the new relations that are applied to salaried work in creative and computational-informational domains. However, much of the value produced in cognitive capitalism is outside or not expressly codified in a waged relation. Google's primary source of value is not the intellectual property and tools produced by its waged labour force, therefore, so much as the subjectivities that these tools are made to operate over: the attention and cooperation of networked users. A lot of the work involved in producing the 'informational or cultural content of the commodity' (Lazzarato, 1996, p.133) isn't captured within the traditional wage labour relation, and can't ever be[25].

In response, sociologist Christian Fuchs (2010a) identifies two distinct forms of variable capital (wage relations) operating through cognitive capitalism. For the first type of work (v1), corporations pay salaried workers a wage; for the second type (v2), value is largely produced for free. In v2, labour becomes a positive externality – something consumed but not necessarily paid for. (Or at the very least what is

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materials, technologies, spaces of production etc.) in order to produce new commodities that are sold with the expectation of making money (profit) that is partly reinvested (Fuchs, 2010, p.180).

[25] These reformulations of the relations between wages and profit will be discussed in further detail in chapter three.

acquired, performed or practiced in the time outside of paid labour is then utilised in the production of commodities.) Consequently, Fuchs argues that the formula for profit rates today requires some adjustment such that the traditional formula:

Rate of Profit = Surplus Value/(Constant Capital + Variable Capital) or p = s/(c + v)

Is expanded to

p = s/(c + v1 + v2) (Fuchs, 2009, p.191)

Where v1 represents wages paid to fixed employment and v2 the costs associated with cultivating or extracting value from the commons. When the immaterial aspect of the commodity becomes the main driver of wealth, a typical situation ensues in which the costs of v2 are made to approach zero and v2 increasingly acts in the substitute of v1. As Fuchs maintains, the rate of exploitation in such a system is potentially infinite (2009, p.77). We don't need to look far for examples of this in organised labour and social production: the rise of unpaid scenarios for graduates and job seekers such as protracted internships, unpaid competitions and portfolio work and the growing value extracted from user-generated content, co-design, crowd sourcing and collaborative consumption outside of organised labour (Bauwens, Mendoza & Iacomella, 2012).

2.4.4 New Divisions of Labour

The operation of this labour requires a certain autonomy. It cannot be managed through the subjugation of the wage or the exigencies of external administrative forces, but instead requires affordances and techniques that facilitate a continuum of cooperative production alongside mechanisms for the extraction of value outside of the wage relation or forms of direct command.

If we now encounter situations in which the whole individual produces, outside of the interstices of manual labour and outside of the wage contract, it is not surprising that the ways in which that labour is organised and managed are also changing. In order to produce, labour requires a very different technical division, one in which communicative and cooperative capacities can flourish. And the technical division of labour produced under industrial capitalism does not support this reproduction of the self, this production of the commons. For innovation to flourish under capital, the relations of production have to be much more autonomous from direct forms of command, while at the same time making themselves open to some degree of

immanent control. This section explores how industrial divisions of labour are breaking down and disunited only to be replaced by a sociotechnical composition that corresponds to a shift from the factory to the network.

A Marxist analysis of the division of labour produces an interpretative framework for the changes we are witnessing. This outlines three discrete stages in the division of labour that correspond to 'formal subsumption', 'real subsumption', and the 'general intellect' (Vercellone, 2007).

Formal Subsumption

Formal subsumption describes the period in capitalism from the early 16th century to the end of the eighteenth century. The labour/capital relation is distinguished by the dominance of expert artisanal knowledge and by mercantile and financial forms of accumulation. Here the labour process continues as before and operates within existing markets, but by enclosing the means of production and subsistence, capital compels the worker to submit to the wage relation and inserts control as an intermediary between the worker and the market. The division of labour in such a system is based on the system of the 'diffuse factory', also known as the 'putting-out system', in which the mercantile entrepreneur organises production by artisans and independent workers in the home (Vercellone, 2007, p.15 *supra* note 6).

Real Subsumption

However, the expansion of capital is understood to be limited by simple recourse to existing forces of production. Capital, therefore is said to transform the relations of production until they accede to the requirements of capital, at which point the worker is *real*ly 'subsumed'. The stage of real subsumption is associated with the industrial revolution. This is characterised by an extreme segmentation and specialisation of work. The division of labour described by Adam Smith in *The Wealth of Nations* (1776) stands as an introduction to industrial political economy, and Smith's analysis of the division of labour plays a fundamental role in the technical and social composition of labour/capital relations in industrial production. He argued that specialisation in cooperation with technologies produced greater skill and productivity at the micro-level of production. To illustrate this, Smith famously used the example of the pin factory where one worker engaged in the production of the head and another the body in cooperation with discrete equipment, over seen by

higher-level organisational roles. Attempts to increase productivity and to save time (based on a labour-theory of value that equates the value of goods with the time taken to produce them) engender a reduction of complex labour into simple, often mechanical tasks (1776)[26]. In industrial capitalism, market size and specialisation are contingent; the higher the volume of domestic and foreign trade, the more that economy can command a strict division of labour (Moulier Boutang, 2012, p.51). Economies of scale, therefore, such as those characteristic of Fordist production, support a high degree of technical specification. The dynamic of such a system of accumulation corresponds to the large factory, and its organisation to the model of the Firm (Aoki, 1986; Benkler, 2002).

Knowledge in such a model is incorporated in machines and in the hierarchical organisation of the overall firm and not with the labouring subject. The Taylorist model of Scientific Management provides a twentieth century edifice for this division of labour[27]. This model proposes a strict division between the cognitive aspects of the organisation of production, a process conferred to managerial roles, with a strong intervention in production towards the manual labourer, who was not employed for his ability to think, but for his physical labour and energy in tandem with thermodynamic machines. Communication in this model was actively retarded in favour of direct command. Further governing such a technical composition is a very strong division between the owners of the means of production and those who have the means of valorising them (Moulier Boutang, 2012).

General Intellect

The final stage of 'general intellect' corresponds to cognitive capitalism. Throughout the industrial age, capitalism exploited human bodies for mechanical labour and energy. Today, as we have seen, it is the higher order acts, decisions, quantitative

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[26] This model is redolent of the traditional American firm described by Coase (1937) or the Japanese firms of Aoki (1986). This model employed a vertical integration model, where the firm fostered its own internal research and development activities, which in turn lead to internally developed products. In an industrial model, the benefits of scale and scope for such internal research activities relative to the size of the external market produced a vertical integration model where large enterprises internalised their firm-specific research and development activities and subsequently commercialised these through insular forms of product development, marketing and distribution.

[27] The archetype of this division is encountered in the photographic studies of the husband and wife team Frank and Lilian Gilbreth. These were rigorously executed stop motion studies of labour activities (Brown, 2008).

processes and interpersonal relations that workers constantly perform and enact that constitute the most significant value they produce. As such, the evolution of Marx's theory of knowledge from *Capital* to *Grundrisse* traces a transformation from the atomised intellectual capacities of the industrial worker towards conditions where 'general intellect' – a collective intelligence that is supported by a technical assemblage - acts as a direct force of production (Marx, 1993; Vercellone, 2007).

The Breakdown of the Division of Labour

The divisions of labour implemented in industrial capital conflict with the necessary organisation of labour in the general intellect, manifesting as conflicts between knowledge and power (Vercellone, 2007) between competition and cooperation, or, simply put, between openness and enclosure. Centralised management hampers innovation. Instead, an economy centred on information, knowledge and culture requires open and fluid forms of social coordination between workers. As a result we are seeing a 'decomposition' of labour. Work is now quantified as the capacity to activate and manage productive cooperation. Instead of planning work on the basis of labour time and establishing degrees of the division of labour based on the expected size of the market, cognitive capitalism organises work on the basis of a kind of cooperative know-how; it takes the team as its unit of measure, the transdisciplinary as the field of study and the 'supreme agility of networks' (Kelly, 1997) as the idealised cooperative state.

We don't need to look very far for examples of this networked organisation: it operates in transdisciplinary institutions within the university[28] and the corporation,

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[28] While there is any number of examples of this model at play, the changing role of the university illustrates this well. Today as Nick Dyer-Witheford has argued, universities are becoming training grounds for the creation of new intellectual properties and technocultural subjectivities necessary to a post-Fordist academic regime (2005). This is captured by a growing number of polemics surrounding the university as corporation such as the 'edufactory' or 'corporate university'.

The traditional role of the university does not fit with this model. Traditionally, the university adopted an insular 'walled garden' model. It was highly centralised, produced a strong disciplinary segregation and was tied to the sovereignty of the nation state and the reproduction of national knowledge and culture (Rossiter, 2006). This model is ill suited to the production of cognitive capital and the capacity of today's universities to remain bound to such a model is greatly diminished. Nowadays, like other corporate institutions, the university must accommodate the complexities of global market dynamics, becoming decentralised, transnational, transdisciplinary and open. This is about socialising production, creating porous spaces in which knowledge and innovation can flow, producing more grants for interdisciplinary science and technology research, and coupling these processes to a stronger enforcement of IP over value produced from research and development activities.

in open innovation and production models (Von Hippel, 2009) and, as will be discussed in chapter three, in the kinds of free culture that proliferates in digital networks.

Take for example the rise of open innovation. The characteristic of openness to productive territories is one of the biggest differences between cognitive capitalism and previous systems of vertical integration and economies of scale. Today, we see business models where innovation is no longer centred on internal mechanisms (the corporate lab), but emerges through cooperation between both internal processes and previously external inputs. While the firm is still in control, other agencies such as suppliers, consumers and external researchers across academia and commercial development now play a significant role in the value chain. Henry Chesbrough writes "open innovation is the use of purposive flows and outflows of knowledge to accelerate internal innovation and expand the markets for external use of innovation respectively" (2006, p.2). Open innovation, therefore, is an umbrella term for a range of production models popular to cognitive capitalism such as co-design, co-creation, crowd sourcing and peer-production (Bauwens et al., 2012). This isn't to say that proponents of a vertical integration model didn't recognise the value of tacit knowledge and social relations; rather, previous to networked modes of production, the transaction costs associated with accessing and utilising external knowledge were too high to justify (Wilbanks and Rossini, 2012). Today, however, the network culture (and its attendant social and technical divisions of labour) provide the

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The establishment of new spaces for innovation and knowledge innovation inside the university is a perfect example of this, with art/science spaces such as Le Laboratoire in Paris, the Idea Translation Lab in Harvard and the Science Gallery in Trinity College Dublin all being cases in point. The Science Gallery, for example, was parts of a broader project by Trinity College in 2009 to develop a more porous interface between the University and the surrounding cultural activity of the city, intersecting with business, academic and creative work throughout the city (Gorman, 2009). As the director argues:

> "In the Science Gallery, a range of activities will allow the university and members of the business community and creative sector to mix with budding innovators" (Gorman, 2008a).

And rationalising that:

> "Universities have an ever-increasing need to engage the public with different areas of research, to justify public funding, to extend their relationships with local communities and to attract potential students" (Gorman, 2008b).

conditions for this extraction of value from the outside. The open innovation model makes heavy use of external knowledge flows to accelerate internal innovation and to expand markets for the external use of innovation respectively. Eric Von Hippel identifies sources of external knowledge in the form of suppliers and customers, universities, private labs, competitors, governments and other nations (Urban & Von Hippel, 1988)[29].

The Network as the Cognitive Division of Labour

When organised labour breaks down in this way, how can it remain under the control of capital? What we see is that as labour becomes fragmented, it is recomposed in a situation where "[t]he network comes to the fore as a form of cognitive division of labour" (Moulier Boutang, 2012, p.64). Just as real subsumption revolved around industrial machinery, the production of a diffuse intellectuality has an evolving techno-material basis. These new social and technical divisions of labour bring the network forward as an organisational model (Benkler, 2002; Kelly, 1997; Lazzarato, 1996; Moulier Boutang, 2012; Rossiter, 2006[30]; Wittel, 2001[31]). As Lazzarato argues, "immaterial labour constitutes itself in forms that are immediately collective and we might say that it exists only in the form of networks and flows" (1996, p.145).

In the networked economy, the social bond is not administrative but informational; it is created by the movement of ideas, the establishment of fluid and fluctuating standards, and the creation and protection of proprietary information. Characteristics

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[30] Rossiter (2006) has written about the emergence of new institutional forms alongside the network, where we see the decomposition or dissolution of traditional sites – the firm, the factory, the state, the university and so on - in their place we have distributive, non-linear "organized networks". Rossiter claims that these organized networks operate against the rigid bureaucracies of traditional institutions (p.49). Rossier's argument is grounded in a dialectic between the networked organization and the organized network, the first characterized by hierarchical and centrally integrated institutions, and the latter referring to decentralized organizations with horizontal modes of integration. For Rossiter these organized networks are described as radical enablers of political and economic change that arise from the limits of both tactical media (Lovink, 1997) and traditional institutional structures in a position to challenge the vagaries of Neoliberalism (p.215). Contrary to Rossiter this thesis understands organization to be re-composed around distributed forces that are immanent to the network. However, these position are not mutually exclusive.

[31] Wittel theorises a network sociality that replaces previous forms of organisation such as the community or the firm. This program of sociality is thought to be particularly visible in cities and in the operation of the cultural industries. It is a form of sociality that is "ephemeral but intense, it is informational and technological, it combines work and play, it is disembedded and generic, and it emerges in the context of individualization (p.1)".

such as openness, reflexivity, horizontal intermediation and horizontal organisation are at the heart of networks (Rossiter, 2006). This is the very opposite of the Smithian division of labour in that it promotes transdisciplinary cooperation and excess: As Kevin Kelly argues, "[t]he network economy rewards schemes that allow decentralised creation and punishes those that don't" (1997, rule #5); wealth is thought to flow from innovation, not optimisation. Benkler too points to networking as an organisational alternative that produces divisions of labour that are far more effective than the market, the enterprise or the firm (2002). If industrial economies of scale are premised upon the efforts of a single organisation to create value for less and in doing so to outstrip competitors, a networked organisation embraces the inverse condition; value is produced by a proliferation of users and competitors, although the gains acquired in such an arrangement are not equally distributed. In cognitive capitalism, the logics of the network emerge within the interstices of the new market paradigms of openness, fluidity and free exchange.

The figure of the network is frequently used in both communications and the sociology of organisation. Together they form an articulated sociotechnical system. In the former, the network specifies a technical assemblage such as an electrical grid, waterworks or a transport system. In the latter the network refers to informal ways of associating together human agents such as through organisations, markets or states (Latour, 2005, p.129). In the context it is applied in the technical composition of labour, however, these two operatives merge; the network becomes a privileged mode of organisation precisely through the extension of information and communication technologies. The network, as such, is not simply a trope for fluid market dynamics or forms of loosely woven sociality. As network theorist Eugene Thacker maintains, the network is also constituted through material and technical relations, and premised on information and communication technologies (Thacker in preface to Galloway,2004).

Global telematic networks and in particular mobile networks are significant to production. They facilitate the circulation of informational and cultural commodities and the various operations of production, recombination, codification, de-codification and distribution that this labour requires. It is not enough to be an innovative human subject, intelligent machines are needed to connect and coordinate in real time the fragments of information production.

Mobile and wireless networks with their endless capacities for locative and just-in-time interventions are particularly significant to the technical divisions of labour under cognitive capitalism, producing a spatial dedifferentiation that enables a continuum of production. As Franco Berardi comments, industrial workers stayed still and the assembly line revolved before them. But today:

> Info-workers, instead, constantly move all along the lengths, breadth and depth of cyberspace. They move to find signs, to elaborate experience, or simply to follow the paths of their existence. But at every moment and place they are reachable and can be called back to perform a productive function that will be reinserted into the global cycle of production. In a certain sense, cellular phones realise the dream of capital: that of absorbing every possible atom of time at the exact moment the productive cycle needs it (2009a, p.90).

So too, control over that labour process is no longer facilitated by vertically integrated organisation or top-down control such as the 'Boss' of the Fordist system. Instead, as a number of network culturists have argued, control comes to operate in a distributed fashion through the network (Galloway, 2004, Galloway & Thacker, 2007). The apparatuses of control and the material consolidation of the network therefore have a significant role in the production of labour as a self-enterprise that is formally autonomous, but substantially dependent (Berardi, 2009a). If labour is re-composed through these networks we have to attend closely to their material organisation and substantial ownership. Because what we see is that we become connected through technologies at the heart of the organisation of capital, which in turn are consolidated in corporate and monopoly positions.

2.4.5 Summary

This section detailed the re-composition of labour in contemporary capitalism. As value shifts from the material commodity to its immaterial dimensions, so too labour is reproduced and organised in new ways. Today the previous divisions between consumption and production work and non-work, production and reproduction are fluid. However, as traditional divisions of labour break down, we see that the network emerges as the new organisational form that structures social production in ways that are productive to capital.

Section 2.5: Conclusion

This chapter demonstrates how the socialisation of knowledge is now central to capital. It produces the informational and cultural content of the commodity, which, as has been demonstrated, is the primary driver of wealth in a Post-Fordist economy. Furthermore, the spirit in which this kind of work is commonly undertaken - as a passionate, free spirited and often voluntary mode of production with only the expectation of the acquisition of knowledge or the social relation itself as remuneration – reproduces the ideas of the liberal subject. Finally, the technical and material composition of this labour, often premised on cooperative relations over digitally networked media, form the ideal topology for the organisation of work under cognitive capitalism.

We can see that in its current configuration, therefore, free culture contains no necessary opposition with the market. While it produces intangible outcomes and allows for free self-expression, these conditions are conducive rather than antagonistic to the relations under which capital must now produce. Furthermore, we can see that the technical concatenation associated with the operation of free culture assists rather than obstructs the operation of cognitive capitalism. This is the model of labour that congregates around mobile and wireless networks, where spectrum-based technologies facilitate "the connection between the needs of semiocapital and the mobilisation of living labour in cyberspace (Berardi, p.193). Even as the network facilitates social production of information, knowledge and culture, communicative and cooperative infrastructure is increasingly consolidated in ways that facilitate the expropriation of social production without substantive remuneration. Capital thrives on a privileged position in the network.

What has yet to be explored is how this privileged position is produced: how value is extracted from these networks of production, and what kinds of interventions are in place to regulate enclose and expropriate the digital commons. To answer these questions, the next chapter will examine value and enclosure in detail via an analysis of rent. This provides the necessary theoretical underpinnings to proceed to a focused discussion of enclosure and expropriation in the regulation and political economy of electromagnetic spectrum.

Chapter Three: The Dynamics of Rent Accumulation in Digital Networks

Section 3.1 Introduction

Chapter two demonstrated that previously external forms of social production now inhere in the market economy. Value resides in immaterial goods such as information, know-how, culture, social interactions and trust cooperation that are socially produced. So too, where these goods are produced through human intelligence in cooperation, the technical division of labour is reconstituted to reflect distributed forms of peer-production and co-creation through loosely or tightly integrated networks. Along with hubs such as cities, academic and research institutions and corporate spaces, social production through digitally networked media, far from being a bastion of nonmarket production, is now central to the new economy. However, we have not yet asked how or through what mechanisms capital accumulates value from these immaterial commodities and, given the nature of the thesis enquiry, how these processes are effected in networked environments.

This thesis proposes that it is through the strategic operation of forms of rent that value is extracted from social production. The mechanisms of this process were obliquely rehearsed in chapter two when financialisation and the growing value of market externalities were first described, but in this chapter they will be given specific attention and applied to the dynamics of value-capture from social production in online environments.

In the previous chapter we identified a crisis of Fordism that sees social production in the commons brought to the fore of the economy. As a consequence of this, a number of theorists propose rent as a new value theory to describe this system and argue that we are witnessing a return and proliferation of forms of rent as the principle mode of accumulation within this assemblage (Chicchi, 2010; Fumagalli, 2010; Gray, 2010; Hardt, 2010; Hardt & Negri, 2009; Marazzi, 2010, 2011; Negri, 2010; Pasquinelli, 2008, 2009, 2010a, 2011; Terranova, 2010; Vercellone, 2008, 2010). When value resides in the commons we see the emergence of a new set of relations in which a theory of value based on labour time and the wage relation are replaced by the extraction of surplus from free labour and social cooperation. As such we are encountering a growing conflation of principles of 'profit', as surplus

that is directly invested in production with those of 'rent' as surplus that is extracted from ownership of a resource. In contrast to industrialism, capitalist accumulation is today characterised by a shift from the productive forms of capitalism that characterised the industrial era towards new modalities in which rent is no longer cast in opposition to profit. Instead, rent, through a variety of mechanisms becomes directly productive. Section 3.2 puts forward this new theory of value and identifies its operation in a number of spaces before proceeding to an analysis of rent in digitally networked media in sections 3.3 and 3.4.

While there are a range of different spaces where rent operates today, from financial rent, urban real estate and rent over physical infrastructure, this thesis concerns the types of rent in operation over the digitally networked media, and mobile networks in particular. The rest of this chapter attends to two core questions:

- What kinds of value is produced and extracted from digital networks and through what channels? (technical, algorithmic, proprietary)
- And secondly, how is a rentier position produced and consolidated in the digital network?

The first question is dealt with in section 3.3, which explores the operation of rent across broadcast, wired and finally mobile networks. This type of rent has an evolving technical basis from one-to-many media formats towards the many-to-many forms of participation occurring in ubiquitous contexts. This proceeds from early theories of audiences towards more engaged modes of production that identify the fixed prosumer and mobile prosumer as valuable productive agents (Fuchs, 2009, 2010a, 2010b; Smythe, 2001).

We also take the opportunity to look more closely at the mechanics of value capture in digital networks, arguing that surplus value produced in the digital commons is not only a consequence of human intelligence but is also directly facilitated by technologies that allow for the aggregation of previously latent information emerging from interaction and cooperation. Powerful algorithms coupled with formidable storage and processing capacities allow for commercial operations not previously possible. The rapid circulation of information over the network not only closes the void between production and consumption. It also allows for recursive and dynamical processes where informational content can be fed back in ways that augment value.

Section 3.4 looks to our second question, and asks how the privilege to extract rent from social production is created and consolidated in the network. This outlines the forms of material, technical and juridical enclosure that facilitate the extraction of value from the common spaces of production. The extraction of rent from digitally networked media is predicated not only on being in possession of the necessary apparatuses to extract data and information but also the proprietary privileges and rights to extract value from social production. This proceeds in such a way that, while access to communications proliferates, the control of network resources is increasingly abstracted from users and instead consolidated with monopoly or oligopoly networks. This commons/property relation facilitates the extraction of rent, but it also points to potential antagonisms in this system of accumulation. Where this preliminary analysis introduces many aspects of the operation of rent over digital networks that are in need of further attention, we also introduce the enclosure of spectrum-based networks as a core object of study for the remainder of the thesis.

Section 3.2: The Becoming-rent of Profit

3.2.1 Introduction

To determine how value is produced and subsequently extracted in cognitive capitalism, we first have to explore the ways in which value is now configured and constituted in relation to income distribution. According to Marx, wages, rent and profit are the three main categories for income distribution emerging amongst capitalist relations (1986, Chapter 48). Where the relations between these three are transformed across industrial and cognitive capitalism (Vercellone, 2008), their individual characteristics and the transformations occurring within these require some elaboration.

3.2.2 Wages, Profit & Rent

Wages

The value form of labour is variable capital, which can be observed as wages. Wages designate the remuneration of productive labour. They are the cost of labour that produces the surplus value that is the origin of both profit production and rent. Surplus value is the basis of accumulation and is value generated in excess of wages. This is labour for which the capitalist does not pay; the accumulation of value is

always in excess of surplus. It is also worth noting that this surplus value is not just the sum of the surplus labour generated by each individual worker. The surplus extracted is greater than the sum of its individual contributions; it is also the surplus of social cooperation itself (Fuchs, 2010a, pp.183-184). The value form of the means of production on the other hand is constant capital. It consists in turn of two parts: circulating constant capital, utilised as raw materials, auxiliary materials and operating supply materials, and fixed constant capital, designating capital that remains fixed or is reinvested in the production process (Marx, 1986, pp. 317-319).

Profit

Profit and rent are the forms of revenue that result from the expropriation of surplus from labour. Profit is understood to be the "internal character" of capital with respect to the process of production (Vercellone, 2010, p.97). An element of profit is conserved within business in order to be reinvested in production (Marx, 1986 pp.248-275). In other words, profit presumes (and requires) the direct intervention of the capitalist in the production and circulation of material commodities. Capitalists purchase labour power and the means of production such as raw materials, technologies and so on in order to produce new commodities that are sold with the expectation of making profit that is partly reinvested (Fuchs, 2010b, p.295). In this way profit is thought to play a positive role in the ongoing development of productive forces and in the struggle against scarcity. It is associated with the ability to generate and extract surplus. In chapter two we refined the expression of rate or profit such that the traditional maxim:

'$p = s/(c + v)$' was refined to: '$p = s/(c + v1 + v2)$'

Where v1 represents waged labour and v2 represents labour for which the capitalist does not directly pay (Fuchs, 2010a, p. 191). This revised equation points to an exponential degree of work that is invested by labour in the production of commodities but which operates outside of direct command, calling a traditional labour theory of value into question. As such, the classic representation of profit appears to be inadequate in its traditional configuration to explain the accumulation of value in contemporary networks. We can see that there are forms of accumulation that are not captured by traditional profit or the operations of waged labour time and this requires a reconsideration of the theory of value (Chicchi, 2010, pp.143-144).

Rent

Where 'rent' is the primary locus of value, on the other hand, the rentier is thought to be external to the production of value, merely extracting the economic rent produced by other means (Pasquinelli, 2008, p.92; Vercellone, 2010, p.91). Rent traditionally is the revenue that can be extracted from exclusive ownership of a resource, where value is contingent on its availability with respect to demand (Harvey, 2001). It constitutes a credit title or control of some immaterial or material asset that grants the right to draw benefit from a position that operates outside of production (Vercellone, 2010). As such it is 'unearned income' (Kleiner, 2010, p.10).

Rent as a concept is arguably more complex than profit. It operates through two processes, both of which require further expansion:

1. Rent operates through the enclosure of the commons. The essence of capitalist rent is thought to be the expropriation of the social conditions of production and reproduction. In other words, rent is what comes into play when capital succeeds in enclosing the commons (Negri, 2010, pp.266-267, Pasquinelli, 2008, pp.94-104; Vercellone, 2010, p.94). To be schematic, we can say that profit is the income made selling commodities while rent is the income made by a monopolistic exploitation of spaces and resources. This is the case with the primitive accumulation of land, as it is the case with financial rent, public debt[32], and the enclosure of collective intelligence. As Vercellone argues:

> Since its historical inception during the process of enclosures, capitalist rent has been the other face of the common. It is the outcome of a process of expropriation that is the starting point and essential feature of the reproduction of capital over time and space. (2008, p.2)

The different forms that rent takes correspond to the privatisation of various social and material conditions of production and to the transformation of forms of the common into commodities. As such, Vercellone argues that rent's varying significance throughout the history of capitalism is closely linked to stages of 'de-socialisation, re-socialisation and the new de-socialisation of the economy' (2008, p.3).

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[32] Public debt is slightly different as it involves an inverse condition; enclosure is produced not through the privatisation of the commons, but through the socialisation of a negative externality.

2. This brings us to a second essential condition of rent. Contrary to the generation of profit, which involves some necessary reinvestment in production as an operation *against* scarcity, rent is premised on the *production* of scarcity (Harvey, 2001; Marazzi, 2011; Vercellone, 2008, 2010). To quote Napoleoni's definition, rent is the revenue that the owner of certain goods receives as a consequence of the fact that these goods, are, or become, available in scarce quantities (1956). Beyond the enclosure of the commons, therefore, the survival of exchange value in rent is increasingly contingent on the destruction of non-renewable scarce resources and/or the creation of an artificial scarcity where these goods are by nature non-rival and reproducible (Marazzi, 2011, p.41)[33]. According to Vercellone (2010), therefore, resources on which accumulation is based today do not tend to increase with rent (as is thought to be the case with productive capital); indeed they do exactly the opposite (p.95). Rent is thus linked to the artificial scarcity of a resource, and to a logic of rarification, as in the case of monopolies. Rent leverages monopolistic or oligopolistic forms of property, and positions of political power that facilitate the manufacture of scarcity. These conditions will be discussed in greater detail in the forthcoming chapters.

3.2.3 The Becoming-Rent of Profit

Today, the changing relations between the production of profit and the conditions under which labour produces require a reconsideration of the category of rent. Many theorists in the autonomist Marxist tradition now argue that we are witnessing a breakdown of the strong divisions between rent and profit that were peculiar to industrial capitalism. In contrast, cognitive capitalism is characterised by a return and proliferation of forms of rent (Chicchi, 2010; Fumagali, 2010; Gray, 2010; Hardt, 2010; Hardt & Negri, 2009; Marazzi, 2010, 2011; Negri, 2010; Pasquinelli, 2008, 2009, 2010a, 2011; Terranova, 2010; Vercellone, 2008, 2010).

Rent in Marxist terms was largely understood as a pre-capitalist legacy, traditionally associated with immobile forms of property such as land, as opposed to the mobile forms of property that characterised industrial production (Hardt, 2010). Hardt identifies how Marx's *Economic and Philosophical Manuscripts* (1998), draws a

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[33] Enclosure and scarcity go hand in hand; there is no chronology as such. The extraction of rent is dynamic and these elements, which are separated for clarity here, are in reality entangled, imbricated and mutually enforcing.

distinction between capital as ownership (interest) and function (performing capital), which is to say between the interest accrued from a speculative role associated with rent and the active profit of an entrepreneurial role. Rent was gradually marginalised in industrial capitalism, as industrialism limited the productive role of rent through the taxation of ground rent; the management of the supply of currency (Vercellone, 2008); and through the establishment of a mode of production that relegated the interests of share holders and other 'unproductive' modes of capitalist valorisation to a secondary role[34]. The role of intangibles such as intellectual property was similarly limited.

Theorists of rent now demonstrate that these divisions between rent and profit are peculiar to the modalities of industrialisation rather than a universal condition; today the lines separating rent and profit are flexible and mobile, both theoretically and historically, and alongside the communism of capital (Virno, 2004), these divisions begin to disintegrate (Vercellone, 2008). Post-operaismo theorists now argue that rent presents itself as a relation of pure distribution (Pasquinelli, 2008; Vercellone 2008). This condition is sometimes described as the 'becoming-rent of profit' (Marazzi, 2007, 2010, Negri, 2010; Pasquinelli, 2008, 2009; Vercellone, 2008, 2010).

How does this happen exactly? When the labour theory of value[35] is in question and the function of labour becomes increasingly autonomous from the managerial

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[34] We see this very clearly where Keynes called for the 'Euthanasia of the Rentier' (1936).

[35] Marx's 'labour theory of value' is a political economic critique of the value form in industrial capitalism; the forms that value takes and the practices and ideologies that emerge around this form are brought into question. This value theory asserts that the value of a good is proportional to the labour time required in its production. The higher the exchange value of a good, the more labour is required in its production. At the level of prices in industrial capitalism, this can be observed by the fact that labour-intensive goods are generally more expensive than those with low labour intensity. Theorists argue that we confront a crisis of the Marxist labour theory of value in cognitive capitalism, where the value of goods now accumulates out of all proportion with the time taken to produce them (Vercellone, 2008). This was seen to be the case with the wealth of conglomerates such as Microsoft and Facebook who accrue wealth not through an increased exploitation of the labour force or through producing a superior product at a lower price, but through value that is extracted from positive externalities (Žižek, 2012). This is a network externality when the good sold is produced as a global standard (in the case of Microsoft) and a knowledge producing or informational externality when the good sold is audiences and demographics (in the case of social media platforms). As such, Wage relations are dramatically transformed under cognitive capitalism. Google 'free time', discussed in chapter two, is a good example of the new relations that are applied to salaried work in creative and cognitive domains; here, a worker is encouraged to pursue personally fulfilling activity that doesn't correspond to the obviously subjugated wage relation of a Taylorist system of scientific management. However, much of the value produced in cognitive capitalism is outside or not expressly codified in a working relation. Google's primary source of value is not the intellectual property and tools produced

functions of capital, the divisions between rent and profit dissolve. As detailed in chapter 2, "the unified cycle of industrial capitalism under the hegemony of productive capital has entered a crisis" (Marazzi, 2008, p.2) and what follows is a progressive expansion of the financial economy as a strategy crucial to the re-composition of capital outside of directly productive positions. We saw the operation of these changes to the organisation of labour in chapter 2, but here we explore the attendant transformations to value accumulation.

As discussed in chapter 2, this manifests as an expansion of accumulation towards the commons. What we see is that as value expands outwards to social production, the mechanisms of control and value-capture must also transform, substituting direct control over labour for a strategic position between labour and the market (Marazzi, 2007, 2010, 2011; Vercellone 2008, 2010). When capital expands to expropriate the 'intangible commons of the mind' (Boyle, 2003 p. 37), value accumulation relies, not on direct intervention, but on the production of a strategic position with respect to social production. Yet another consequence of the crisis of a labour theory of value is the risk of "a drastic reduction of the monetary value of production and its related profits" (Vercellone, 2010, p.102). As a result, in an attempt to keep the premium of exchange value in place and guarantee profits, capital is led to develop mechanisms of revenue based on the rarification of supply. Because these two related conditions (enclosure of the commons and the production of scarcity) are understood to be the foundations of rent (Vercellone, 2010) we arguably see a return and proliferation of species of rent in the contemporary economy[36].

Today instead of producing profit by exacting an extreme subsumption/discipline over the relations of production, rent is produced through the establishment of a calculated position with respect to the continuum of social production. The direct control over labour that characterises industrial production is substituted for command over markets (Fumagalli, 2010, Vercellone, 2010) in an "exteriorization of

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by its waged labour force, in free time or otherwise, so much as the subjectivities that these tools are unleashed upon: the attention of millions of web users worldwide. It makes sense therefore that a lot of the work of immaterial labour isn't captured within the traditional wage labour relation, and can't ever be.

[36] There have been a number of criticism of a rent theory of value. For these see Ahn, 2012; Caffentzis, 2013 and Fuchs, 2009. A rent theory is applied in this thesis as it allows us to identify new systems of value accumulation operating over social production in digitally networked media in the way a traditional labour theory of value does not.

capital with respect to production" (Vercellone, 2010, p.105). In fact, there is a deep relationship between an increasing autonomy of labour in the production process (chapter 2) and capital's tendency to "indirect forms of domination of production and of the mechanisms of surplus appropriation realized by means of the sphere of monetary and financial circulation" (Vercellone, 2007, p.22).

For Vercellone, this composition resonates with the formal subsumption of mercantile capitalism, which does not exert discipline over the relations of production but allows them to take their natural/common forms:

> the unified cycle of industrial capitalism under the hegemony of productive capital has entered a crisis, and we are now witnessing the return of a mercantilist and financial logic that is reminiscent of the pre-industrial formal subsumption of capital. (Vercellone, 2008, p.2)

As Caffentzis describes it:

> Instead of the factory, the production of contemporary cognitive capitalism has as its model the putting-out system[37] where the merchant provides the wages, inputs, and at times the machines and receives the product in return (Caffentzis, 2013, p.104) [38].

Examples include the cottage industry or the domestic industry common between the sixteenth and eighteenth centuries, but this arrangement also resonates with the provision of communicative capacities the capitalist has enacted control over to forms of online labour.

Capital inserts itself as an intermediary between labour and the market. While command may now operate outside of the direct control of production, it continues to exert itself through the enclosure of the commons, through the control of supply and through the control of markets. This is how rent, traditionally described as external to production, comes to be productive.

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[37] It is so-called because the capitalist 'puts-out' the raw materials to be worked, and sometimes the tools.

[38] Caffentzi's description here is accurate but it occurs in the context of a critique of the becoming-rent of profit. Caffentzis is actually very critical of this analogy in that he argues that the putting-out system involved a deep level of planning and organisation of the work process as opposed to a position of exteriority.

3.2.4 Examples of Rent

Before proceeding to an exploration of rent in digital networks, it is useful to look at a few other examples of the operation of rent. As we proceed further into this thesis we will see that there are different types and densities of rent. However, these can be attributed to two categories: direct and indirect rent which in turn have correspondences with Marx's categorisation of absolute and relative rent[39] (Harvey, 1976). The first concerns income that *directly* accrues from the enclosure and control of some resource, such as renting a house for shelter or renting out a field to those who wish to work it. This is receiving returns for access to some means or element of material or social reproduction. Where this is a classical definition of rent, increasingly we see the emergence of *indirect* forms of rent. These are more complex and concern income that accrues from the enclosure and control of a common resource that in turn grants access to some autonomous element of social production, (types of 'work' that have developed in response to social needs as opposed to the economic needs of capital).

Natural Resources

Though theories of rent in cognitive capitalism often point towards the spiralling value of social media and networking, capital continues to impact natural resources also, the exploitation of which continues as one of the world's main sources of rent. For example, any attempt now to relate fluctuating oil prices to the fluctuation of production costs or the price of exploited labour is meaningless; production costs are negligible as the price we pay for oil, instead, this price represents the rent a resource owner can command by way of limited supply (Žižek, 2012).

Financial Rent

Though rent is traditionally associated with contractual payments for the hire of land, real estate and intellectual property, we can also consider interest as a financial rent to which the property title of a security gives credit (Marazzi, 2011). Financial rentiers are the owners of wealth where interest on monetary assets constitutes a

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[39] In Marxist theory, absolute rent is unearned income from appropriation, while relative rent is produced from the value of labour added to the property (Harvey, 1976 pp.154-155). There is a broad correspondence between absolute and relative rent and the direct and indirect categories of rent here except that we use the term direct rather than relative to also incorporate the new forms of command and not simply to describe the differential produced by investment in a tangible resource.

contractual payment for the loan of finance. Rent, as such, has been a key instrument for value capture and transfer in the form of monetary capital on all spatial and temporal scales, ranging from transactions between individual firms up to global financial flows. These financial rentiers transfer and centralise financial income based on their proprietary titles (Marazzi, 2010, 2011). As Zeller illustrates:

> Property owners in the metropolitan countries profit as rentiers from the yields on credits, portfolio investments, direct investments and royalty payments. But also in the emerging and peripheral countries, owners of property titles are those who can pocket interest income, which can be obtained due to the increase of domestic debts and foreign exchange reserves in their countries (Zeller, 2008, p. 20).

Real Estate

Speculation and real estate also feature heavily in the becoming-rent of profit. David Harvey's 'Art of Rent' (2001) is an early, persuasive account of the ways in which immaterial surplus may be successfully channelled through very material properties without directly intervening in production but simply through controlling supply. Harvey examines the gentrification process occurring in Barcelona at the turn of the century, describing how local cultural injections and forms of urban 'commoning' (Linebaugh, 2009) produced positive externalities. These externalities were subsequently used to leverage the value of real estate in the surrounding area. This type of relationship between cultural activities in cities and capital is well described in theories of the creative class, the creative city and creative industries put forth by Caves (2000), Brooks (2010), Florida (2002), Howkins (2002) and so on. Similarly, Florida asserts that metropolitan regions with a high concentration of creative and knowledge work across arts and music and IT engender a higher level of economic development and attract business and capital (2002).

3.2.5 Summary

This section demonstrated the centrality of rent and looked at its operation in a variety of spaces. However, this thesis explores the operation of rent through the enclosure of the digital commons. This is particularly intense because the primary object of rent concerns access to the communicative and cooperative capacities of people. The next section argues that it is through the operation of rent that strategic positions within the network can extract surplus value from social production in online environments.

Section 3.3: Rent Accumulation in the Digital Commons

3.3.1 Introduction

The core enquiry of this thesis is the expropriation of the digital commons, using the enclosure and valorisation of spectrum-based networks as a lens. Following on a discussion of the transformations to labour and accumulation in forms of online social production in chapter 2, this thesis proposes that it is through the strategic operation of forms of rent in the common spaces of networked production that value is now extracted from online production. Where the operation of rent was explored and demonstrated in a number of fields in section 3.2, we now proceed closer to the core enquiry of this thesis and explore in detail its operation across digitally networked media.

3.3.2 Digital Rent

Digital technologies have opened a whole range of dynamic spaces and networks to apply rent in novel ways (Pasquinelli, 2008, p.96). The basic business models that dominate in digitally networks are the advertising model, the service/infrastructure model and various combinations of these (Kang & McAllister, 2011). Rent operates at many different layers: over the infrastructure that makes communications possible, such as hardware, core infrastructure, bandwidth, data storage and energy, through to proprietary arrangements in software, platforms and online content. New forms of rent are increasingly generated in this digital space, such as the rent over the attention economy performed by web advertising, or the rent of Internet Service Providers (ISPs) over bandwidth and Mobile Network Operators over electromagnetic spectrum.

Rent in the digital commons is particularly complex as it proceeds through a variety of channels, both direct and indirect. It might be a fee applied on ICT infrastructures when they establish a monopoly on infrastructure, media, bandwidth, protocols and standards, software, platforms or virtual spaces. This corresponds to rent as a fee extracted by the proprietors of core infrastructure (the state, telecommunications providers) from corporations looking to roll out services or platforms. As discussed

in section 3.2, this kind of rent is direct[40]. However, rent also refers to income extracted by Internet service providers, platform providers and software conglomerates when they establish a monopoly over users; content; attention, data and metadata, and social network affiliations. This corresponds to rent as a fee extracted by these companies from other commercial enterprises and advertising companies who require access to the products of the commons. This form of rent is indirect.

But as we will see, the conditions for the extraction of both kinds of rent are deeply imbricated. At the heart of both direct and indirect forms of rent over the digital commons are the communicative and cooperative capacities of users; value in both situations converges on the general intellect. The primary issue, therefore, is where different commercial actors lie within a value chain[41]. For example, for a telecommunications provider the value of the resources they provide accrues according to a) demand for communications and b) the possibility network resources afford to create a strategic position in the network. This is reflected in the significant auction value of network resources such as spectrum. For a social media conglomerate, on the other hand, the value of their platform accrues according to the aggregate of hyper-segmented users they can market to advertisers and other commercial entities with a vested interest in user data, information and knowledge (Gross, 2012, Ippolita, 2013; Kang & McAllister, 2011; Manzerolle, 2010; Pasquinelli, 2009; Spreeuwenberg & Poell, 2012; Walker, 2002). In some cases an agent might occupy both positions. This is particularly the case with large software, social media and media content conglomerates such as Google, Facebook and Amazon whose value chiefly derives from user-generated content, while their network position is firmly consolidated in auxiliary investment in infrastructure such as servers, bandwidth, spectrum and so on (Fehrenbacher, 2010; Ippolita, 2013; Reed, 2012). In other cases, as with third party and agnostic providers of network

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[40] Direct is the term chosen and applied in this dissertation. Pasquinelli uses the term 'technological rent' to describe a straightforward lease of ICT infrastructure (2008), as distinct from 'cognitive rent' which is a rent applied over attention and communicative capacities etc.

[41] Further, it is an acknowledged truth within telecommunications that significant value resides close to the user, and as a result, the straightforward provision of telecommunications resources is becoming a less viable business option (Dawson, 2011). I discuss these transformations in detail in a 2012 publication for the Fibreculture journal (O'Dwyer & Doyle, 2012).

infrastructure, or with less influential software providers such as third party app developers, the commercial agent accrues income through just one aspect of this market[42]. However, while value in the network inevitably points to the intangible asset that is the communicative and cooperative capacities of users, secondly, the privilege to extract this intangible value is generally conferred by possession of certain tangible[43] assets that constitute a strategic position within the network. This condition will be analysed in further detail in 3.4.

As digitally networked media opens up new spatiotemporal avenues for the extraction of rent from users, we are witnessing a total colonisation of everyday life. This is not to take the deterministic position that digital networks 'usher in' cognitive capitalism. As discussed in chapter two, the new relations of online production and accumulation have a broader genesis. That being said, digital networks do provide a range of technological affordances that allow for the monetisation and command of forms of production previously outside the interstices of the market. As networks become increasingly pervasive this is more and more the case.

We are faced with a number of questions that the remainder of this chapter will try to answer:

- What kinds of value are extracted from the digital commons, and through what channels?
- How is a strategic position produced, consolidated and controlled within the network? (In other words, what forms of material, technical and juridical enclosure confer the privilege to extract rent from the common spaces of digital production?)

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[42] Depending on a conglomerate's control of different aspects of the network or the relationships formed between different network monopolies, this situation can be mutually beneficial or antagonistic.

[43] A Tangible, generally references a resource that is non-produced/ naturally occurring (SNA, 1993). These might be tangible because they are physical and rival or tangible because they are juridically consolidated in a rival and scarce position.

3.3.3 What Forms of Value Are Extracted from the Digital Commons and Through What Channels?

Let us begin by asking: What forms of value are extracted from the digital commons? First of all, we have to identify the forms of value that online social production can be said to produce. Those detailed in critical Internet culture include:

- Attention: The *time* and *focus* that users give to commercial messages and the *responses* they produce to this through acts of online consumption, recommendation or circulation (Jhally & Livant, 1986; Smythe, 2001). Where information proliferates, attention is now a scarce commodity.
- Information, Data and metadata: The informational content that users produce or coproduce, from personal or semantic information they consciously contribute, through to the data they inadvertently produce through online activities such as search, consumption and social interaction (Pasquinelli, 2009).
- Cultural Content: the cultural content that users produce in the form of rich media such as images, text, audio and video or through their online interactions that contribute to taste making, preferences and habits of consumption (Terranova, 2000).
- Network affiliations, cooperation and sociality: The value users produce through their extended or ephemeral connections with others (Dean, 2013; Pasquinelli, 2009)[44].

For clarity, these are presented as four discrete categories, but they are in no way mutually exclusive.

Secondly, we ask what kinds of technical concatenations facilitate the production of different forms of user-generated value? The extent of the operation of rent is directly proportional to the evolution of a techno-material substrate from mass media through to forms of networked mobile and locative media. Different network topologies have historically potentiated different degrees of value production, beginning with the value of an attention economy in broadcast media and

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[44] For more see: Ahn, 2012; Cohen, 2008; Dean, 2012, 2013; Fuchs, 2009, 2010a, 2010b, 2012; Ippolita, 2013; Jakobbson, 2010b; Jhally & Livant, 1986; Kang and Mcallister, 2011; Manzerolle, 2010; Pasquinelli, 2008, 2009 2009, 2010a, 2010b, 2011; Wittel, 2012.

progressing to the multivalent processes afforded by ubiquitous computing. In exploring the question of value production through digitally networked media, therefore, we must consider the relations between what forms of value are produced and the affordances and constraints of particular media forms.

Political Economy of Communications:

A good way of tracing the concurrent development of value production and media forms is through literature from the political economy of communications that deals with the role of communications in capitalist relations of production (Mosco, 2009). Despite similarities between early theorisations of value production and capture within the political economy of communications and more recent post-operaismo theories of the general intellect, there has not been a lot of correspondence between the two bodies of literature[45]. They are brought together here because a historical materialist analysis of communications media is significant to our analysis of rent (Fuchs, 2009, 2010a, 2010b, 2012; Jhally & Livant, 1986; Manzerolle, 2010; Mosco; 2009; Smythe, 1987, 2001). Developed in the second half of the twentieth century to explore the work performed by traditional broadcast audiences (Jhally & Livant, 1986; Smythe, 2001), these theories have more recently been applied to the labour of online communities (Fuchs, 2009, 2010a, 2010b, 2012) and digital labour over mobile networks (Manzerolle, 2010).

The Audience Commodity:

Dallas Smythe's theory of audience commodification is particularly significant to our analysis (2001). It provides an early theorisation of the operation of rent over broadcast audiences, arguing that corporate liberal control of mass media conferred a privilege to extract unearned income from the free labour of the broadcast audience. In response to media theory that specifically emphasised the ideological role of mass media as producing a 'false consciousness'[46] in the audience, Smythe also called for a historical materialist approach to the role of communications media in capitalism. He argued that Western Marxism had neglected to engage the full economic and political significance of mass communications media, choosing to focus on their

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[45] Though Christian Fuchs does not subscribe to a rent theory of value, he has provided a literature review of autonomist theories of rent alongside the political economy of communications from individuals such as Smythe and Mosco.

[46] See Adorno and Horkheimer, 2007.

ideological role in the furthering of hegemonic capitalist positions, while subsequently ignoring the economically productive function they also serve in the commodification of audiences (2001). Smythe asks instead what the commodity form of mass-produced advertiser-supported communications under monopoly capitalism can be said to be, and concludes that it is the attention and affective responses of audiences.

> Because audience power is produced, sold, purchased and consumed, it commands a price and is a commodity…[y]ou audience members contribute your unpaid work time and in exchange you receive the program material and the explicit advertisements (Smythe, 2001, p. 233).

As such, an early theory of how collective intelligence is commercially productive was outlined in Smythe's theory of the audience commodity. This suggests that in the context of media advertisement models, the audience constitutes a commodity that is sold by the mass media to advertisers. There are discrete types of audiences segmented across psychographic, demographic, geographic, biometric and behaviouralist data. This is the main commodity produced by a media form that earns its primary revenue from advertisers. In the commercial broadcasting model historically employed by mass media forms such as public radio and television, the audience's attention to commercial messages is exchanged for access to media content over these platforms, a situation Smythe refers to as the "free lunch" (p.232). In turn, the audience performs the work of consuming and responding to commercial messages outside of waged employment, in turn boosting production and profits through the sales of commercial goods. By performing this service free of charge, the audience works for media capital by marketing goods and services to themselves and their social network. In so doing, "[a]udiences thus labour for advertisers to assure the distribution and consumption of commodities in general" (Jhally & Livant, 1986, p.67). Where Smythe performed an analysis on radio broadcasting, this framework was later extended to television broadcasting by Jhally (1986).

The commodification of audiences has an evolving technical and material basis. The title to audiences is contingent on the control and exploitation of communicative (and increasingly cooperative) capacities. When Smythe was writing, this largely referred to one-to-many broadcast models of mass media, such as public radio and later television (Jhally & Livant, 1986). As Smythe detailed, the development of

spectrum-based technologies that infiltrated the spaces between work and leisure were central to the commodification of discrete audiences (1987, 2001). However, the power to commodify audiences was still relatively limited by a broadcast topology, which broadcast commercial information to audiences but did not yet extract information back from its users in any widespread sense.

The Prosumer Commodity

However, alongside the growth of an economy of user-generated content that places not only the user's attention, but also his or her social production at the centre of the value chain, we encounter a hypertrophy of Smythe's theory of the audience commodity. If Smythe's theory detailed the commodification of audiences through one-to-many mediums, today we are witnessing the evolution of this theory towards Fuchs' 'prosumer commodity' (2010b), describing surplus produced through the consumption, production and distribution of informational and cultural capital over many-to-many networks such as the Internet. Contrary to a techno-utopian ideology that associates such a network topology with liberal democracy, Fuchs extends Smythe's political economy to explore the prosumer (a networked subject outlined in chapter one) as a more absolute commodification of the general intellect wrought through network media.

Fuchs, among others, argues that the figure of the prosumer as an autonomous and critical agent obscures the exploitation of labour performed by digital cultures. Like the audience commodity, the typical accumulation strategy is to put-out some form of free access to online platforms or services. These in turn enable Internet service providers to bundle target audiences for third party advertisers *and* to access user-generated content that can be used to rationalise future commercial activity. As such the prosumer, in comparison to the audience, is a double object of commodification: the prosumer is first commodified when they are sold as audiences to advertising clients in turn resulting in their increased exposure to commercial logic (Fuchs, 2010b). This is a commodification of attention and desire. Secondly, the prosumer is commodified when their online activity produces valuable informational and cultural content for commercial interests, producing a commodification of collective intelligence and everyday sociality as it occurs and is captured in online spaces.

The value of the prosumer, therefore, is not just derived from attention but also information, knowledge and data that is consciously or inadvertently contributed

through online activity. This includes cultural content, such as rich media, text and personal tastes and preferences, and informational content, including data and metadata inadvertently produced such as personal information, search profiles and habits of consumption. These in turn produce value for corporations who can attach advertisements to user-generated content or user information gathered to facilitate various forms of market research (Fuchs, 2009, 2010a, 2010b; Kang and McAllister, 2011).

An integrated (and consequently well-rehearsed) example of this occurs in the range of algorithms associated with Google's advertising programs (Fuchs, 2009, 2010a, 2010b, Ippolita, 2013; Kang and McAllister, 2011). Most of Google's revenue drives from an advertising model based on pay-per-click or cost-per click advertising services (Perez & McMillan, 2007). This is produced through the confluence of two related programs: AdWords and AdSense (Fuchs, 2009; Ippolita, 2013; Kang & McAllister, 2011; Spreeuwenberg & Poell, 2012). In particular we can point to the AdWords program as a primary engine of value operating at the centre of the Google monopoly. AdWords is a pay-per-click keyword advertisement program that allows advertisers to associate messages with particular keywords that relate to their content. Where this feature is limited to its own WebPages, it also runs AdSense, a global ad-placement program that uses Google's search capabilities to position advertisements on third-party websites. Any website owner can register their site as part of a global advertising network managed by Google. In their study of what they describe as a "'click-through' form of behavioural commodification" (2011, p. 141) Kang and McAllister describe the underlying commercial system at play in AdSense:

> The cost of the keyword-matching advertising service and the revenue from those who participate in the AdSense program are based on the keyword-bidding system. Advertisers can choose any keywords that they want to link advertisements, and bid an amount they are willing to pay for each click (i.e., cost-per-click (CPC)) on the advertisement displayed on Google or one of its partner's sites. The higher the amount of the bid, the greater the chance the advertisement appears on the first page of the search result, or on a good location of one of [sic.] web-pages participating in AdSense program. Google's advertising software scans and processes the text on the results pages of each keyword search and enables Google to target ads precisely related to the site's content and ultimately each web user's needs. Google places advertisements, which they call "sponsored links," on the upper right hand side of the

search results page. (p.146)

Using the AdWords algorithm, Google positions third-party advertisements on websites with similar content; for example, a website or search on the history of Crete might be supplemented by advertisements for Greek tourism, hotels and restaurants. These relations are not always so straightforward, however, and by aggregating multiple histories and online behaviours to precision its advertisements, Google can further infer user interests and profile consumers. The necessary data for this precision-based activity is produced through a variety of search engines and platforms: Google's primary search engine, Google's social media platform Google +; YouTube; Google Books etc (Fuchs, 2010b). Gmail, Google's advertiser supported email client, is similarly coordinated by AdWords so that users are exposed to targeted advertisements when they read or make communications on the platform.

Mobile Networks

The forms of commodification described in the audience and prosumer commodity were developed to describe broadcast media and the wired Internet. However, these forms of commodification expand ever further outwards as computation migrates from the traditional desktop model (Weiser, 1994), shifting from the discrete to the pervasive, becoming invested in everyday spaces, temporalities, materials and bodies through mobile and pervasive media. Mobile networks, in the configuration they occupy today (a combination of cellular communications and the mobile Internet), provide the idealised base for the extraction of value from digital labour (Manzerolle, 2010; Spreeuwenberg & Poell, 2012). Mobile devices today are more than communications technologies, presenting myriad possibilities for the consumption and production of data on the go. They are also identified as an emerging point of purchase for consumer goods of all kinds (Manzerolle, 2010). Here we see a shift from the commodification of audiences, through to the commodification of producers and finally the total colonisation of human subjectivity through mobile media.

There are a number of reasons for this. Mobile media such as mobile phones, smart phones, tablets and other wireless internet-enabled devices blur already tenuous boundaries between the times and spaces of work and non-work (Ito, Okabe & Matsudo, 2006). In part this is because the constant possibility for communication,

connectivity and documentation they represent produces situations where free time becomes increasingly subordinate to forms of digital labour. But also, as a sociotechnical assemblage, they mix previously discrete forms material and immaterial production, productive and unproductive labour, circulation, consumption, production and distribution, as well as the forces and relations underpinning these practices. Mobile media also contribute to a much more total abstraction of the individual 'audience'. Mobile media creates a material and technical basis for scalable audiences and all kinds of layers of heterogeneity and segmentation for the purposes of direct marketing (Manzerolle, 2010). As deeply personalised devices, they are employed to produce a constant market surveillance presence under the guise of democratising culture. Mobile networks, therefore, are instrumental in a total colonisation of the human subject. The integration of mobile technologies into the management of individuals as knowledge persons, social persons and physical persons is part and parcel of the general mobilisation of productive capacities across entire populations (Stalder and Mayer, 2009). As Manzerolle maintains, with the convergence of mobile, "the intensifying rhythms of capitalist production are increasingly inseparable from those of the human body" (2010, p.461).

Through mobile media, we encounter not only the progressive fluidity of labour and social spaces, but also the dynamic extraction of everyday demographic, psychographic, relational, locative and even biometric data from mobile consumers. Take for example the hugely popular Nike + app. Nike + applications for iPhone and Android allow runners to monitor workouts. This includes mapping and tracking runs, monitoring personal fitness, and logging and sharing workout results and regimes with a social network of other Nike+ users. The mobile application utilises location-based information such as GPS and local weather; social networking capabilities; demographic information; biometric information such as height and weight, gait, speed and performance; as well as personal tastes and habits of consumption such as running shoes purchased and preferred music playlists. Nike attributes a significant increase in their market share in sports clothing to the global success of this social media application (Swallow, 2011). Not only is the application designed to build a strong customer base for Nike products, identified revenue streams also include the possibility to tailor products to the consumer through

location-based and highly personalised offers on the go. "Ultimately, we are about connecting with the consumer where they are", says Nike's Global Digital Brand and Innovation director Jesse Stollak.

> We started with the notion that this was about publishing to them with the right message at the right time. We've quickly evolved to focus on conversations and engaging them to participate as opposed to using new media in traditional ways (ibid).

Other examples of note include AdMob and iAd, two mobile advertising platforms valued for their abilities to monetise data traffic to and from mobile devices. AdMob is an advertising platform acquired by Google and specifically targeted to mobile environments. This follows the same technical script as the wired AdWords and AdSense algorithm but augmented with location aware capabilities. Here, [m]obile advertising provides you with targeted access to mobile users and is easy to buy and measure", allowing advertisers to "[t]arget users by demographic, interest and behavior, what device they have, which network they're on and with keywords" (AdMob, 2013).

After failing to successfully acquire AdMob, Apple developed iAd for its iPhone, iPod Touch and iPad line of mobile devices (Spreeuwenberg & Poell, 2012). This allows third party developers to directly incorporate mobile advertisements into their mobile applications. Similarly, iAd invites the advertiser to "reach the most engaged audience in mobile":

> Each ad is shown only to the audience you want to reach, in the apps they love and use the most. Our highly-effective targeting can leverage demographic data, as well as unique interest and preference data that taps into user passions that are relevant for your brand. Whether they are reading the news, playing a game or checking the local weather, your ad will make an impact (iAd, 2013).

The commodification of audiences progresses and advances alongside the integration of networks. It is contingent on the control and exploitation of communicative (and increasingly cooperative) capacities. As Smythe detailed, the development of spectrum-based technologies such as radio and television that infiltrated the spaces between work and leisure were central to the production of discrete audiences across social institutions such as the family, the workplace, the school, the city and the state (1981). Today such intense activities are reliant on a range of next generation high-

speed architectures for mobile broadband such as 3G, 4G, LTE and LTE advanced and facilitated by the ubiquity of personal networked mobile devices such as the iPhone, iPad and iPad mini, iPod Touch, Blackberry and Google's Android applications. Contemporary spectrum orientated networks pervade spaces and bodies, not just through the influx of smart phones and tablets, but through ambient sensor networks, meshes, smart grids and even microscopic sensing systems, all of which rely on electromagnetic waves for transmission. Control of the electromagnetic spectrum today facilitates the extraction of value across a whole range of subjectivities, expanding and networking previously diverse forms of social production.

Network Commodities

Alongside the attention and informational-cultural production that has been discussed in the genesis of the audience and prosumer commodity, there is another significant way in which rent is extracted from online users. This relates to what Pasquinelli terms 'network surplus value' (2011). As previously discussed (section 3.2), the overall surplus capital subtracts from labour is greater than the sum total of surplus produced by each individual worker. This is particularly true of forms of value accrued from networked media, where sociality, connectivity and node/edge relations[47] play a crucial role in the extraction of rent. As Pasquinelli argues:

> if a commodity is traditionally described by use value and exchange value, network value is a further layer attached to the previous ones to describe its social relations (2009, p158).

Pasquinelli describes network surplus as a form of value that exceeds traditional use and exchange modalities to directly monetise the value of social relations, capitalising on the power-law distribution that characterises complex networks (Barabasi & Albert, 1999). This operates in a few ways. As previously discussed, much of the wealth of software corporations is premised on network effects, where companies have succeeded in imposing a communicative or cooperative capacity as a global standard. This is the case with Microsoft word, or Facebook profiles: the value of the commodity derives from a network externality; capital insinuates itself

[47] Node/Edge relations describe the relations between objects in a network.

in the social relation and uses the value of network sociality to establish a monopoly over communications, users and audiences.

It is also the case when a corporation establishes rent on what Pasquinelli describes as the *meta* dimension of collective information (2009, p.160). This logic is reflected in Google's PageRank[48] Algorithm. PageRank is the logic behind Google's large-scale hypertextual web search engine; it mines the totality of human attention and activity to describe the network value of each page on the Internet. It does this by setting a numerical weighting (a 'rank' value) to each element of a hyperlinked set of documents in the World Wide Web in order to measure their relative importance within the set. Hyperlinks represents human authority, attention and support: the greater the number of hyperlinks that point to a page, the higher the perceived importance and rank. The algorithm in turn organises web pages according to their popularity and the search engine returns a hierarchy of results according to their rank.

A link coming from a node with a high rank has a greater network value than a link coming from a node with a low rank (Pasquinlli, 2009). PageRank measures this so effectively it has become the most important authority and source of visibility, even outside of the digital sphere (Carr, 2008). PageRank has even been described as an unofficial currency of the global attention economy (Pasquinelli, 2010, p.157) as it so influences the visibility of individuals and corporations. This value can then be monetised in various different ways; if an analysis of links is at the core, revenues from advertising platforms or reputation value are what exploit this knowledge.

Arguably it is through this network surplus that the value of the biopolitical subject is truly realised. It is the surplus of biopolitical subjects and not a surplus as an excess of manual labour. As Deleuze writes "We no longer find ourselves dealing with the mass/individual pair. Individuals have become *'dividuals'* and masses, samples, data, markets of *'banks'*" power embodied in databases (1992, p.4). Network Surplus can be allied with concepts such as Benkler's 'Wealth of Networks' (2006) or the 'Wisdom of Crowds' (Surowiecki, 2005), but in reality it is more complex than this,

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[48] The first description of Pagerank was in Brin and Page's 1998 paper 'The anatomy of a large-scale hypertextual web search engine'. It constituted a break in information retrieval technologies and in the search engine panorama of the late 1990s. For the first time the Internet was shaped by dynamic hierarchies according to the visibility and importance of each website.

describing the ways in which information produced over computational networks comes to act as a productive agency in and of itself.

3.3.4 Machinic Surplus Value

The previous discussion identified forms of value produced by social production in online environments. Now it is necessary to look more closely at the mechanics of this system of accumulation. Digital technologies are particularly adept when it comes to tracing and condensing the social relations that constitute the production of the common. While the surplus value produced through the operation of rent over social production is a product of the general intellect, it is also a consequence of the organisation of these productive forces into a sociotechnical machine.

As discussed in chapter two, the exploitation of labour power has shifted the primary exploitation of mechanical labour towards the numerous higher order acts, decisions and quantitative processing functions that workers constantly perform and enact. As such, the evolution of Marx's theory of knowledge from *Capital* to *Grundrisse* traces a transformation from the atomised intellectual capacities of the worker towards conditions where 'general intellect' becomes a productive force that replaces the previous divisions of labour (1993). This productivity has been said to proceed along two dimensions (Pasquinelli, 2011). First, collective knowledge is productive as fixed constant capital when it comes to be objectified in machines: embodied in industrial machinery and increasingly in the cooperation of collective intelligence across digital networks. Second, the general intellect is productive as a kind of living labour embodied in the machine that in turn gives birth to new forms of biopolitical life. In the transformation from industrial production towards the primacy of the general intellect, fixed capital loses some of its precedence in the production of surplus and in its place information that is produced and distributed through computational networks emerges as an economic force (Pasquinelli, 2011).

As Pasquinelli identifies (2011), Deleuze and Guattari were among the first to diagram a new system of accumulation driven by information. They outlined this 'machinic ontology' in 1972, at around the same time that industrial divisions of labour begins to break down and cognitive production escapes the boundaries of the industrial factory. What emerges in its place is a form of surplus generated through the emergent effects of sociotechnical machines that facilitate the extension of work outwards to the commons.

To describe this, Deleuze and Guattari introduce the concept of a 'machinic surplus value', "recognizing that [sociotechnical] machines[49] too *work* and produce value, that they have always worked, and that they work more and more in proportion to man, who thus ceases to be a constituent part of the production process, in order to become adjacent to this process" (p.232). Machinic surplus is the productive value of machines; it relates to their ability to augment value. This is a new value theory, therefore, that identifies an *active* cognitive component embodied in informational machines. To illustrate this, Deleuze and Guattari distinguish between the concept of a 'tool' or 'assemblage', whose role it is to relay a given flow of information, and machines, which are thought to have the capacity not only to aggregate, but also to augment and amplify these flows.

Following the tendency for falling rates of profit, machinic surplus value emerges alongside cybernetics and automated management as an economic force that is added to human surplus value (purchasing power of wages) to correct the "relative diminution" of the latter (p.234), both of them coming together to constitute the capitalist system. As such, it is framed as a specific part of human surplus value resulting from "scientific and technical flows of code" (p.197), or scientific innovation. It is surplus that is generated by the networked labour of the general intellect.

> [T]here is a machinic surplus value produced by constant capital, which develops along with automation and productivity, and which cannot be explained by factors that counteract the falling tendency - the increasing intensity of the exploitation of human labour, the diminution of the price of the elements of constant capital, etc. - since, on the contrary, these factors depend on it. (Deleuze and Guattari, 2004, p. 232).

Machinic surplus value is therefore part of a new Post-Marxist value theory. If human surplus value for Deleuze and Guattari is expressed in terms of income and purchasing power, then, machinic surplus represents a pure economic force, it is a "flow possessing a power of mutation" that "*does not enter into income and is not*

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[49] This concept of machine understands it as a functional structure under the command of a higher unity (Deleuze & Guattari, 2004). As such the 'machine' in this instance is people connected through networks, and not the technical network by itself.

assigned to purchases, a pure availability, nonpossession and nonwealth" (p.237, emphasis in original):

> [T]he importance of human surplus value remains decisive, even at the centre and in highly industrialised sectors. What determines the lowering of costs and the elevation of profit through machinic surplus value is not innovation itself, whose value is no more measurable than that of human surplus value. It is not even profitability of the new technique considered in isolation, but its effects on the overall profitability of the firm in its relationship with the market and with commercial and financial capital (pp. 233-234).

Instead of a value theory that posits the inversion of the relations between people and things, Deleuze and Guatarri identify a differential relation between two flows of money in which "desire" circulates in a decoded state while being contingent on the principle of maximisation of profits. As such, they are among the first to identify a shift from the direct production of commodities towards sociotechnical relations founded on a speed differential.

Arguably, 'machinic surplus' today describes the operation of rent through digitally networked media. The ability to represent higher order information numerically and the fact of its modularity and variability as digital code means that information (in the cybernetic sense) is absorbed by machines with the capacity, to trace and condense it to produce surplus value as information and knowledge. It is precisely these processes of aggregation, manipulation and transformation that turn human information into a quantifiable unit of value. As Pasquinelli argues, digital machines are not just linguistic devices; they are relays between knowledge, information, and data[50], "operating as a numerical interface between the domain of knowledge and

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[50] Data, information and knowledge are dynamically connected but they do refer to different things, and this distinction is necessary to understand how types of information and knowledge are productive. Data is the lowest level of abstraction from which information and knowledge are derived. It largely concerns raw symbolic descriptions. Information occurs when these symbols are aggregated, processed and subsequently used as referents, producing a message or code that can be transferred and that affects the structure of a dynamic system. Knowledge, finally, is the human application of information. It can be considered to be the integration of information that has been acquired by humans in ways that produce 'meaningful' conclusions. As an example, the height of Mount Everest might constitute data, a document or file detailing certain physical characteristics and attributes of the site constitutes information, and a detailed account of the best way to reach the summit constitutes knowledge (Bellinger, Castro & Mills, 2004). In cognitive capitalism 'data' concerns the extraction of psychographic, demographic, geographic, and biometric details from consumers, where ICTs facilitate their aggregation and circulation as valuable information. Data represents a biopolitical unit of measure (Deleuze, 1992), the unprocessed details of populations. This data in turn produces information that can be stored and circulated. It is applied as knowledge when it used to profile

capital, the digital code transforms information into value" (2011, p.2).[51] Information that is generated through algorithmic processes can be subsequently fed back into manufacturing and marketing procedures, assembling the user into a broader machine that is put to work outside of employment.

Algorithms

This numerical dimension refers to the transformation of logic into a language that machines can understand and use to perform operations: the algorithm. The algorithm is mathematical and therefore abstract, but it only remains so up until the point where it comes to be attached to a prototype, recipient or producer (Mackenzie, 2006, p.48). As such, algorithms mark a break between mathematical abstract thinking and the practical application of numerical operations to computation; they are the inner logic of machines. These are performative iterations that produce social, political and ontological effects, both engineered and emergent. We are no longer speaking simply of a mathematical abstraction, but a confluence of logic and control structures (Goffey, 2008) that act in the world, a kind of writing that projects a very physical subjectivity (Kittler, 1995)[52].

Algorithms have a productive power because they produce actions in the world. As well as putting things into action, algorithms have a strong temporal function that is very significant in the productive potential of rent. Algorithms operate on conditions and times other than the present, but they also produce measurable temporal effects (Miyazaki, 2012). This is essential to the operation of finance and the productive potential of rent, which so often is about leveraging existing information in order to perform an operation in some just-in-time moment in the future.

In the context of rent over the digital commons, the algorithm produces the machines that capture and transform general intellect into surplus value. They are used in data

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audiences and consumer demographics, or reflexively to fine-tune the functioning of digital machines (Pasquinelli, 2011).

[51] Romano Alquati has written about 'valorising information' that enters the machine and is transformed into knowledge with a productive value. For Pasquinelli, this theory provides a conceptual bridge between theories of information in cybernetics and questions of general intellect in Marxism (Pasquinelli, 2011).

[52] Alexander Galloway has underlined however that "code is a language, but a very special kind of language. *Code is the only language that is executable*" (2004, p.165) Kittler also remarked on the performativity of code (1999): "[in contrast to assembly code] there exists no word in any ordinary language which does what it says. No description of a machine sets the machine into motion".

processing and collection, as well as automated forms of calculation, reasoning and management. The numerical dimension of cybernetics means that a worker's higher order knowledge can now be encoded easily. When networked and coupled with the falling costs of storing and warehousing large datasets, it is now possible to gather vast quantities of data on which sophisticated forms of statistical inference can be performed (Fuller and Goffey, 2012, pp. 50-52). This in turn can be used to influence higher level economic planning and decision-making.

In the simplest sense we can speak about algorithms:

- That accumulate and extract data and in turn transform that data into information;
- Those that take human knowledge and turn it into information;
- Those that take information and translate into other kinds of information that can be circulated or transformed back into knowledge that produces value.

In turn, this proposes three different types of analyses at play. These include cluster analysis[53], used to profile and classify individuals into market segments; link analysis[54] used to identify connections between individuals and affinity analysis[55], used to explore co-occurrence relationships performed by or recorded about specific

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[53] Cluster analysis: In database marketing systems, cluster analysis is used to profile and classify individuals and groups into market segments. Key data points include contact information, gender, age, race, birthplace, residence, current location and connections with others. Through mobile media in particular users are made open to the extraction of everyday demographic, psychographic, relational, locative and even biometric data. This kind of analysis is so fundamental and hegemonic in the Internet that we can point to literally any commercial database system to identify some form of clustering, classification or profiling of users (Berry & Linoff, 1997).

[54] Link Analysis: Link analysis identifies connections between individuals and groups. It is a data-analysis technique used to calculate the relationships between nodes and in turn to calculate the value of these social relationships. We can truly say in such contexts that capital is a social relation; these analyses provide a detailed map of the social relations that constitute the nature of capital and produce the commons. Well known examples include Google's PageRank algorithm. Other examples of link analysis include FaceBook's EdgeRank algorithm for evaluating social relationships between Facebook users (INC, 2013). Link analysis plays a significant role in locative media today, where real world interactions between individuals are productive of a whole range of information for mobile customer profiling, location based services and the fine-tuning and functionality of networks and machines.

[55] Affinity Analysis: Affinity Analysis explores co-occurrence relationships performed by or recorded about specific groups or individuals. They are the primary facilitator of recommendation engines and market basket analysis (i.e. people who purchase x type of computer are more likely to purchase y colour printer within six months). As such they are a subset of the algorithms that use consumer information and data in order to forecast and respond to future behaviours (Han, Kamber & Pei, 2006).

individuals or groups (Cohen, 2008). Coupled with physical infrastructure such as data warehouses and network infrastructure, this provides a monopoly position for various software conglomerates advertisement channels.

3.3.5 Summary

This section looked at the forms of rent extracted through digitally networked media. It demonstrated that the operation of rent over the digital commons has a strong sociotechnical component, using software algorithms coupled with processing and storage capacities to extract information from the nonmonetary production of online communities and to transform and channel this information into different streams of value. In the extraction of rent, therefore, capital inserts itself as a powerful intermediary in the capture of the commons.

However, the algorithmic component discussed in this section, while significant, is only one element of this process. While it acts on a strategic position, software by itself does not produce this privilege. Instead, as Galloway asserts "ultimately the entire bundle (a primary object encapsulated within each successive protocol) is transported according to the rules of the only 'privileged' protocol, that of the physical media itself (fibre-optic cables, telephone lines, air waves etc)" (Galloway, 2004, p.11). We therefore need to look more closely at how a strategic position in the network is produced and consolidated through the enclosure of network resources. In other words, what forms of material, technical and juridical enclosure confer the privilege to extract rent from the common spaces of digital production?

Section 3.4 Digital Enclosures

3.4.1 Introduction

By now it should be clear that the growing centrality of social production in web 2.0 is part and parcel of a series of transformations – to the relations of production, to the composition of labour and to the mechanisms of value capture that see the commons emerging at the centre of cognitive capitalism. In turn we are now faced with a number of questions: Through what ongoing practices is the digital commons enclosed? How is the privilege or title to extract surplus value from social production enacted outside of a typical wage relation? What species of enclosure are at play in online production in mobile environments? This section will analyse the nature of

enclosure in digitally networked media, show how it proceeds alongside the development of collusive networks and identify a core object of enclosure to study the operations and antagonisms of this system further.

3.4.2 Defining the Digital Enclosure

As Andrejevic reminds us: "much still depends on who owns and controls the networks, who sets the terms of entry, and who gathers and sorts this information for what ends" (2007, p.300). While we encounter new levels of access to the tools necessary for social production in ubiquitous networked media – for freedom of expression, for creativity, for cooperation and for communication in its fullest extent – this activity circulates alongside an attendant concentration in systems of accumulation that expropriate the commons. These systems comprise a range of discursive, material and juridical arrangements, emerging as an exercise of power that is consolidated in property and fully supported by the law (Hardt and Negri, 2009). This amounts to rights to control access, to exclude, to transfer and to extract benefits from online production. Service providers; equipment manufacturers; software developers; and software and media conglomerates hold these privileges. The network is consolidated so that the necessary forms of access might flourish at a logical level, providing open access to platforms, services and computational capacities, while at another level we encounter a vertical integration of resources such as core infrastructure, processing and storage capacities and communication channels. As Dyer-Witheford argues, this proceeds alongside the watchwords of deregulation and privatisation, the reduction of government limits on free enterprise activity and the conversion of public property into corporate assets (1999, p.201). By enclosing access to these resources, capital is in a position to extract value from social production. This is how a rentier position is produced with respect to social production in online environments.

It is necessary to briefly tease out precisely what we mean by 'enclosure', as this term acquires a dual fluorescence with respect to the enclosure of the digital commons. On one hand it refers to the expropriation of communicative capacities through the privatisation of network assets, where enclosure is understood as the alienation of the labour force from the means, conditions and elements of social production. As De Angelis elaborates, this is understood as part and parcel of a more general form of primitive accumulation involving "an accumulation of capital claims

– of titles to existing assets which are accumulated primarily for speculative reasons" (1998, p.4). On the other, it alludes to the *active construction* of a productive space (the 'platforms' of networked media parlance) in which these tools may be redistributed to labour, now bounded by techniques and laws that facilitate the control and capture of user-generated content[56]. Today the channels through which we are obliged to relate to one another or to work together so often involve technical and commercial mediation: 'media' forms in the most direct sense of the word, as spatiotemporal processes that intercede in 'immediate' congress (Sterne, 2003, p.100). Andrejevic embraces this model of digital enclosure when he describes "the construction of privately owned and operated interactive enclosures that serve to separate users from the means of interaction, transaction, communication and expression" (2007, p.304). Once produced, these endlessly reproduce the social relations secured within the digital enclosure.

Enclosure, therefore, points to the user's separation from forms of social reproduction in online environments, but also to an immersion initiated by media broadcasting and exemplified by the pervasive computing we now encounter through interaction with the mobile Internet, cellular networks, ambient environments and the Internet of Things (Van Kranenburg, 2008). In order to secure cooperation and reap the economic benefits of immaterial labour, capital must first appropriate the communicative and cooperative capacities of the labour force (Dyer-Witheford, 1999). As Negri (1989) has argued, "communication is to the socialised worker what the wage relationship was to the mass worker" (p.118). This is not to suggest that access to communications replaces the wage relation[57]. Specifically, Negri suggests that access to the necessary tools such as information and communication technologies is a prerequisite for social production in much the way the wage is necessary to material reproduction. In the enclosure of information, knowledge and culture, this has involved the dispossession and progressive deregulation of communications. Rights to the production and circulation of information are appropriated and filtered through administrative channels, at which point they are

[56] Furthermore, this model of the enclosure is supported by the new spatial hybrids enacted between ubiquitous networked media and geolocation.

once again distributed as part of the services capital must deliver to the labour force in order to ensure its ongoing development (Negri, 1989).

This process also reproduces a contradistinction at the heart of cognitive capitalism: that the enclosure of the digital commons necessitates commensurate forms of disclosure. It should hardy be surprising, therefore, that we encounter twin tendencies in the political economy of network communications today. Where openness proliferates at the level of tools and platforms for production in web 2.0, we encounter a proprietary consolidation in physical layer infrastructure and supportive technologies. In contrast to the widely lauded possibilities for the free distribution of source code and APIs, material resources operate under different property relations. These continue to face tangible constraints to their ownership, scale and distribution. This concerns not only the physical injections of capital required to implement and scale a communal substrate, it is also subject to the impressive political constraints structuring the ownership and distribution of requisite real estate, electromagnetic spectrum, satellite technology, servers, bandwidth and energy. Despite the widely celebrated properties of decentralisation and non-discriminatory protocols, the core network remains substantiated in property, subject to material limitations of artificial scarcity and a modularity/scale that prohibits access to all but the most powerful actors[58].

What we are seeing is that alongside open standards we have the development of oligopolistic networks governing access to physical layer resources. As computation migrates to everyday environments becoming pervasive and diffuse, powerful actors

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[58] In asserting the importance of network resources, it might seem here as though this is reproducing a strong dichotomy between immaterial and material processes, rival and non-rival goods or tangible and intangible assets. In arguing against an ideology of free culture that fails to privilege the persistence of the material substrate of the network, we might instead go too far and assert the primacy of physical property over intangibles. This perspective proceeds alongside media theorists such as Pasquinelli, who suggests that rent is extracted laterally along the frictions between delineated material and immaterial strata, such that "whatever exchange value is derived from the information commons will always be captured by the owners of real property" (2008, p.86). While it is certainly the case that it is easier to consolidate physical property and more economically beneficial to manage informational and cultural content as public goods, the situation is also more nuanced, involving various arrangements of different property relations rather than always involving a simple equation of immaterial labour coupled to physical channels. Just as it can be argued that cultural and informational products are also 'material goods' requiring material (if not always tangible) labour (Caffentzis, 2013) and very material channels, we should also recognise that these material channels are produced through and reliant on affective and informational regimes. There is not an absolute distinction between the two. Instead, in the political economy of digital networks we encounter an economic rationality that conflates abstract and vital processes.

are multiplying their investment in core infrastructure. Google as a software conglomerate has recently invested in networked infrastructure including satellite, wireline and electromagnetic channels, custom-designed cloud infrastructure, large scale information and communications technologies for development and even energy provision, becoming a registered electricity provider in 2010 (Fehrenbacher, 2010). Amazon too, with a legacy in content distribution, has recently emerged as a network provider, with services provided not only through their managed device platform, but also through a range of cloud and hosting services such as EC2. Facebook as the largest social media platform at the time of writing, has been seminal in the production of their own custom designed servers, circumnavigating third party hardware vendors in the development of custom-designed 'open computer' hardware in their data centres (Brodkin, 2013b).

This appears to form part of a broader system of management where, as access to computing becomes mobile, ubiquitous or 'everyware' (Greenfield, 2010), intelligence and control is increasingly abstracted from users and consolidated in vertically integrated infrastructure. 'Cloud computing', as the core example of this phenomenon, involves the creation of large data centres to provision dynamic and scalable processing and storage capacities as a service over a network[59]. Cloud computing as such does not reference one particular technology so much as a broader trend towards the centralisation of substantial network control with powerful corporations operating alongside the distribution of intelligence into everyday spaces. Migrating from the mainframe to the personal desktop computer through to 'everyware', this is presented as a logical progression in the evolution of the Internet (De Filippi & McCarthy, 2011; Weiser, 1991, 1994). If the personal computer was once a cumbersome object and storage and transfer were performed through now defunct physical media, today computational power is Internet-based; it resides not with the user and their end device, but in the network. As Žižek argues, intelligence is abstracted from users who no longer have need for expertise in or control over the technological infrastructure 'in the cloud' that supports them (Žižek, 2011, pp. 405-

[59] Typical services include Infrastructure as a service (IaaS), Platform as a service (PaaS), network as a service (NaaS), software as a service (SaaS), storage as a service (StaaS) and data as a service (DaaS).

407). Software and connectivity is distributed to computers and networked mobile devices such as smart phones and tablets in an 'ad hoc' fashion: where, when and as needed. By consolidating computational resources in a centralised location the user can access personal data, web-based tools and applications from portable devices without the necessity of storing these abilities within the device itself, a key feature for small mobile devices. Instead they are located in a remote climate controlled 'elsewhere'. The formation of clouds is redolent of a vertical integration occurring around mobile network infrastructure: a single corporation has a controlling interest at all layers of the technical network, from the material substrate of hardware through to software and applications in all their forms. Everything is accessible, but this access is mediated, monitored and controlled by a commercial entity.

Today, users participate in these enclosures in a variety of ways: when using software applications supplied by third parties such as Google docs and Gmail, through remote storage facilities such as Dropbox, through managed device platforms such as e-readers, smart phones, tablets and mp3 players; through social media networks and through online databases and search engine queries which are performed by thousands of remotely connected computers sharing resources (Jaeger, Lin, Grimes & Simmons, 2009). The examples of such enclosures are ubiquitous. All rely on proprietary resources such as storage and processing facilities, core infrastructure, base station controllers, satellites, radio access infrastructure, and crucially, the channels the "privileged protocol" through which transmissions are performed: electrical and optical cables, and as computing becomes pervasive, the electromagnetic frequencies used for wireless transmissions (Galloway, 2004, p.11). As such, enclosure in the digital commons proceeds along strategic property/commons relations, oscillating between access and control.

3.4.3 Antagonisms or Points of Resistance in the Operation of Enclosure

This thesis aims to explore how such an acquisitive logic continues to operate over social production, and asks what technological apparatuses, property rights and systems of accumulation proliferate in this space. Once we have developed a thorough understanding of how these work and reproduce themselves, we can begin to ask what possible political or economic forms of conflict might also emerge from such a composition. While exploring the dynamics of rent accumulation in the digital commons through enclosure and the control of supply, this thesis identifies emerging

antagonisms in the operation of rent over the digital commons. These should already be starting to become evident: while on the one hand we can point to an intensification of property rights operating within 'open access' digital networks, this process also reveals a contradistinction at the heart of rent, such that the enclosure of the digital commons necessitates commensurate forms of disclosure. For now we can briefly state that value capture is premised on the enclosure of the commons and the rarification of supply, while value production relies on forms of openness, access and autonomy that are potentially excessive to the forms of enclosure currently operating over digital networks. This produces antagonisms and conflicts that will lead either to the disaccumulation of this system, or to a transformation of the nature of digital enclosure. We can already point to specific examples of these in emerging controversies over network neutrality, and intellectual and material property rights in networks. To closely attend to all of these is beyond the scope of this thesis. Consequently, one particular lens is identified to produce a more detailed analysis from which to generalise a thesis on the dynamics and antagonisms of rent accumulation as it operates over the digital commons.

3.4.4 Case Study

By now it should be clear that to understand how rent operates we need to look not only at the role of software, but to how a privileged position is produced through the enclosure of network resources. For a lot of theorists, emphasis is placed on the role of intellectual property regimes in the enclosure of the digital commons, where Intellectual Property, Digital Rights Management and copyright over knowledge forcibly enclose the outputs of a cooperative intelligence by placing unnatural constraints or scarcities on information knowledge and culture in order to transform these into marketable goods. This is sometimes described as the 'second enclosure' movement, a form of primitive accumulation associated with the necessary foundations for cognitive capitalism (Boyle, 2003). However, just as the enclosure of natural resources is an ongoing process and not a historical singularity (De Angelis, 2001), the enclosure of the digital commons arguably precedes the intensification of intellectual property by many decades. Here this situation extends not only to the appropriation of informational and cultural outputs but also to the ongoing enclosure of resources and capacities that structure communication across time and space. This includes the enclosure of radio spectrum; bandwidth; processing resources; storage

resources; cooling resources; energy; man power; mineral resources and more. To really grasp what is at stake in such an arrangement, it is necessary to place attention towards the enclosure of physical spaces and signals and to the ongoing consolidation of communication networks in forms of monopoly or oligopoly control.

The purpose of this case study is to closely attend to the operation of rent in one particular example of network infrastructure; to identify and analyse possible antagonisms; and to see if these antagonisms produce the possibility to develop autonomous networks or simply point to a re-composition of capitalist accumulation. This study is reflexive; if the theoretical framework of rent allows us to think more critically about how 'open' networks are economically consolidated, the nuances of one case study also provides rich material to reflect on and refine a burgeoning political vocabulary for the political economy of network media. The remainder of this thesis will therefore explore these questions using a key example from network infrastructure: electromagnetic spectrum.

In the case study model, one case or a small number of case studies are studied in detail using appropriate methods. While there may be a variety of specific purposes and research questions, the general objective is to develop as full an understanding of that case as possible (Punch, cited in Silverman, 2010, p.150). In section 3.3, mobile networks were identified as the contemporary form of network production and also as the most intensive operation of enclosure over social production in effect today, exceeding both traditional broadcast and wired networks. However, the mobile network does not present a discrete object for study. It is a vast sociotechnical assemblage that comprises users, mobile devices, and media content, as well as a whole range of logical and physical strata underpinning these operations (Goggin, 2012). Areas for exploratory study were identified through a deconstruction of mobile networks involving the identification of cases across content production, software application and physical infrastructure in which forms of peer production and/or commons based systems of resource management were identifiable alongside proprietary frameworks. This was to identify how forms of enclosure operated over mobile networks, facilitating the extraction of rent.

Exploratory research included studies of:

- Various mobile network topologies including cellular communications, the mobile Internet and mobile ad hoc networks (MANETs);
- The constraints and affordances of community mobile networks including wireless mesh, virtualised GSM cellular and VoIP networks;
- The proprietary control of networks through radio access infrastructure;
- The proprietary control of networks through core infrastructure;
- The proprietary control of mobile networks through proprietary handsets and managed devices;
- The control and enclosure of mobile and wireless networks through electromagnetic spectrum[60].

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[60] ***Mobile Ad Hoc Networks (MANETs):*** Preliminary research in the development and use of mobile ad hoc networks (MANETs) produced a rich exploratory study of distributed open networks (O'Dwyer, 2011). The principle feature of the mobile ad hoc network is that it routes information through pair-wise connections between mobile individuals carrying enabled devices. This involves passing data from individual to individual using open protocols for personal area networks such as Bluetooth and ZigBee. The topology produced is entirely contingent on the mobility and interactions of people for the routing and sharing of information (Forde, Doyle & O'Mahony, 2006). In the last decade mobile ad hoc networks have been lauded as ideal platforms for autonomous social production as they are thought to operate independently of proprietary physical infrastructure such as cellular or the wired Internet. As such, this makes the ad hoc configuration a popular choice in disaster scenarios, where infrastructure might be subject to damage, but also in community-orientated mesh networking projects, as they are seen to operate outside of sovereign or commercial intervention in a way wired networks and proprietary cellular communications are not (Bassoli, Brewer & Martin, 2006). However preliminary research in mobile ad hoc networks explored the development of a variety of techniques for the extraction of valuable user data through centralised upload and download points and through proprietary handsets (Richter, Yom-Tov & Slonim, 2010)[60]. Secondly, the scale and development of mobile ad hoc networks beyond a small range was constrained by the limits of unlicensed spectrum.

Open Networks Another similar exploratory research study was conducted on the various constraints and affordances facing community mesh networking projects and open mobile networks generally. While this included broad research into a number of platforms, such as Mesh Potato, Village Telco (Song, 2011) and Internet in a Suitcase (Meinrath, 2010), the primary focus was the open source development community of Open BTS, developers of a virtualised open source mobile network (Burgess & Samra, 2008). This included interviews and research across the open source development community of Open BTS and the proprietary offshoot Range Networks in California; the salaried developers of OpenBTS; the open source community developers and the global development community. This research culminated in the development of an OpenBTS mobile network in Trinity College Dublin in June and July 2012 as part of Hack the City (O'Dwyer et al., 2012).

OpenBTS is an open source low power GSM stack that virtualises the core network, eliminating the need for costly infrastructure. When used with an open source software-defined radio such as the universal software radio peripheral (USRP) it presents as a GSM air interface to any standard GSM phone, replacing the traditional base station with no modification to the terminal device. This is utilised in conjunction with open source Asterisk VOIP software acting as the private branch exchange (PBX) to connect calls. The combination of the global standard GSM air interface with low-cost VoIP backhaul forms the basis of a new type of cellular network that can be deployed and operated at substantially lower cost than existing technologies in many applications, including rural

From this exploratory research, electromagnetic spectrum was chosen as a focus. The proprietary consolidation of electromagnetic spectrum currently produces one of the most significant affordances and currencies for commercial incumbents in the extraction of value from mobile networks (Seybold, 2012), and the most significant constraint in the development of autonomous networks (Burgess & Samara, 2008; Song, 2011). Consequently, spectrum is a key operative in the political economy of the mobile network. It is also one of the least well-understood elements of this network.

Spectrum is an ideal case study because its historical enclosure allows us to theorise the foundations of enclosure of the digital commons. So too, its current prominence in the political economy of mobile networks allows us to analyse the dynamics of rent accumulation in the current information economy. Finally, recent controversies surrounding the proprietary regulation of spectrum allow us to analyse the antagonisms produced by such a system of accumulation between on one hand the necessity of a property relation for the extraction of rent, and on the other, the necessity of a socialisation of resources for productivity in the commons.

The case study material included both primary and secondary source materials. The material and discursive construction of spectrum as a form of land relies largely on textual analysis of primary sources from the early twentieth century. This includes scientific literature, legislation, economic papers and journal articles of the time describing radio spectrum and discussing proposed forms of regulation.

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cellular deployments and communal cellular networks (Burgess & Samra, 2008). It is hardly surprising, therefore, that their operation has produced strong objections from commercial incumbents. However, because GSM networks rely on proprietary spectrum in all parts of the world, the operation of an Open BTS is currently illegal. This has resulted in significant constraints to their operation and implementation worldwide. To implement one in Dublin, our team (Rachel O'Dwyer, Keith Nolan, Coleman O'Sullivan and Seamus McGettrick) acquired special permissions from the mobile incumbent 02 and the Irish communications regulator Comreg (O'Dwyer et al., 2012).

Small Cell Networks Other points of focus included a shift towards dense small cell networks, exploring the future potential of femtocells and picocells to form part of modular community based networks (Thanki, 2012). Once more preliminary conversations with developers and open source activists such as Sascha Meinrath from the New America Foundation (March, 2012 in conversation with the author) revealed that while small cells reveal exciting possibilities for the development of bottom up mobile networks, control is still tightly consolidated with mobile incumbents. One of the more significant ways this was effected was through lobbying for exclusive licenses from the FCC for vertically integrated cells built and operated by incumbents (AT&T, 2012).

In order to explore technological innovations and decisions in the early history of multiplexing, it was necessary to refer to technical literature such as Oliver Lodge's own scientific publications from that time (1900).

The majority of analysis of different interest groups in radio relies on secondary sources from historians such as Susan Douglas, Hugh Aitken and Thomas Streeter. Douglas in particular documents the development of early wireless radio communities prior to the Radio Act of 1912 in her work on the history of broadcasting. However, where these resources recount the history of various communities involved in the development of US commercial radio, with the exception of Aitken (1972) they fail to engage specific facets of technological innovation and regulation of the radio spectrum. In order to demonstrate decisions and innovations in the early history of multiplexing it was necessary to refer to early technical literature such as Lodge's work (1974 [1900]) in order to gain a more thorough understanding of multiplexing techniques at that time.

Chapters five and six deal with the contemporary monetisation of spectrum and analyse proposals for new forms of regulation. These make use of primary sources. In the early stages of research this included exploratory interviews with US-based telecommunications companies with a stake in spectrum regulation such as the New America Foundation, the Open BTS foundation and Range Networks. Chapter six hinges on a textual analysis of three reports published in 2012, detailing possible implementation of spectrum-sharing as well as additional technical literature commissioned and published by the regulatory bodies the FCC and Ofcom that detail constraints and possible future solutions to spectrum scarcity. National accounting Reports from the period 2003-present were consulted to gain an understanding of how licenses to spectrum are currently amortised and monetised in accounting standards.[61]

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[61] The case study material included both primary and secondary source materials. The material and discursive construction of spectrum as a form of land relies largely on textual analysis of primary sources from the early twentieth century. This includes scientific literature, legislation, economic papers and journal articles of the time describing radio spectrum and discussing proposed forms of regulation. In order to explore technological innovations and decisions in the early history of multiplexing, it was necessary to refer to technical literature such as Oliver Lodge's own scientific publications from that time (1900).

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Electromagnetic Spectrum: An Overview

The political economy of mobile media involves a network of devices and core, backhaul and radio access infrastructure. As the communications channel for all 'radio' transmissions, the electromagnetic spectrum is a core component in this system. The enclosure of spectrum within exclusive usage rights, property regimes and market dynamics forms part of the technological composition of cognitive capitalism.

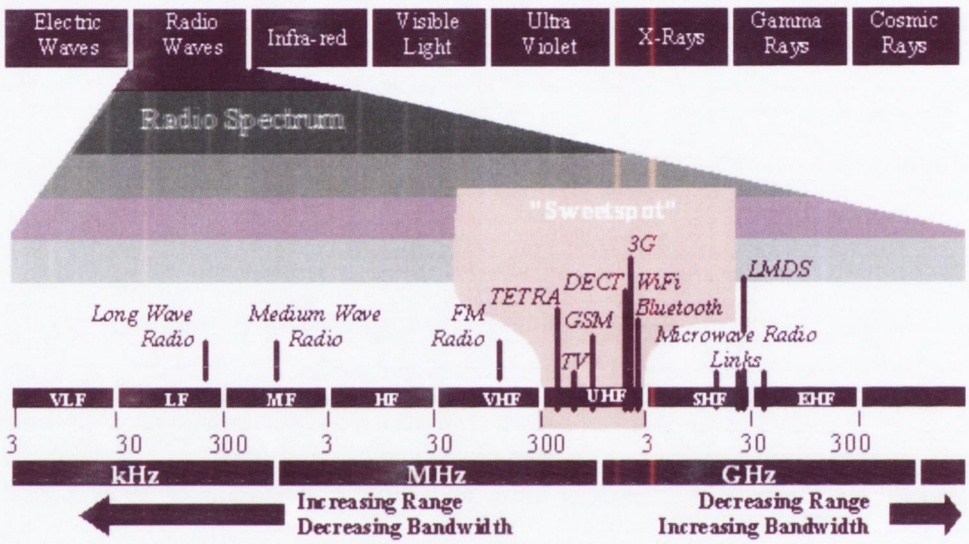

Fig 3.1. Spectrum Usage. Source: Ofcom

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the development of early wireless radio communities prior to the Radio Act of 1912 in her work on the history of broadcasting. However, where these resources recount the history of various communities involved in the development of US commercial radio, with the exception of Aitken (1972) they fail to engage specific facets of technological innovation and regulation of the radio spectrum. In order to demonstrate decisions and innovations in the early history of multiplexing it was necessary to refer to early technical literature such as Lodge's work (1974 [1900]) in order to gain a more thorough understanding of multiplexing techniques at that time.

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Research was also informed by an ongoing research practice including artistic practice and curatorial work. Most significantly this included the curation of a four day festival on the digital commons www.openhere.data.ie and the implementation of an open mobile netwok as part of Hack the City https://dublin.sciencegallery.com/hackthecity/themobilecommons/.

But what exactly is spectrum? Albert Einstein, when asked to explain radio, is reported to have replied:

> You see, wire telegraph is a kind of very, very long cat. You pull his tail in New York and his head is meowing in Los Angeles. Do you understand this? And radio operates exactly the same way: you send signals here, they receive them there. The only difference is there is no cat.

In any wireless communications system there are a variety of radio devices: transmitters and receivers, and the electromagnetic waves that pass between them. Radio technologies involve the transmission of signals encoded in these electromagnetic waves in the same way a fixed network involves the transmission of messages through copper or fibre-optic cables. The term 'radio spectrum' references electromagnetic waves that traverse space with a frequency range between 3,000 and 400 billion cycles per second[62]. These waves provide the necessary channel through which messages propagate. All wireless communication, from radio and television transmissions, wireless networks, through to cellular technologies, personal networking devices and domestic radio appliances, rely on electromagnetic radiation within this frequency range for the circulation of data. The physical properties of radio waves – specifically how they traverse space and interact with physical objects – make some frequencies more desirable conduits than others. The frequencies most suitable for commercial applications are typically those between 300 MHz and 3,000 GHz, in which television broadcasting; cellular services such as GSM and 3G; Wi-Fi and Bluetooth take place. These frequencies are attractive because antenna size is reasonable and the radio waves are of a dimension that is less susceptible to corruption by high-rise infrastructure or mountainous terrain.

Spectrum is 'spectral'. Its incorporeal and invisible qualities relegate it to something resembling the fluid medium of the victorian ether – an amorphous substance through which messages mysteriously propagate. However, the fact that radio waves have a physical dimension that interacts with surrounding matter and, furthermore, that these waves play a central role in the information economy, makes spectrum *material*, both as network infrastructure and as a resource with an accelerating market value. In this way, spectrum echoes many of the properties of informational

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[62] This range is outside human visibility, but these waves are comprised of the same elements as the visible spectrum of colours - the portion of the spectrum that is visible to the human eye.

products in its seeming intangibility and lack of physical degradation, while at the same time belonging to the material world of radio devices that are rivalrous and subject to constraints regarding how they interact and negotiate interference.

This conceptual ambiguity, as we will come to see, has made governance of the electromagnetic spectrum a difficult issue, where regulatory debates surrounding the accurate modelling of use, occupancy, interference or scarcity often appeal to conceptual metaphors to perform political work. At the same time this material/immaterial ambiguity also makes electromagnetic spectrum and the legacy of its management an ideal lens for the digital commons. Rather than positing an immaterial realm of production that is fundamentally separate to the material economy, spectrum controversies go a long way to demonstrating the confluence of immaterial and material forces and relations of production in the digital domain. This is to say not only that communication proceeds along material and energetic channels, but that these networks involve highly confluent arrangements of contradictory strata, at one level freely reproducible and held in common and at another finite, rarefied and consolidated in property. Recent debates around spectrum management, therefore, problematise many of the normative assumptions about the digital commons and highlight many of the conflicts between the informational flows of a digital economy and its proprietary underbelly. As such it is an ideal lens for the dynamics of rent accumulation.

Spectrum's economic value is based on the right to build wireless communications infrastructure and the possibility to leverage networks, services and commodities upon that infrastructure (Forge et al., 2012). In turn control of spectrum as an element, means or condition of production is a crucial foundation in the enclosure of mobile audiences and mobile users. At the heart of this value are the communicative, cognitive and cooperative capacities of a network of users. Exclusive control over and access to these capacities is central to the accumulation strategies of cognitive capitalism; it plays an integral role in the expropriation of surplus from the digital commons. As digital computation migrates to mobile and pervasive environments, and becomes more and more reliant on spectrum-based technologies for support, this is increasingly so.

As such, the role of spectrum in the broader political economy of communications has expanded over the past decade. In the twentieth century, non-federal spectrum

was central to broadcast media such as public radio and television. Smythe (2001) argued that control of these electromagnetic channels was a locus for value accrued through an attention economy over media audiences, where the attention and affective responses of the audience to commercial messages was the primary source of revenue accrued by station operators from advertisers. Today this relation is intensified in keeping with Christian Fuchs' extension of Smythe's theory towards the 'prosumer commodity' (2010b, 2012), discussed in section 3.3. In turn we can trace a correspondent intensification of the technical assemblages that facilitate this extraction. Contemporary spectrum-orientated networks pervade spaces and biologies, not just through the recent influx of smart phones and tablets, but through networks of all kinds that are reliant on electromagnetic waves for transmission. As a result, control of the electromagnetic spectrum today facilitates the extraction of value across the whole range of human subjectivity, expanding and networking previously diverse forms of social production.

The history of the radio spectrum is emblematic of a process through which common communicative capacities were progressively enclosed within various property regimes. Since the first radio acts in the early part of the twentieth century, spectrum has been largely consolidated in a command and control framework under the guardianship of a national regulatory authority. Regulatory frameworks are broadly dictated by the International Telecommunications Union (ITU), a UN organisation that intercedes with the national regulatory authorities of various territories to define a global standard of allocation. Licenses confer exclusive usage of a band of frequencies in a given geographic territory to an incumbent. This provides the holder of the license with the right to build mobile and wireless infrastructure and/or to implement wireless transmissions for services such as television and radio, cellular communications and the mobile internet. Due to the technical and juridical consolidation of these licenses, rights to spectrum are consolidated with powerful incumbents such as mobile network operators, Internet sevice providers and public service broadcasters who can afford to invest in expensive, long term and large scale infrastructures.

Despite the prevailing belief that the radio waves constitute a 'public good' held in trust by National Regulatory Authorities such as the FCC or OFCOM, the reality is that this supposedly public resource is consolidated in ways that favour the media

and communications industry. These powerful incumbents treat licenses more or less like property, the market value of which is clearly reflected when such corporations are valued. Despite its historical status as a public good, therefore, licenses are arguably circulated without direct benefit to the public. Instead, powerful corporations and institutions that succeeded in privatising the commons extract this revenue through rent (Smythe, 1987).

While the majority of spectrum is consolidated in exclusive usage, a small range of frequencies, such as the 2.4 GHz band, have remained unlicensed for common use. This means that anybody can build and transmit in these frequencies, provided they adhere to certain regulations. This unlicensed spectrum has given rise to hugely successful protocols such as Wi-Fi, Bluetooth and Zigbee, but it is also subject to regulatory constraints that restrict the scale of nonmarket and non-proprietary networks. Not only does unlicensed spectrum comprise a very small frequency band, it is also governed by power-transmit rules and propagation characteristics that constrain transmissions to within a very limited geographic radius. Any infrastructure that intends to scale and provide coverage over a wide area or to a large community requires access to spectrum that is licensed and auctioned on a scale that suits powerful commercial entities. Ownership and control of spectrum, therefore, confers economic power to incumbents, and in turn not having possession or rights to this resource is a major constraint to the development of a common communications infrastructure. This has led to ongoing advocacy for the expansion of unlicensed spectrum by digital activists, community network developers and open source communities.

Spectrum is thought to require regulation through a state or a market because it is subject to natural limitations that make it insufficient to satisfy unregulated demand/demand outside of a pricing system. In wireless transmissions overcapacity manifests as 'interference', a term that usually refers to the physical degradation of a signal that occurs as a result of particular programs of radiation. Wireless communications involves the transmission of messages via electromagnetic waves. Depending on the characteristics of the radio receiver, a confluence of signals may produce conditions where the receiver is unable to determine the intended signal from the surrounding and unintended 'noise' of other spatially or temporally coincident transmissions. This results in an intolerable signal-to-noise ratio and a

degradation of the transmitted information or content. To draw on an archetypal example: in April 1912, the tragedies falling out from the fatal collision of the Titanic – unintelligible and unheard calls for assistance; confused rescue attempts; contradictory information regarding the safety and whereabouts of the vessel - were attributed to intolerable interference in wireless communications produced in part by the 'overcrowding' of the airwaves by amateur and hobbyist radio operators (Douglas, 1989). In order to maintain the integrity of communications, regulation by some central authority or through a pricing system was thought to be necessary to efficiently provision spectrum as an imperfectly rival good[63]. Today this confers exclusive licenses to federal institutions such as the military and to commercial operators who are willing to pay for licenses.

However, the telecommunications industry and associated regulatory authorities for spectrum now identify an imminent 'spectrum crunch' where current demand exceeds the capacities of the resource in its current proprietary arrangement. Mobile data traffic is now doubling every six months (Forge et al.., 2012). According to the Organisation for Economic Cooperation and Development (OECD), the number of devices connected to mobile networks worldwide is around 5 billion today and could rise to 50 billion by 2020 (PCAST, 2012). Such astonishing growth in mobile media requires a rapid expansion of networks. This presents as not only a desire for increased bandwidth, but also a greater fluidity of infrastructure in response to rapid fluctuations in the network architecture. The legacy form of spectrum regulation - the command and control model of exclusive and permanent licensing - is anathema to these requirements. Today we are seeing the emergence of market forces that trade, re-farm and otherwise reapportion licensed spectrum, and growing arguments in favour of license exempt spectrum coupled with dynamic spectrum access techniques (Cochrane, 2006; Forge et al.., 2012; PCAST, 2012; Werbach, 2003). A number of factors favour an unlicensed approach to spectrum regulation, including the exponential demand for mobile bandwidth; the production of newly available spectrum in the switch from analogue to digital television; the huge success of

[63] Spectrum is understood to be rival, in that a finite number of transmissions can take place in the same geographic region at any moment in time. However, the current use of a frequency to broadcast does not impede future transmissions and therefore spectrum is imperfectly/durably rival as it is not subject to any permanent degradation through transient use.

innovations in the unlicensed 2.4 GHz band and finally the development of a variety of non-exclusive techniques that make cooperative negotiation of the electromagnetic spectrum feasible. Today, the idea of shared spectrum has a currency beyond a core group of long time advocates of 'open spectrum' and commons infrastructure, emerging at the heart of neoliberal enterprise, with several high-profile government reports published in 2012 recommending a paradigm shift from exclusive access to forms of shared and non-exclusive regulation (Forge et al., 2012; PCAST, 2012; Thanki, 2012).

The implications of these recommendations are difficult to unpack. It is as yet unclear if this communality of previously proprietary frameworks represents a disaccumulation of capital or simply its reorganisation through ever more distributed channels. On one hand, communality appears to inflect all layers of the network and undermine the necessary enclosures that formed the conditions for the extraction of value from the digital commons. Expropriation of the digital commons appears to be premised on property rights to extract value from a position external to production. If these property rights break down, how does accumulation reorganise and continue to operate?

Section 3.5: Conclusion

Moving between political theory and engineering, the rest of this thesis will attempt to answer these questions. Chapter four will detail the history of the enclosure of spectrum, exploring the conceptual, technical and juridical foundations upon which the current regulatory model in spectrum is based. Chapter five builds on this early enclosure, examining the ways in which commercial markets and de facto property rights were gradually established around the resource in the latter decades of the twentieth century, transforming spectrum from a public good to an intangible asset held by commercial network operators. This brings us to the present constitution of spectrum, putting us in a position to detail the operation of forms of rent in contemporary mobile networks. Chapter five then identifies potential antagonisms emerging in the dynamics of rent accumulation between, on the one hand, the technical and juridical consolidation of frequencies in exclusive property relations and artificial scarcity and, on the other, the necessary fluidity and access that is now required to support a burgeoning mobile economy. Chapter six examines a number

of high profile proposals advocating a significant increase in shared and license-exempt spectrum as a solution to the current scarcity of spectrum. It explores the major tenets of these proposals and looks in turn at the implications of new regulatory frameworks proposed for the negotiation of shared, commons and unlicensed spectrum.

Throughout this discussion, the focus moves between the case study and supporting theoretical frameworks from the intersection of neo-Marxist analysis and new media theory. This study is reflexive; while the burgeoning political vocabulary emerging around rent accumulation and the communism of capital offers a number of critical insights into the expropriation of social production in digital networks and into the potential ramifications of open spectrum in particular, a close exploration of the mechanisms and controversies of spectrum regulation also provides a case to reflect on some of the theoretical underpinnings of this new vocabulary.

Chapter Summary

This chapter identified rent as the primary operand of value accumulation in digital networks. Beginning with the shifting relations between wages, rent and profit, it was demonstrated that value accumulation has transformed from the relations associated with profit towards those in which rent and profit are increasingly convergent. The principles of rent accumulation were identified, demonstrating that rent describes the contemporary system of accumulation, where proprietary control constitutes a privilege to extract value from an exterior position with respect to production. This allows us to theorise the ways in which value is now captured from social production in online networks. Several instances of non-digital rent were explored to provide a broader overview of this dynamic. However, where the focus of the thesis is on the modalities and antagonisms of accumulation as it operates over digital networks, this proceeded to a more detailed operation of rent accumulation in online spaces.

It was demonstrated that digital networks provide a variety of different spaces from which to extract value. Social production in the form of attention, consumption, voluntary informational and cultural production and network sociality were all identified as key forms of value that are voluntarily or inadvertently produced through online activities. Where previously these forms of value were outside of the market because there was no way of effectively capturing and measuring them, today

the technicity (Simondon, 1980) of digital networks means that these forms of value can now be effectively aggregated and extracted from everyday life and everyday spaces. So too, through the sociotechnical construction of networked media, these streams of data can be transformed into information and effectively fed back into the network where they are used to mobilise further forms of consumption and production.

The final section identified how a proprietary and privileged position was produced with respect to digital production. It identified that through a proprietary consolidation of substrate resources such as data storage and physical communications channels, commercial incumbents can extract rent from online production. However, because this position involves fragile alliances between forms of enclosure and the commons, this system also produces antagonisms. To fully identify the dynamics of rent accumulation and the nature of these antagonisms necessitates a more focused exploration. This is performed through a case study. Electromagnetic spectrum, as the primary underpinning of all wireless communications, was identified as a case study and will be the focus of the remaining three chapters of the thesis. Spectrum is an ideal lens because its historical enclosure allows us to theorise the foundations of enclosure of the digital commons. This lens allows us to analyse how control of electromagnetic spectrum facilitates the extraction of rent from social production in the contemporary economy, but also, through an examination of current controversies in spectrum regulation, to analyse how relations between the enclosure of the digital commons and the necessary conditions for social production are potentially antagonistic.

Chapter Four: The Enclosure of Electromagnetic Spectrum

Section 4.1: Introduction

The first half of this thesis traced the emergence of a new system of accumulation based on the social production of networked users. The second half of this thesis now analyses the foundations, antagonisms and transformations to this system through the lens of electromagnetic spectrum regulation.

This thesis identifies three stages in the development of cognitive capitalism. While these stages may exist concurrently - indeed, the conditions we encounter today suggest alliances and antagonisms between competing modalities - there is a general perioditisation at play also. The first stage can be characterised as the enclosure of the socially produced commons, and includes the historical regulation of communications networks and the early intensification of intellectual property alongside the emergence of new forms of cultural industry. The second stage appears to correspond to an advanced capitalist society, in which information, knowledge and cultural work are hegemonic, where "producing increasingly means constructing cooperation and communicative commonalities" over networked ICTs (Hardt and Negri, 2000, p.302). In this second stage we can identify overlapping, fragile and sometimes conflictive alliances operating between the proprietary enclosure of social production and the necessary autonomy required for cognitive and cooperative forms of work. These conflicts are arguably leading to a third stage in the development of cognitive capitalism, the outcomes and particulars of which are still unclear. The next three chapters correspond to these three stages. As such, this chapter explores the initial enclosure of wireless networks through the origins of radio regulation and the historical enclosure of the broadcast spectrum in the early decades of the twentieth century.

4.1.2 The Enclosure of the Information Commons is an Ongoing Process

Drawing on literature from Marx (1986) through to the Midnight Notes Collective (De Angelis, 2001; Federici, 1992; MNC, 1990) we can identify enclosure as the destruction of the commons and the rights associated with it, specifically, the destruction of communal control of the means of social and material reproduction in favour of public or private property. Reproduction here refers not just to the material

requirements for subsistence of the labour force such as food and shelter, but also the reproduction of the self, the ongoing construction of subjectivities and social relations with others based in communication and cooperation. In light of the enclosure of communications, however, we can think of this 'enclosure' not just in terms of an alienation from the means of communication, or the destruction of rights of access to data, information or knowledge that is collectively produced, but in terms of how this dispossession proceeds alongside the wilful production of a 'topos' (common place) in which these activities might circulate and be productively organised.

Enclosure is not a historical singularity (De Angelis, 2001) but something that is continually produced. Despite the way it is often represented in the literature, therefore, the enclosure of what Boyle calls "the intangible commons of the mind" (2003, p.37) and Hardt and Negri the socially produced commons (2009, p. viii) is not a recent condition. As contradictory as it sounds, digital enclosure does not begin with the Internet, the World Wide Web, Web 2.0 architectures or the codec; it does not begin with the intensification of intellectual property rights, digital rights management or the various legislations that threaten the neutrality of digital networks. The history of the 'new enclosures' has a much broader legacy, traced through the genesis of signals and spatiotemporal variables capable of translation and action at a distance and admitted in the production of a political rationality where economic and vital processes become deeply intertwined (Terranova, 2009, p. 235).

In many ways a program for cognitive capitalism is expressed in the early economy of these wireless signals. In particular, the history of electromagnetic waves traces the first tentative transformations from an industrial economy concerned with the manipulation of physical matter towards an economy of the immaterial, based on ethereal networks and forms of action at a distance. Similarly, many of the early controversies surrounding the sociotechnical construction of some 'thing' called 'The Spectrum' provide insight, not only into the abstractions required for the enclosure of intangibles, but also illustrate the tensions and antagonisms that arise in this process.

4.1.3 The Purposes of this Chapter

Spectrum is an ideal lens for an exploration of the struggles between commons and enclosures in cognitive capitalism. In this chapter this lens provides a historical

materialist overview of the development of an economic rationality centred on immaterial production: beginning with the invention of radio; the early relations between commons and proprietary interests; the various strategies employed in enclosure; and the tensions arising from this process. This is the critical foundation required to analyse the political economy of mobile communications as it operates today.

We should understand the historical development and regulation of electromagnetic spectrum as a foundation in the ongoing enclosure of the digital commons. Today the enclosure of spectrum as a resource is central to the operation of cognitive capitalism because control and/or possession is an indispensible element in the commercialisation of wireless communications of all types, from next generation cellular communications through to ubiquitous sensor networks (Manzerolle, 2010). So too, in previous decades, rights of access to this capacity were central to the commercialisation of radio and television broadcasting through advertising revenue (Smythe, 1987). This history illustrates how spectrum was invented and subsequently regulated, exploring how forms of commoning (Linebaugh, 2009) in wireless communications were progressively destroyed in favour of strong commercial interests.

4.1.4 Chapter Outline

What follows is not a chronological history of the discovery, invention, regulation and commercialisation of radio spectrum. However, it does provide a historical overview of the topic that further analysis can progress from. This chapter begins with some necessary background, briefly exploring the various actors, interests and interpretations that shape the transition of radio from a scientific discovery to a technology with economic possibilities. There is a period of 'interpretative flexibility', where competing approaches and interests between the commons, the state and the market coalesce and compete before radio becomes a stable technical object (Bijker, 1992, 1997; Williams & Edge, 1996). Specifically this concerns the early production of spectrum as an informational milieu thought to require forms of external regulation.

We then proceed to a detailed analysis of the transformation of electromagnetic capacities into a terrestrial reserve called the spectrum. We trace how a relational capacity for communication between transductive devices is conceptually, materially

and juridically constructed as a physical entity similar to land or a finite, naturally occurring ecological resource. The long and complicated history of radio regulation makes it difficult to see that what is being enclosed in this instance is primarily a capacity to communicate information across time and space. This capacity, which is not a 'thing' but a relational facility or a potential, has to be made to appear as a tangible resource subject to use, degradation and scarcity in order that it can be codified, commodified and enclosed. This involves a "tension-ridden effort of abstraction" (Streeter, 1996, p.9). In many ways, therefore, enclosure and invention coalesce in the history of electromagnetic signals; unlike the enclosure of land, the act of bringing forth spectrum as a coherent natural object and corralling spectrum as an economic asset are concurrent.

It requires discourse, technoscientific invention, material constitution and juridical regulation to make the relational solid. This process begins with discursive practices, exploring in particular the use of conceptual spatial metaphors in scientific and journalistic literature on radio communications. This work is still ongoing in how we speak about, design and legislate for spectrum, but much of its conceptual underpinnings can be traced to the early regulatory period. From the resources of language, we then explore how technoscientific methods help to solidify this way of thinking, producing multiplexing techniques and technologies that favour proprietary approaches to spectrum and discourage communal access. We analyse the consequences of these discursive and material practices, identifying how they provide the foundations for enclosure, framing spectrum as some*thing* rival, divisible and alienable. Finally the introduction of state regulation solidifies this perspective, fixing radio as a proprietary resource subject to state or corporate control and firmly suppressing nonmarket and non-proprietary activities.

This brings us to the third focus of this chapter. Where the work of producing spectrum as a rival and bounded space is very significant in enclosure, the enclosure of the commons also requires the concerted alienation of the workforce from communicative and cooperative capacities, producing them instead as an audience. This is detailed alongside the corporate liberal development of a commercial broadcasting model that extracted income from the commodification of radio audiences' cognitive, affective and attentive work. From this foundation, access to and control of radio spectrum emerges as a key ingredient in the ongoing

expropriation of social production. This chapter finishes by briefly tracing the early stages of this process, as radio becomes identifiable and aligned with a broadcasting model reliant on advertising revenue.

This analysis focuses on the history of spectrum regulation primarily within the context of the United States. There are a number of reasons for choosing to focus on the history of the United States and not for example, a European perspective, specifically British or Irish history or indeed an overview of spectrum controversies in the Global South. First, the early history of regulation in the United States is more thoroughly documented than a European or global history of regulations. And this is related to the second reason for choosing the United States as a case study; the history of US regulation is more thoroughly documented in part because early controversies between commons and property approaches to spectrum were more pronounced here than in Europe or Great Britain. Finally, the US provides a justifiable case study because decisions regarding regulation and deregulation of communications in the US have proved seminal elsewhere. This is particularly true of early legislation. As William Boddy observes "The first two decades of wireless activity in the United States precipitated [the core issues of regulation] in their starkest form, anticipating many of the ways the same topics would be taken up in subsequent controversies" (2004, p. 16).[64]

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[64] While United States history is detailed here for its historical and contemporary conflicts between commons spectrum and highly commercialised models, other global histories reveal similar battles between openness and enclosure of spectrum as alternatively a public, private or common resource. Irish media history in particular details strong instances of alternative community-driven radio practices emerging alongside the development of a nationalist broadcasting program. The greatest exemplar of this is probably in the first historical broadcast made by the Irish Republican Army during the Easter Rising of 1916. Contingents occupied the Wireless Telegraphy Office opposite the General Post Office and issued a more code radio broadcast proclaiming the foundation of the Irish Republic and the takeover of Dublin City by the Republican Army (Morash, 2009, p. 126). This affinity to radio progressed alongside the development of transatlantic Broadcasting, where Ireland's position in relation to the United States saw it playing a crucial role in early transatlantic broadcasts. Following the foundation of the Free State, the Irish government conducted a debate as to whether radio broadcasting would be a state or a commercial enterprise, opting for a state-controlled broadcasting body. In 1926, 2RN was established under the control of the Irish Free State. This later became Raidió Teilifís Éireann (RTÉ). Much like in the United States, commercial advertisement played a significant role in the funding model for the state-governed entity with the fist commercial advertisements appearing on air in 1927. However, unlike in the US, enforcement of radio infringement was much weaker and this in time lead to a strong pirate radio community until the early twenty-first century. A lack of commercial radio until 1989 and a lack of strong enforcement on the part of the Office of the Director of Telecommunications Regulation (OTDR) provided conditions for pirate radio stations throughout cities such as Dublin, Cork and Limerick and in surrounding rural areas. 1989 saw the development of independent local radio stations that in part displaced informal piracy arrangements. However, some stations continued to broadcast until the establishment of the

Section 4.2: Competing Understandings of Early Radio Communications

4.2.1 Introduction

The forms enclosure takes and the effect enclosure has are both created by and reflected in the different discourses within which the electromagnetic spectrum is articulated. And there are a variety of discourses at play in the history of the spectrum. Theorists of Social Construction of Technology (SCOT) emphasise the early stages of research, invention and dissemination in technical systems (Bijker & law, 1992; Bijker, 1997; Misa, 1992; Williams & Edge, 1996). They pay particular attention to the activities of relevant social groups in an interval of 'interpretative flexibility', thought to occur primarily in the period before a technology achieves material and ideological 'closure' or once again if some form of controversy re-opens a stable technical system to competing interpretations[65]. Once this closure is achieved, the object obtains a relatively stable identity and the various struggles and controversies involved in the social shaping of the system or artefact begin to recede from view. Everyday artefacts are made to seem coherent, as though they embody a neutral and objective technoscientific reason and could never have been otherwise: a mode of transport, an electrical or communication system or a dominant protocol (Bijker & Law, 1992; p.3-11). Critiquing this perspective, social constructionists understand technical systems to be the systemic outcome of competition between actors. This is to say that everyday technical realities that may appear grounded in the objective criterion of technoscientific success or failure, more often reflect the interests of hegemonic groups. Similarly, theorists of actor-network-theory (one stream within social constructivism) emphasize the need to unpick seemingly stable

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Commission for Communications Regulation (ComReg) in 2002. Succeeding the OTDR, ComReg dedicated resources to the abolishment of pirate radio stations, introducing a much stronger regulation of spectrum in Ireland. Britain too is not without conflicts between various models of radio regulation and forms of enclosure. The first broadcasting collective in the United Kingdom was not state governed; the origins of the BBC were as the British Broadcasting Company, a commercial collective comprised of a number of different commercial entities (Briggs, 1984). The British Broadcasting Corporation, a state-governed entity, replaced this in 1927. The government felt that the spectrum resource was too significant to be relegated to commercial interests alone. Attitudes to commercial advertising reflect this belief and these differed significantly from the US, with the BBC adopting a strong user licensing fee as opposed to an advertising revenue fee approach in order to fund programming and station costs (Briggs, 1984). In contrast overseas contingents BBC Normandie and BBC Luxembourg adopted a commercial advertiser revenue model from the outset to support programming. The public resource was countered by various pirate radio stations.

[65] For a full account of 'interpretative flexibility' see Bijker, 1992; for 'closure', see Misa, 1992.

objects through recourse to the historical archive; the research laboratory; moments of failure, rupture and controversy; or various 'resources of fiction' such as art, literature or critical design (Latour, 2005, pp. 79-82).

To argue that a technical system is the outcome of ongoing struggles and controversies between competing interests rings particularly true for spectrum-dependent radio technologies and their regulation, where a variety of different agencies have shaped the medium, from early theoretical experiments in electromagnetism through to mobile communications and the mobile Internet. Historian Hugh J. Aitken has observed that early technoscientific, economic and cultural representations of the radio spectrum "literally did use different vocabularies, speak in different languages and respond to different cues" in describing the same 'thing' (1985, p.17). Wireless transmissions meant something different to different actors: amateurs; corporate institutions; entrepreneurs and inventors; engineers; and state and military interests. They all had conflictive ideas about what radio was, how it should be used and how access should be negotiated, and these gradually coalesce into a sociotechnical system we are familiar with today. This isn't to say that the shape wireless communication takes is only the product of powerful commercial or state actors. Instead radio practices and meanings that were cultivated by amateur communities (Douglas, 1989) appear to converge with early commercial interests looking to make radio commercially productive.

Competing perspectives of early radio all seem to coalesce around a concept of the spectrum as an unknown terrain for exploration and/or conquest. For the nation state and the military, the spectrum comprised a new territory for occupation and a technological stronghold required for international warfare and defence[66] (Aitken 1976, 1985 Douglas, 1989). For commercial interests the airwaves represented a verdant reserve for monopoly rent (Streeter, 1996, Smythe, 1987). And for amateurs (the portion of the general public who had a practical investment in the spectrum at this time) radio held a powerful appeal as a networked public sphere, presenting a possibility for new forms of sociality and the acquisition of knowledge (Douglas, 1989, pp. 187 – 215).

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[66] Although this military focus is less pronounced in a history of American radio regulation than in European regulation.

While a broad historical overview of the genesis of radio is well beyond the scope of this thesis, an overview is necessary to understand the sociotechnical context of early radio regulation.[67] This section briefly explores how alternatively proprietary and non-proprietary approaches to the electromagnetic spectrum competed and coalesced in the historic period prior to its enclosure in corporate liberal regulation and material closure as a commercial broadcast medium.

4.2.2 Action at a Distance

The genesis of radio as both a technology and institution involves a protracted transformation of scientific knowledge towards technological research and innovation. Let us start with the ideological environment in which the invention of radio is situated, as certain ideas propagating at the turn of the century appear to have anticipated wireless communications. Specifically radio and spectrum emerges alongside a cultural preoccupation with the possibilities for 'action at a distance'[68] (Lodge, 1900, p.7), a term employed in early descriptions of the radio apparatus. As John Durham Peters notes:

> Though one might be amused at external forms of enthusiasm to connect mediumless communication to deep metaphysical interests, early radio history is inseparable from daring imaginings about the flight of souls, voices without bodies, and instantaneous presence at a distance. Dreams of bodiless contact were a crucial condition not only of popular discourse but of technical invention as well (1999, p. 14).

This is corroborated in technical literature by William Crookes in 1892, who notes in 'Some possibilities of Electricity'

> Whether vibrations of the aether[69], longer than those which affect us as light, may not be constantly at work around us, we have, until lately, never seriously inquired. But the researchers of Lodge in England, and of Hertz in Germany give us an almost infinite range of ethereal vibration or electrical rays, from wavelengths of thousands of miles down to a few feet. Here is unfolded to us a new and astonishing world –

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[67] For detailed histories of early radio, see Aitken 1975, 1986 and Douglas, 1989.

[68] The term 'action at a distance' appears as a technical description twice in Lodge's 1900 publication *Signalling Through Space Without Wires: Being a description of the work of Hertz and his Successors*.

[69] This is an alternative historical spelling of ether.

> one which it is hard to conceive should contain no possibilities of transmitting and receiving intelligence (p.174).

Visions of early radio appear as a portent of transformations from a world of thermodynamic energy and the manipulation of matter towards a world of action at a distance, where invisible rays connected individuals through radiotelegraphy, broadcasting, television and later cellular networks. The ether, or 'spectrum' as it comes to be termed, is not just a conceptual metaphor or a physical landscape; it is the burgeoning development of a spatiotemporal site of circulation. It would seem, therefore, that the invention of spectrum as an informational milieu is part of a new economic rationality that anticipates the network, positioning it as part of a complex historical trajectory (Terranova, 2009). However, if the decentralised network topology has since emerged as an organisational form for stabilising and regulating these unstable spaces, much of the twentieth century history of spectrum reveals tensions between the production of an unstable site of circulation for information and the techniques of regulation and control that attempt to corral and organise it productively.[70]

4.2.3 Competing Actors

In the early incarnations of radio we encounter free-floating ideas about action at a distance and the ether operating alongside the development of technologies for performing scientific research on the properties of electromagnetic waves, but it is a while before there is any coherent connection between these. Maxwell's theoretical equations demonstrating that electricity and magnetism propagate together as a wave were intriguing, suggesting that electromagnetic fields might be propagated through space as well as through conductors, and that the rate of propagation was finite

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[70] To tease this out we have to acknowledge that the ether as a spatiotemporal topology operates in two planes, both natural and constructed, material and semiotic. In the first case, the ether is presented as the physical conduit "needed to account for action at a distance of one body on another" (Foucault, 2009, p. 36). It functions as both the medium of an action and the element in which it circulates. Here, ether was understood as something that existed in physical realty, comprising a "thin subtle matter, or medium, much finer and rarer than air" through which celestial bodies, light and communications of all sorts propagate (Schaffner, 1972, p.7). In the second case, the electromagnetic ether, or 'spectrum', as it becomes known, emerges as a space for abstract forms of control "a temporal and uncertain constituent [...] that the new techniques of power fabricate and stabilise from within by means of localized, flexible and yet coordinated regulation" (Terranova, 2009, p.241). In this way an early preoccupation with ether conceptually aligns with new biopolitical technologies of power in which circulation is organised productively. The ethereal space of early radio anticipates the contemporary network dispositif.

(1865).[71] How such a current could flow and through what sort of medium was still unclear. Hertz realised these theories through practical experimentation in 1888, artificially generating electromagnetic waves, detecting them and measuring their velocity, developing a device that would resonate when electromagnetic waves of a particular frequency acted upon it (Aitken, 1976)[72]. The device that Hertz developed to observe electromagnetic waves subsequently formed the basis for spark transmission, and spark telegraphy, the earliest radio apparatus used to relay messages wirelessly. The technique is subsequently taken up and applied in different contexts, used commercially to relay ship-to-shore messages and subsequently by an amateur community to propagate wireless messages through Morse code (Aitken, 1976, 1985; 1994; Douglas, 1989).

Commercial Operators

Early entrepreneurs were instrumental in transforming radio from exploratory research to a resource with an applied commercial potential that could be rarified and enclosed. In the hands of inventor/entrepreneurs such as Oliver Lodge and Guglielmo Marconi, Hertz's experimental spark-gap transmitter gradually shifts from an instrument of knowledge to commercial application, forming the material basis for an economy of wireless transmissions (Streeter, 1996, Aitken, 1994). In the following decade various refinements improved the tuning capacities and propagation characteristics of spark-gap transmissions. Beginning in the 1890s, Marconi developed a complete system of transmitters, receivers and antennas for long-distance wireless communication, modifying and improving on some of

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[71] In his publication 'A Dynamical Theory of the Electromagnetic Field' (1865), JC Maxwell demonstrated through a system of mathematical equations that electricity and magnetism are intrinsically connected and propagate together as a wave. He was led to this discovery by an apparent contradiction between the laws of electricity and those of magnetism, coupled with the basic physical laws of continuity that stated that electrical charge could neither be created nor destroyed. An answer to this apparent contradiction could be resolved by the insertion of a new term in Ampere's law of thermodynamics – one that had the characteristics of an electrical current except that it flowed through an insulator (through space) rather than through a conductor. Maxwell called this a 'displacement current'; if it fluctuated with time, a fluctuating magnetic field must also exist (Aitken, 1975, p.21).

[72] As predicted by Maxwell, the velocity of the electromagnetic waves produced were the same of those of light. As such, light itself was a form of electromagnetic radiation that occurred within a particular spectrum of wavelengths. Unlike light, the waves that Hertz generated were invisible to the human eye and he had to produce an apparatus to observe these. Drawing on previous research, he developed a device that would resonate when certain frequencies acted upon it. This formed the basis for spark-gap transmissions (Aitken, 1975, pp.22-26).

Lodge's earlier work in syntony (Aitken, 1975)[73]. This was a service based on transmitting messages wirelessly between nautical vessels and from ship-to-shore. As such it had a number of valuable applications for naval and nautical security, for national and international trade, and as a potential rival for wired telegraphy. In 1897, Marconi established the first Wireless Signal Company and applied his communications system to naval and nautical point-to-point communications (Aitken, 1975; Sterne, 2003; Streeter, 1996).

As Streeter (1996) maintains, this marks the first episode in an economic history of radio. Although Marconi did not consider radio as a broadcasting technology, but as a point-to-point medium, he is significant in shaping the modality of radio as a commercial medium. The Marconi Company would adopt a service-orientated business model, designed to extract profit, limit competition and enhance market advantage, not by manufacturing devices for sale, but by regulating access to the communications system. This was not yet achieved through control or licensing of specific electromagnetism frequencies; such a concept had no currency in relation to early spark-gap transmissions[74]. Instead, Marconi cultivated technical patents and leased his devices exclusively, even providing trained radio operators for vessels and prohibiting these from accepting communications from rival companies (Douglas, 1989, p.195). This attempted to enclose the frequency continuum within the control of a single commercial entity. Like no other individual, therefore, Marconi's influence has been argued to be significant in the sociotechnical construction of radio transmissions as something subject to enclosure (Streeter, 1996, pp. 72-74).

Amateur Operators

In the period prior to regulation, however, we see a set of competing possibilities for the outcome of radio, where proprietary and non-proprietary approaches to spectrum competed. Alongside the commercial interventions of individuals such as Marconi, or a military focus that sought to colonise radio as a territory of empire, a burgeoning amateur community understood radio as a new sphere for communication, cooperation and sociality.

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[73] Lodge's chosen term for tuning a radio to a particular frequency (Aitken, 1975).

[74] Spark gap transmissions transmitted across the available spectrum in its entirety.

The period prior to 1912 has been described as a 'golden age' of unlicensed radio, where transmitting sets were readily accessible and regulation did not yet govern their use[75]. This open access to the means of transmissions and to electromagnetic frequencies led to a strong amateur influence in the genesis of radio technology and radio broadcasting. In *Inventing American Broadcasting,* historian Susan Douglas describes in detail how legions of young enthusiasts formed their own informal communications networks, exchanging technical information about construction, reception and tuning over the airwaves and hacking together their radio sets[76] from everyday domestic and found objects (1989, pp.187-215).

Three aspects of this practice are significant to this discussion. First, the amateur radio community was integral to the technical development of radio in a variety of ways (Douglas, 1989, Aitken, 1985). Significantly, their skill-share approach to the development and improvement of radio devices improved and refined the technologies of the time. Where amateurs paid little attention to the intellectual patents of Marconi and others that curtailed competitive commercial innovation, their equipment was frequently of a superior quality to those of closed operations (Douglas, 1989, p.207). Furthermore, radio amateurs often went further than their commercial counterparts in their experiments with the possibilities of the medium. As an example, the early exploration of radio's omnidirectionality by amateurs directly engaged the future possibilities of one-to-many communications, expanding commercial understandings of the medium from the point-to-point applications of wired telegraphy towards that of a fluid space for broadcast communications (Aitken, 1994, p.694). These early understandings of radio as a broadcast medium would later prove integral to the commercial success of radio.

Second, through experiments such as these, the amateur community cultivated an understanding of radio as a technology for sociality and cooperation, developing

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[75] Cultural critic Susan J. Douglas has described the role of amateur research and development in the genesis of radio and broadcasting, beginning with the figure of the boy-inventor in the first radio boom and proceeding to their significant input into the development of shortwave broadcasting techniques following the development of continuous wave technologies (1989, pp.187-215).

[76] The first significant development in amateur radio occurred in 1906 with the dissemination of the crystal set, a device that could detect radio waves (Aitken, 1994, p.697. Douglas, 1989). The device could be easily constructed from simple parts, and was directly powered from radio waves themselves through a long antenna. As Douglas argues 'The crystal set contributed more than any other component to the democratisation of wireless, the concomitant wireless boom and the radio boom of the 1920s. (p.196)"

wireless collectives (Douglas, 1989, pp. 205-206). While the actual size of the amateur network is difficult to gauge, their activities are thought to have surpassed US Navy and United Wireless activities by 1910, before regulations in the coming decades curtailed their operation. Many 'wireless clubs' were established, and by 1912, the New York Times estimated that 122 such organisations existed across America (ibid). Most of the clubs' meetings took place 'in the air' on a prearranged wavelength. Collins summarised the development in 'The Wireless Man' saying:

> An audience of a hundred thousand boys all over the United States may be addressed almost every evening by wireless telegraph. Beyond doubt this is the largest audience in the world. No football or baseball crowd, no convention or conference, compares with its size, nor gives closer attention to the business at hand (Collins, cited in Douglas, 1989, p.205).

Third, these activities occurred under the proviso of radio as a nonmarket and non-proprietary space. For amateurs, the spectrum was not the proclaimed territory of the government or an exclusive resource serving commercial interests; radio was conceived of as a networked sphere that was held and produced in common (Streeter, 1996, p.224). These three aspects appeared to be directly related: new informal networks were producing information, knowledge and culture. It was not only that amateurs were collaborating and innovating outside the confines of formal research institutions, laboratories and commercially invested spaces, but precisely that the informal composition of labour afforded by wireless communications appeared to directly support such outcomes[77].

These activities were facilitated because, from 1906-1912, a de facto commons was in place in radio transmissions. In contrast to the acquisitive outlook of interest groups such as the state, the military and large corporations, amateurs cultivated extralegal approaches to shared access within the technological limits of the period (Aitken 1994; Streeter, 1996). This involved negotiating informal sharing arrangements and codes of conduct among themselves, or occasionally in cooperation with commercial operators, such as time and channel-sharing arrangements in populous areas (Streeter, 1996, p.74); informal traditions and codes

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[77] Viewed in light of development communities congregating today around Linux, Arduino and Raspberry Pi, the radio club is an early incarnation of the vibrant open source software and hardware communities active online today.

of etiquette for on-air behaviour; and eventually, a volunteer network for relaying messages that spanned the nation (op. cit, p.224)[78]. As Streeter observed:

> If there is a legal precedent to the vision implicit in amateur activities, it is the medieval tradition of the commons, which, in its ideal form at least, functioned as a common public space open to all, owned neither by individuals nor by the state, and maintained as much by shared traditions as by legal policing (ibid).

Where the introduction of property rights and/or regulation was proposed, therefore, amateurs did their best to challenge any 'ownership' of the airwaves. This largely pitted the growing amateur community against the US navy in league with commercial operators, with the amateurs challenging the military's assertion that it should take automatic priority in the air. The amateurs maintained that within this wireless realm the individual did not have to defer to the authorities of commerce or the state. The spectrum was outside the remit of hierarchical bureaucracies, they argued; it belonged to the people (Douglas, 1989, p. 210).

4.2.4 Early Radio Regulation

We can see therefore, that all relevant actors understood radio as an informational space, but with competing understandings in the genesis of radio of that communicative space as a commons, a public or a private space. However, beginning with the Wireless Ship Act of 1910 and the Radio Act of 1912, and progressing into broadcasting legislation in the 1920s and 1930s (FRC, 1927, 1934), the possibility of a spectrum commons was eliminated through the assertion of technical and legally enforced limitations on spectrum access. Here a public interest in spectrum as it represented any common claim to communications was marginalised in favour of strong alliances between governments and commercial enterprises looking to exploit the economic possibilities of radio (Slotten, 2000; Streeter, 1996).

As commercial and amateur interests multiplied, the communicative capacity of spectrum as a natural resource was presented as limited and subject to over-crowding, requiring regulation through the state or the market to enable priority access. Accusations of harmful interference were increasingly brought against

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[78] An amateur's group in Chicago with one hundred members worked out a spectrum-sharing arrangement with local radio entrepreneurs in 1910 to the mutual satisfaction of both groups (Streeter, 1996, p.75).

amateur communities. The most significant example of this occurred alongside the sinking of the Titanic in 1912 (Aitken, 1994; Douglas, 1989; Hazlett, 1998), where various rescue attempts were understood to have been frustrated by forms of interference: both in the form of untenable signal-to-noise ratios during the rescue attempt and in the form of wilfully misleading messages concerning the location of the ship and the safety of the vessel (Douglas, 1989, p. 229)[79]. In the aftermath, some amateur operators maintained that commercial operators were the tactical instigators of this activity, hoping to influence a poor public opinion of unregulated transmissions (ibid). In response, the 1912 Radio Act licensed all radio transmissions and assigned operations to specific frequency bands, relegating the amateur community to a shortwave portion of spectrum thought at the time to be unusable. From 1915 onwards, amateurs were eliminated almost altogether (Aitken, 1994, Douglas, 1989; Streeter, 1996). The amateur's response to the regulations of 1912 varied, with some enthusiasts dismantling their sets and ceasing to broadcast altogether, while others continued to do so but with a new deference to military and commercial operations. This doesn't mark their exit from the development of radio; instead, following their relegation to the shortwaves, amateur innovation was a significant catalyst for the development of broadcast techniques used in commercial radio. As Levin argued of the regulatory decision "relatively deprived users [were] virtually forced to innovate spectrum-economising, spectrum-developing technology" (1971, p.18)[80].

4.2.5 Summary

This section traced the development of spectrum from early conceptual and scientific understandings through to its solidification as a territory for regulated wireless communications. This history also identified competing understandings of the spectrum as both a space for commercial exploitation and social production in the

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[79] At this time, amateurs were frequently accused of acts of 'malicious interference' such as sending false or obscene messages to the navy and disrupting rescue attempts. The most famous example of this occurred with the sinking of the Titanic in April 1912, where a congestion of enquiries and reports produced a false message that the vessel had been rescued and was moving safely towards Halifax. This message was in turn relayed to the International Press. When the truth emerged that the ship had in fact sunk, amateurs were accused of manufacturing deception (Douglas, 1989).

[80] In a similar vein to the expropriation of open source in today's knowledge economy, amateurs and hobbyists represented a significant investment in the research and development for future radio that went unremunerated. As well as contribution to the development of early technologies such as spark-gap transmission, tuning and the crystal set, amateurs were instrumental in developing viable techniques for shortwave broadcasting.

genesis of radio. Following the enclosure of spectrum, however, the communicative capacities that were cultivated by amateur communities are progressively put to work in the interests of capital. The following section analyses in detail the ways that this enclosure occurs through variously discursive, material and juridical practices.

Section 4.3: Some 'Thing' in the Air

4.3.1 Introduction

> [T]he essence of the commodity structure has been pointed out. Its basis is that a relation between people takes on the character of a thing and thus acquires a 'phantom objectivity', an autonomy that seems so strictly rational and all-embracing as to conceal every trace of its fundamental nature: the relation between people (Lukacs, 1967).

Following on the development of communicative practices in radio, this section explores how these are enclosed through the transformation of a relational artefact into a spatial resource called the electromagnetic spectrum. It involves a concerted effort to make a territorial resource of intangible electromagnetic signals. Here 'the spectrum' as a geographic trope performs an integral function in the enclosure of the commons. Decisions made in the 1920s to zone spectrum by service and to assign exclusive licenses to incumbents have shaped the contours of wireless communication to the present day (Werbach, 2011).

If any image is synonymous with the consolidation of spectrum today, it is probably the FCC allocation chart (Fig 4.1. FCC, 2012b).

This image is a graphic single-point-in-time portrayal of the Table of Frequency Allocations used by the Federal Communications Commission (FCC) and the National Telecommunications International Association (NTIA) as of 2012. It represents the FCC's allocation of specific bands of frequencies to designated services such as military use; emergency services; broadcasting for TV and radio; mobile services; radio navigation; and radio astronomy. This chart is arguably the closest evidence of some *thing* called 'The Radio Spectrum'. It traces a century long process, the outcome of struggles and controversies surrounding the regulation and enclosure of wireless transmissions.

Since the 1927 Radio Act, wireless communication has been a licensed activity occurring under the guardianship of a national regulatory authority. Regulatory frameworks are broadly dictated by the International Telecommunications Union (ITU), a UN organisation that intercedes with the national regulatory authority of various territories to define a global standard of allocation. Where 'allocation' refers to the partitioning of bands of frequencies to specific applications such as radio, television or cellular networks, each regulator is responsible for further 'assignment', referring to the attribution of licenses to service providers within each allocated frequency band (Kwerel & Williams, 1993). Today, these assignments are determined through comparative hearings and competitive auctions or lotteries (Benkler, 2002). As discussed in chapter three, licenses confer the exclusive usage of a band of frequencies for a specific purpose within a given geographic territory. Due to the technical and juridical consolidation of these licenses, the development of which will be discussed in this section, rights to spectrum are consolidated with powerful incumbents such as mobile network operators, Internet service providers, and public service broadcasters who can afford to invest in expensive, long term and large-scale infrastructures (O'Dwyer & Doyle, 2012).

Despite the prevailing belief that the radio waves constitute a 'public good' held in trust by National Regulatory Authorities such as the FCC or OFCOM, therefore, the reality is that rights both to transmit and to receive information using wireless 'radio' technologies are governed by a system that either legally embraces *de jure* property rights in spectrum or leverages *de facto* property rights embodied in a license (Benkler, 1998).

4.3.2 Discursive Practices

As discussed in chapter three, the enclosure of social production involves not only the destruction of the commons and the separation of the general intellect from the means and products of communication. As these capacities are appropriated they are filtered through administrative channels and redistributed as part of the services necessary for labour to ensure its ongoing development. This involves not only a segmentation and a closing off, therefore, but also an opening up: the active production of an informational environment in which communications may circulate freely but are now exposed to commercial expropriation.

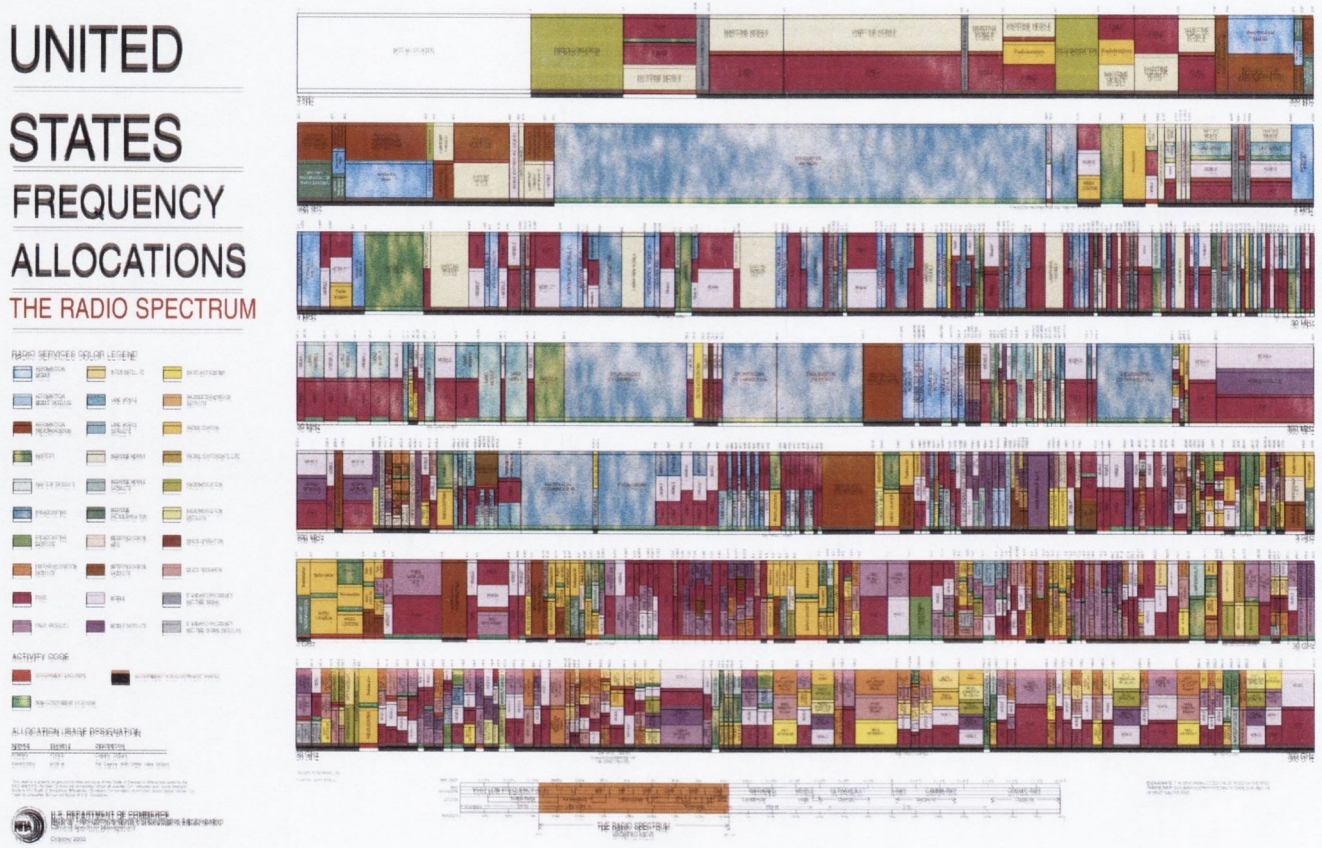

Fig 4.1. FCC Allocation Chart, 2012.

Today, the enclosure of wireless transmissions involves the construction of what Streeter describes as a "legally enforced boundary in the formless continuum of the radio spectrum" (1996, p. 219). But there is nothing inherent to the spectrum that indicates precisely where these boundaries should be drawn (Aitken, 1975, p.34), just as there is nothing particularly inherent to radio transmissions that dictate their organisation on a frequency continuum where wavelengths are analogous to geographic territory (Streeter, 1996; Werbach, 2003, 2004, 2011). The current system is a result of ongoing struggles and controversies in the political economy of wireless signals that begin with the ether and progress to the present day. The ways in which spectrum is currently conceptualised, consolidated, divided, bought, sold and owned are the result of ongoing discursive practices.[81] In turn these discursive practices help to shape non-discursive acts– the institutions and policies structuring communications.

Electromagnetic spectrum is strictly speaking a *capacity* (Benkler, 1998, p.3) or *potentiality* (Streeter, 1996, p.65); unless a radio signal is generated, nothing exists, not even the 'ether' that was once imagine to be the omnipresent substance though which wireless messages propagated. To clarify, in a wireless communications systems there are two or more radio devices and the electromagnetic wave that pass signals between these. In information theory, this inter-device relationship is referred to as a 'channel'. The communications channel that occurs between two devices is contingent; it does not exist independently of these technological interactions. In other words, radio signals, contrary to popular conceptualisations, do not traverse an invisible medium redolent of the Victorian ether or 'The Spectrum'. "They *are* the medium" (Werbach, 2004, p.15).

In a wireless communications the divisions ('bands' or 'channels') and technical standards that make up frequency allocation charts are a human projection onto a continuum and not a scientific description of a natural object. Nonetheless, spectrum is almost universally treated as a spatial/physical rather than a relational artefact,

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[81] In Foucauldian theory, discursive practices concern the historical and culturally specific rules that produce different forms of knowledge. In turn we can relate these discursive practices to the non-discursive: institutions, political and economic events and processes that are shaped by the underlying discourses (Foucault, 1998).

where frequency is analogous to geographic territory, signals are phenomena that traverse this space and radios are sentient agents operating within this territory (De Vries, 2007, 2008). The more difficult to envisage reality, according to De Vries, is closer to a distribution of related entities that range over a set of values, such as, in its current regulatory arrangement, radio energy indexed by frequency (2008, p.1).

In other words, although the electromagnetic waves that make up the electromagnetic spectrum have scientifically measurable qualities and are emitted by both natural sources and human technologies, the radio spectrum is for the most part a construction that is "simultaneously real, like nature, narrated, like discourse, and collective, like society" (Latour[82], 1993, p.6). What is materialised or embodied is the heart of social production itself: the communicative and cooperative capacities of networked individuals. This is not just a question of ideology, or of uncovering something previously hidden, but of exploring how through a "series of practices that are coordinated by a regime of truth, something that does not exist can become something" (Terranova, 2009, p.239).

Spectral Geographies: Language and Metaphor in Representations of Spectrum

What kinds of operations produce(d) spectrum as a tangible resource in need of government or market regulation? An important place to begin is with language - specifically with the conceptual metaphors that proliferate around spectrum and produce it foremost as a finite and scarce space that is subject to interference. As something largely intangible, difficult to sense and difficult to understand, spectrum is particularly open to the resources of tropes, analogies and metaphor. Such conceptual exercises perform powerful work that is, for the most part, invisible. As de Vries notes:

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[82] In Science in Action (1987) Latour describes the ways in which science is produced through a set of interrelated social practices. Latour proposes apprehending science before it becomes normative scientific fact or inscribed in technological innovation. This involves arriving before facts or technological apparatuses have been 'black boxed', which is to say before they retreat into invisibility and everyday use and convention. This necessitates conducting research while facts are still in dispute or if this is not possible, reopening the sphere of fact or normative understanding to dispute. Latour identifies investigations into the role of scientific literature, the activities of laboratories and the institutional context of science in the modern world as methods to elucidate the many ways in which scientific discoveries are accepted, become part of a repertoire of established facts and norms and are subsequently applied to technological innovations. Within this context, Latour describes the use of rhetoric in scientific discourses (P.30). Latour argues that far from being a dispassionate and equivocal discourse, scientific and technical literature evokes a great number of external alliances in the social construction of 'fact' and makes use of conceptual metaphors to perform highly political work .

> Spectrum has had attached to it a rich set of connotations borrowed from the physical realm, like utilisation, scarcity and ownability. These attachments occur in our conversations and in our minds through the workings of metaphor." (De Vries, 2008, p. 1).

A metaphor is a figurative use of words that describes a subject by asserting its similarity on some point of comparison to another otherwise unrelated subject (Richards, 1965). Metaphors allow for the compression and inscription of historically developed collective understandings. They reduce complexity and contentious detail in favour of complacent and general knowledge. It is important, however, to recognize that metaphors are not just linguistic devices; according to Lakoff and Johnson, they form the basis of our cognitive conceptual system (2003)[83]. In this way, their expression in everyday discourse points to a vast weight of implicit and corporeal understanding that shape and sometimes limit patterns of thought, belief systems and ideological constructs, all of which may or may not be formally articulated.

In the enclosure of spectrum, the most common constructions describe spectrum as a naturally produced 'resource'. For example:

> The spectrum has been called a 'limited' natural resource because...there is only a finite portion available for beneficial uses at any one time. The word scarce is appropriate (Herter, 1985, p.652).

A resource supposes something that is tangible and produced by nature as opposed to manual labour or a social contract (SNA, 1993). It also engages the concept of a 'stock' or 'supply' that is drawn upon. It is suggestive therefore both of utilisation and of a physical limitation that necessitates negotiation through regulatory or economic activity (Boal, 2005). Land, fish stocks, mineral resources and fossil fuels are all common examples of natural resources, but where spectrum is concerned the inference of spectrum as a form of 'land' is by far the most common (De Vries, 2007, p. 374). Spectrum today is frequently represented as a non-physical space where electronic communications proliferate. One does not need to look very far to see evidence of this metaphor at work in scientific and journalistic literature: 'vast

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[83] Lakoff and Johnson have amassed a large body of empirical data to support the interactionist theory of metaphor (2003).

portions of spectrum space are left vacant'; 'a wide swathe of frequencies'; 'adjacent channels'; 'licenses are important when bands fill up' and so on (De Vries, 2007, p. 374).

Early conceptualisations of the ether, a metaphysical substance through which disembodied communications were thought to travel, form the likely conceptual basis for such an approach. As discussed in section 4.2, the ether was used in both scientific and spiritual discourses to describe forms of action at a distance. As such it had a liminal status in the late nineteenth century, describing a classical element; a spiritual dimension; and a physical conduit believed by early physicians to be the medium through which waves (of light or sound etc) propagated (Schaffner, 1972). Radio waves have been semantically connected to the ether since their discovery and the concept is invoked in technical and popular accounts of radio communications from the 1880s well into the twentieth century, even after the existence of any such medium was disproved by Einstein's theory of relativity (Werbach, 2003, p.15)[84]. Where radio was concerned, ether conceptually spatialised the action and propagation of radio waves, as it imagined an intangible space in which such communication occurred.

Furthermore, a spatial metaphor is supported, but also somewhat confused by the fact that radio signals exist conceptually in frequency 'space' but also propagate physically in geographical space, and also by the fact that different wavelengths possess different physical characteristics in terms of their interactions with space and physical objects. As such, the use of spatial metaphors is both corroborated and confused by the intersection of physical wave propagation with a geographic plane.

Metaphor allows for the conceptual mapping of knowledge and experience from a source subject to a target[85] (Richards, 1965). This process of metaphorical mapping leads to the production, not only of the most salient features between target and source, but to a whole range of inferences. Once this conceptual model is well

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[84] For example, Herbert Hoover makes reference to the 'ether' as a 'public medium for public benefit' in his speech at the fourth National radio conference in 1925 (Hoover, cited in Corbet, 1996, *supra* note 43).

[85] We use the terms 'target' and 'source' for the two halves of metaphor. The target is the principle subject, while the source, which carries the metaphor, is the domain from which the salient features are drawn and then attributed to the target. For example, in the familiar metaphor "Juliet is the sun", Shakespeare's Juliet is the target and the sun the source, conferring a host of features associated with the sun onto the character without seeking to draw an identity-relation between the two.

established, various properties of the source (rules and inferences from the spatial domain) can be transferred to the target subject (wireless systems). Gradually, certain ways of thinking about spectrum become natural. Conceptual metaphors can be a useful way of making abstract concepts intellectually concrete, but there is more at play here than a necessary disambiguation; metaphors also normalise certain relations, crystallise some habits of thought and discourage others. In this model the available frequencies for radio communications become analogous to a discrete spatial domain, one that can be segmented as zones or regions, or the frequency 'bands' of spectrum parlance. Transmitting radios become *agents*, frequency becomes *territory*, the act of transmission suggests *occupation*, and interference suggests the physical *collision* of promiscuous objects operating within a bounded space.

Interference, Spectrum Space and Scarcity Discourses

The concept of interference deserves special attention here. In section 3.4, we discussed how the fidelity of wireless communications are sometimes degraded by circumstances that inhibit the reception of signals. It is this condition, known as interference, which is thought to necessitate centralised management or formal regulation of wireless transmissions. The spatial metaphor understands wireless transmissions as a mode of spatial assembly that sees agents accumulating in an intangible radio territory, or in the case where the spatial metaphor is not invoked, as a collective use that progressively depletes a natural resource. This in turn has significant implications for how forms of interference in wireless systems are collectively understood and managed. Following from this construction, interference is framed, not as a technical concern, but as a consequence of overuse or overpopulation such as in Hardin's 'Tragedy of the Commons' (1968) scenario, (invoked with predictable regularity in regulatory debates surrounding spectrum). If the occupation of radio space is not formally managed and negotiated through markets or state regulation, the argument goes, the productivity of this space is degraded for all users. As such, interference is generally equated with the 'over-population' of radio 'space' by transmitting devices, and in turn is the primary rationale in favour of exclusive licenses and against proposals for spectrum 'commons'. As one early advocate of regulation stated:

> [R]adio by virtue of the interferences, is a natural monopoly; either the government must exercise that monopoly by owning the stations, or it must place the ownership of these stations in the hands of one concern (Hoover, cited in Coase, 1959, p.4).

Or take this famous quotation from Justice Frankfurter as a further example:

> The plight into which radio fell prior to 1927 was attributable to certain basic facts about radio as a means of communication -- its facilities are *limited*; they are *not available to all* who may wish to use them; the radio spectrum simply is *not large enough* to accommodate everybody. There is a *fixed natural limitation* upon the number of stations that can operate without interfering with one another. (Frankfurter, cited in Benkler, 1998, p.10, my emphasis).

Here the judge begins by extolling the "basic facts" of radio spectrum, that in some form or another it is "limited", and proceeds smoothly from this acknowledged 'fact' to a position that a theoretical limitation predicates interference and as such necessitates regulation and enclosure.

Much like the controversies over spectrum as a spatial resource are problematised by the spatial propagation characteristics of waves, interference is presented in two ways in technical and policy literature: sometimes as a program of harmful radiation, or at other times as a degradation that occurs at the receiver (ITU, 2011; Ofcom, 2006, 2008)[86]. Rather than speaking about intersecting signals that vie for space, however, it is more accurate to say that interference is the effect of unwanted energy on a radio receiver, degrading its performance or causing information loss from an intended signal. As David Reed argues, we are not dealing with a fundamental competition of the waves themselves, as these waves naturally pass through each other unobstructed, but an inability of the radio receiver to extract meaningful

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[86] Interference is defined by the ITU as that which "endangers the functioning of a radionavigation service…or seriously degrades, obstructs or repeatedly interrupts a radio communications service" (ITU, 2011). While the term interference is not formally defined in Ofcom's 2006 Spectrum Usage Rights Consultation, Ofcom refers throughout to 'interference levels' as electromagnetic radiation that is under the control of a transmitter, as in 'the interference a licensee is allowed to cause, rather than the signal it is allowed to transmit' (1.6). Ofcom, in its more recent Spectrum Common Classes Consultation (2008), however, states that "interference occurs when an undesired Radio Frequency signal appears at the spatial location of a receiver, in its receiver channel frequency, at the same time the desired signal is present and with a power level high enough so that the reception of the desired signal is disturbed". Here two different senses of interference are put forward: Interference as degradation at the receiver and interference as a program of radiation. These in turn have different implications for radio regulation, where the concept of harmful radiation supports a scarcity discourse in the way receiver degradation does not.

information in a particular context (Reed, cited in Weinberger, 2003). Interference cannot and should not be defined outside the specifications of a technical system and certainly not as an avoidable outcome of multiple transmissions (ibid). However, the spatial metaphor supports an economic scarcity discourse, understanding interference as the indisputable 'overpopulation of the airwaves' in a way that receiver degradation does not.

Spectrum Real Estate

It should be clear that the current metaphorical framework gives rise to a whole series of inferences: spectrum is a physical territory and therefore, spectrum is limited, can be occupied, trespassed on, "zoned" and divided into a series of small landholdings that are just like real world property holdings (Hunter, 2002, p. 39). Ideas about productive or unproductive use or activity are suddenly intelligible, as are those of ownership. Spectrum 'real estate' starts to seem like a natural approach to the inherent 'scarcity' of a resource. It is hardly surprising, therefore, that forms of regulation produce rights and limitations similar to those involved in the enclosure of land, only in this context it is an invisible spectrum 'space' that is apportioned. This is not to say that a spatial metaphor automatically presumes a property right; historically there are non-proprietary and communal ways of relating to land such as the commons. However, property rights become broadly intelligible when spectrum takes on the characteristics of a tangible non-produced resource subject to temporal degradation. We see this enacted today in controversies over spectrum auctions and liberal property rights, but also in the history of twentieth century regulation. For example:

> Are we not simply dealing with space in a fourth dimension? Having reduced space to private ownership in three dimensions should we not also leave the wavelengths open to private exploitation, vesting title to the waves according to priority of discovery and occupation? (Childs, 1924).
>
> If the government own a tract of land on which you raise cattle, they charge a man for the use of the land. Why would it not be just as reasonable to charge a man to use the avenues of the air as it would be to use that pasture? (Rogers, cited in Coase 1959, p. 17)

> There is no difference in principle between the ownership of land and the ownership of the airways. The only issue is the task of defining the application of property rights to this particular space. (Rand, 1964, par. 3)

To further argue this point we can make brief reference to some alternative metaphors in spectrum. Throughout the history of regulation, we can identify a number of counter-narratives that frame spectrum differently. For example, a number of writers across law, engineering and technology studies have theorised the electromagnetic spectrum in relation to other forms of sensory spectra such as audible sound waves and the visible portion of the spectrum perceived as wavelengths of colour (Benkler, 1998, 2002; Coase, 1959; Forge et al., 2012; Reed interviewed in Weinberger, 2003; Werbach, 2003, 2004). In some ways, given that all are wavelengths of electromagnetic energy, this is more appropriate than analogies to geographic terrain. However, unlike spectrum as land or real estate, recasting spectrum as colour disrupts proprietary arguments and stalls economic thinking as a 'science of scarcity' (Boal, 2005).

For example, open spectrum advocate David Reed recasts the statement "WABC-AM has an exclusive license to broadcast at 770 kHz in New York City" to "the government granted WABC-AM exclusive license to the colour forest green in New York City" (Reed, interviewed by Weinberger, 2003). Similarly in a seminal article from the 1950s, Raymond Coase draws analogies between radio regulation and the regulation of other kinds of frequencies in the visible spectrum and audible frequencies economist:

> Every regular wave motion may be described as a frequency. The various musical notes correspond to frequencies in sound waves. But it is not necessary to allocate to different persons or to create property rights in the notes of the musical scale or the colors of the rainbow... (1959, p.33)

As a consequence this tactic is sometimes employed by open spectrum advocates to conceptually disrupt the dominant rhetorics of government regulation or free market control of spectrum[87].

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[87] Other proposed metaphors liken spectrum to a network, drawing on technical knowledge in transport protocols and standards to conceptualise a decentralized regulatory system (Werbach, 2011).

Ultimately, treating spectrum as a resource as opposed to a capacity favours regulatory approaches that enclose and privatise the use of spectrum (Benkler, 1998). As a natural resource subject to scarcity, it now affords the basic tenets of property: possession, divisibility and alienability. At the heart of this property – radio energy indexed by frequency and auctioned to the highest bidder – is a social contract or relation between people. Spectrum as a territory or resource draws the intangible relations between cooperative agents into a material domain, where, to echo Lukacs, they acquire a new objectivity, and a new substantiality, which they did not possess in the age of episodic exchange (1967, p.9). What is enclosed the heart of social production itself: the communicative and cooperative capacities of individuals. Where discursive practices are a crucial step in this process, material and juridical constitutions are also significant. These will be discussed in the coming sections.

4.3.3 Technological and Material Processes

These ways of thinking and speaking about spectrum are further solidified through the constraints and affordances of technological and material artefacts. As Bijker and Law remind us:

> Technology does not spring *ab initio* from some disinterested fount of innovation. Rather it is born of the social, the economic and the technical relations that are already in place. A product of the existing structure of opportunities and constraints, it extends, shapes, reworks and reproduces that structure in ways that are more or less unpredictable. And, in so doing, it distributes or redistributes, opportunities and constraints equally or unequally, fairly or unfairly. (1992, p. 11)

Particular world-views can be reproduced through and embodied in technological approaches. This perspective offers a constructivist as opposed to the traditionally deterministic perspective applied to the development of radio regulation. While stable technical systems are generally born out of conflict, difference or resistance, and there is a high degree of latitude in the early stages of any artefact, the form a technology ultimately takes will embody particular relations of power, authority and privilege (Winner, 1984). This is not a deterministic perspective, so much as admitting that the shape a technological artefact ultimately takes is thought to be "strongly compatible with" if not to require a particular set of social and economic conditions (p.125). And furthermore, once this technology is part of a broader sociotechnical system it helps to solidify and reproduce these initial imperatives.

Certainly this is very much the case with radio spectrum. It is well accepted that the historical configuration of radio technology according to exclusive frequency/wavelength assignments has shaped the ongoing political economy of spectrum more than any other material innovation. As discussed in section 4.2, this historical influence prevails in contemporary spectrum regulation, despite the existence of a variety of alternative technical approaches that do not require exclusive channel allocations and support dynamic and shared access (FCC, 2012b).

When referencing the history of radio, in social and in engineering literature it is generally accepted that decisions to employ frequency division multiplexing were driven by the affordances and constraints of scientific and technical knowledge at the turn of the century (Marcus, 2004); if current technical regulation is a political maelstrom of powerful incumbents lobbying for exclusive access to spectrum, initial technical decisions were thought to be largely neutral and subject to necessity. However, we can also argue that an imperative towards proprietary regulation of spectrum had a significant weight in the development of early multiplexing techniques. In particular, early articulations of spectrum as a spatial resource may have ushered in attendant approaches to engineering and legislating radio. Aitken has obliquely suggested that proprietary interests coupled to a spatial discourse guided early technical approaches to spectrum as much, if not more, than any quest for efficiency in transmissions (1976, pp.33-35).

Certainly the early activities of entrepreneurs such as Marconi (discussed in 4.3) seem to corroborate such a perspective. While early spark-gap transmissions have no locative or frequency-specific component that supports the concept of geolocation, Marconi had already developed techniques to rarify radio transmissions prior to frequency allocations, producing a monopoly in ship-to-shore communications through patent libraries and service exclusion (Streeter, 1996). In the early period of radio, prior to regulation, electromagnetic transmissions were a scientific discovery that as yet required an economic frame to produce this intangible capacity as a rival good. And central to such a project was the establishment of some means by which rights of use could be produced and maintained (Aitken, 1976, p.33). Alongside rhetorical devices, technoscientific artefacts and associated technical knowledge was a very effective means of imposing a particular regime onto the formless continuum of the radio spectrum (Slotten, 2000).

The enclosure of spectrum would in time require all sorts of supporting legislation and institutional arrangements, but before such a regulatory system could be created, Aitken argued, "technology had to solve the problem of how *locations* could be *found* and *kept*. Legal rights could not be established until technology discovered what kinds of rights could exist" (Aitken, 1976, p.34 my emphasis). Such an approach is made possible by frequency dependent multiplexing, initially known as 'syntony' (Lodge, 1900) and informally as tuning. This makes it possible to locate a radio transmitter or receiver at a particular frequency or wavelength in the radiofrequency spectrum and none other. This technical approach allows for the management of multiple signals, making radio devices more efficient. It also makes not only the concept of spectrum 'place' more intelligible, but rights of occupancy and possession thoroughly preferable.

Marconi originally thought that only one signal could be transmitted in a given geographic area. Developing on syntonic innovations by Oliver Lodge[88], Marconi patented a technique for expanding capacity based on the principle of sympathetic vibrations. Using this model, one radio can be associated with a specific carrier wave frequency while others coupled with other frequencies can operate in the same geographic area without causing interference, a technique referred to as frequency dependent multiplexing. As the standard technique for operating multiple simultaneous transmissions, the frequency divisive approach forms the basis for radio policy and regulating radio was very quickly equivalent to regulating frequencies, by apportioning wavelengths exclusively to particular licensees and services. And so it remains today, despite the ready availability of a variety of techniques that support shared and nonexclusive access. In short, Aitken's description of early approaches to technical issues implies that a conceptualisation of spectrum as a space primed for enclosure *precedes* technical innovation. We can argue, therefore, that the techniques underpinning regulation are at least in part a

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[88] In 1897 Oliver Lodge, a UK based inventor developed a technique called 'syntonic wireless telegraphy' that was based on the realisation that is a transmitter and receiver used an induction coil made from equal lengths of copper wire and with an equal number of turns in the coil, they could be electrically resonant (Douglas, 1989: 37). Two syntonic coils would respond sympathetically to each other so that the receiver might distinguish signals from its paired transmitter from others broadcasting in the same geographic area. Marconi refined Lodge's work and filed a patent in 1900 for a system using four as opposed to two tuned circuits. The patent also includes a description of the tuning dial used to enable ease of selective reception. Marconi in turn uses the term 'tuning' instead of Lodge's chosen 'syntony'.

consequence of proprietary interests in spectrum. This is in contrast to the general consensus that proprietary interests arose from the inherent constraints and affordances of a frequency dependent approach to signal multiplexing.

While frequency is a salient physical property of electromagnetic radiation it is not the exclusive property; amplitude, power, directionality and time are also inherent features of signals. Today, where signals are digitally processed, the different algorithms for coding and decoding signals are also significant. As such, frequency dependent multiplexing is not the only possible approach to multiplexing signals. Another possibility is time-division multiplexing, used to regulate telegraph transmissions as early as the 1870s (Fischer, 2012). It is certainly more complex and traditionally requires all devices in a communications system to synchronise their clocks in order to know which signal operates in which time slice. But it also supports shared access to spectrum. In addition to time and frequency, spatial multiplexing can also be performed based on three-dimensional relative location of the transmitter and the angle at which a signal hits an antenna[89]. This evidence has led open spectrum advocate Kevin Werbach to argue that the decision to produce frequency exclusive licenses is "an artefact of radio technology, not a necessary attribute of communication (2011, p. 40). This observation almost goes without saying today, where a bewildering number of dynamic spectrum access techniques are eschewed in favour of exclusive frequency dependent licensing approaches (IEEE-USA COCP, p5). However, it is also worth noting that early decisions that shaped the medium were also politically influenced.

As well as the role that material technologies take in shaping the future of radio in one way or another, technocratic expertise and testimony from engineers in a position to advise on radio regulation was frequently used to legitimise particular political and economic perspectives in regulatory debates (Slotten, 2000, p.11). Policy decisions that supported powerful incumbents could be rationalised through recourse to the indefatigability/neutrality of a specific technical problem such as the technical issue of interference or the technical limitations of particular frequency bands. Expert testimony from engineers played a significant role in regulatory debates in early Radio Acts and later in controversies surrounding radio and

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[89] These and other non-exclusive techniques will be discussed in more detail in chapters five and six.

television commercial broadcasting, cable television and cellular communications (ibid).

4.3.4 Juridical Regulation

So far, we have looked at how ways of speaking about and engineering for spectrum usher in a proprietary approach. Finally, law assumes the double function of concretely and rhetorically fixing the totality of these discursive and material relations (Edelman, 1979, p.92). First the law fixes a realisation as a natural given in the sphere of circulation, and second, this assurance in turn makes production within that sphere possible (ibid). Although there was still confusion and much debate about the nature of electromagnetism and the correct approaches to its management and negotiation, the 1912 Radio Act is the first time we can begin to conceive of spectrum as property in a juridical sense. Following on a range of discursive practices, the creation of licenses for frequency channels is the copestone in this process.

These initial acts of juridical regulation: zoning spectrum, allocating bands for specific purposes, and assigning channels to various incumbents, are not simply a case of granting exclusive or shared access to some resource that already exists, but a final act of creation. When a regulatory authority instates a legal regime that controls access to spectrum, a decree such as "we grant operator X license to channel 90' constitutes a performative, a "production that creates the effects of the natural, the original and the inevitable" (Butler, 1990, p.xxxi). In particular, the 1912 Radio Act performs many of the now hegemonic relations to spectrum into their solid form, concurrently producing the wireless territory and the rights structuring access. From this moment, spectrum is not just something thought of or designed for; it has become a veritable territory for jurisdiction.

Before 1912, wireless transmissions developed outside of the legal control of governments or large bureaucratic corporations (Douglas, 1989). In 1903, Germany sponsored a preliminary conference concerning wireless technology, designed to establish a general basis for wireless telegraphy regulations. It highlighted issues for different governments to review pending an international conference in 1906. As radio was a marine communications technology at this time, the main issue concerned ship-to shore communications. The issue for discussion was not so much congestion or occupancy of this territory, as one of fixing an appropriate protocol by

which radio operators could communicate with each other (Aitken, 1985). Considerations centred not so much on 'naturally' occurring forms of interference given the lack of transmissions at that time, but on the negative effects of corporate monopolies on the smooth operation of wireless communications generally and specifically, the safety of ships at sea. This was largely because the Marconi Wireless Company had implemented a restriction on Marconi operators prohibiting them from accepting or relaying messages from non-Marconi operators (Streeter, 1996). Regulation was therefore required to implement international protocols: designating standard frequencies as distress or calling frequencies; mandating that all ships over a certain size carried equipment and trained operators; and ensuring that radio stations using different equipment would communicate with each other (Aitken, 1985; ITU 1990). In turn, the 1906 Berlin convention actualised many of these recommendations. The result was a comprehensive agreement: the International Wireless Telegraph Convention adopted on November 3rd and coming into effect on July 1st 1908. Although US representatives signed this agreement it didn't ratify the convention until spring 1912. From 1906 until 1912 however, complaints of interference prompted debates concerning state regulation, with the sinking of the Titanic forming a catalyst for a comprehensive radio act in 1912 (Douglas, 1989).

The 1912 act as of yet did not give authority to the secretary of commerce to deny a license to any individual; it therefore upheld a public conviction that since the spectrum belonged to the people anybody might posses a license (Aitken, 1994). However it did perform a broad allocation of the frequency continuum, relegating different users and interests to different frequency bands and requiring all stations to possess a license. This divided the geography of the United States into nine discrete territories (radio inspection districts) with a radio inspector headquartered at a major port in each district. These inspectors had the primary responsibility for controlling radio in the days before the development of the Federal Communications Commission (Slotten, 2000).

The propagation characteristics of particular frequencies render them more or less valuable for wireless transmission, and this was particularly true at this period in history, when transmitters and receivers were comparatively primitive. Shortwaves were thought to be unusable. Longwaves incurred various technical constraints.

Precedence was given first to the military and then to commercial operations, with the navy granted the wavelengths between 600 and 1,600 metres and commercial operators those above 1600 and between 200 and 600m. Amateur operators, on the other hand, were relegated to a portion of the spectrum then considered to be useless: short waves of 200 metres or less. They could listen in on any frequency but only transmit in this short-wave portion of the spectrum (Radio Act of 1912[90]). In contrast, to this "exile to an ethereal reservation" (Douglas, 1989, p.234), the new legislation produced hegemony of the spectrum for the US navy. Commercial operators also benefited significantly; with the amateurs safely consigned to short waves and the navy to the 600 – 1600 metre range, the act ensured that in America, the Marconi Wireless company would have portions of the spectrum entirely to itself (ibid).

According to Douglas, the 1912 act represents a watershed in wireless history, the point after which individual exploration of 'the ether' would diminish and corporate management and exploitation, in close collaboration with the state, would increase (Douglas, 1989, pp.234-238). Legislation acknowledged that property rights could be established in spectrum, and furthermore that the main claimants to such rights were institutional and commercial users. While amateurs had attempted to argue in the years preceding the act for a legitimate public interest in how the spectrum was used, 1912 shifted authority from the spectrum commons towards corporations and government institutions as the guardians of the public interest (Benkler, 1998; Douglas, 1989; Streeter, 1996).

4.3.5 Summary

So far this chapter has traced the genesis of radio from a programme for action at a distance towards a wireless enclosure. Section 4.2 detailed the development of competing understandings of radio both as a proprietary space, and as a commons for forms of wireless communication and cooperation. Section 4.3 detailed the discursive, technical and juridical foundations of the enclosure of wireless communications, exploring how a relational artefact is, over time, produced as a spatial resource thought to be in need of external regulation. However, enclosure is

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[90] The full title of which is 'The Senate and House of Representatives of the United States of America in Congress: An act to regulate radio communication (1912)'.

not a singular process and while this is a significant step in the enclosure of the general intellect, it is not the whole process.

While radio is understood as a space in need of regulation at this time (1912), public access is still permitted and commercial actors are still limited in their claim to radio. The general public still has to be separated from the means of communication and cooperation and put to work in ways that are productive to capital, in this particular case shifting from an amateur community towards a broadcast audience. This process occurs alongside the rise of commercial broadcasting, which takes place in the 1920s and 1930s. Section 4.4 analyses this.

Section 4.4: The Rise of Commercial Broadcasting

4.4.1 Introduction

The conditions described in 4.3 produced a consensus that spectrum is a limited space subject to necessary regulation. However, it was still framed as a 'public good' or common property held in trust by the state as opposed to a commercial space (Corbett, 1996). There are more operations still to discuss in enclosure. These largely occur alongside the rise of commercial broadcasting in radio. The rise of broadcasting precipitates two radio acts that grant a controlling interest in the spectrum to commercial licensees, allowing them to multiply their investment in radio (FRC 1927, 1934). At the same time these acts progressively deny public access to radio transmissions, reducing the general public investment in radio from the active engagement that characterised amateur developments to the passive reception that characterises the mass media audience. Furthermore, the early years of broadcasting and continuous wave technology see the development of a commercial advertising revenue model for radio that puts the newly enclosed audience to work in ways that are productive for commercial incumbents and the state (Streeter, 1996).

Alongside the rise of a one-to-many broadcasting model regulated by the state, this section details the total separation of amateurs and non-profit interests from the means of wireless transmissions, in favour of the production of selective licenses that are conferred to commercial incumbents and come to operate more or less like a property right. This transformation is performed through Radio Acts in the 1920s and 1930s designed to regulate the new broadcasting applications (FRC, 1927, 1934). To frame this shift, we explore the alliance of state regulation and commercial interests

as a form of corporate liberalism that gradually reframes questions of licensing in the public interest towards a consideration of commercial and economic benefits. This in turn rationalises the introduction of an advertising revenue model for radio that produces the audience as a commodity.

As previously discussed, early amateur innovations in radio cultivated a non-proprietary and informal approach to wireless communications, and from 1906 - 1912, a de facto commons was in effect (Streeter, 1996, p.224). In contrast to the acquisitive approaches of powerful interest groups such as the state, the military and large corporations, amateurs managed shared access within the affordances and constraints of the technologies of the day. Commoning developed without recourse to formal legislation or formal property rights. Where such measures were proposed, the amateur community did its best to challenge any 'ownership' of the airwaves (Douglas, 1989, p.210).

However, beginning with the Radio Act of 1912 and progressing to the 1927 and 1934 broadcasting Radio Acts, 'public interest' in the spectrum as it manifested a common right to communication or free speech through electromagnetic channels was curtailed in favour of a corporate liberal approach to regulation, with strong alliances between state and commercial enterprises seeking to exploit the economic potential of broadcast radio (Streeter, 1996). In an observation redolent of the crises facing Internet cultures today, historian Susan J. Douglas describes how utopian visions of a decentralised and democratised communication were replaced with corporate-defined systems emphasizing public acquiescence to corporate control of the technology:

> The visions of 1900 had depicted the invention as the instrument of individual freedom; now, with the possibility of millions listening to 'one man's voice' radio was cast as an agent of conformity and passivity (1989, p. 250).

Most significant in this is the rise of commercial broadcasting in radio and later television. While there were innovations in continuous wave technology and broadcasting as early as 1906, from early 1920 a 'broadcast boom' swept through the United States[91]. As the technology grew more popular, enterprise came to consider

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[91] The demonstrated ability of continuous wave technologies to transmit audio waves as speech or music, coupled with a ready availability of radio equipment and trained radio operators suggests that conditions were ripe for such an explosion (Aitken, 1985).

the potential of a one-to-many medium for publicity and, more specifically, consumer advertising. In the coming decades, the state, firmly aligned with corporate interests, would transform broadcasting into the 'linchpin of the consumer economy' (Streeter, 1996, p.61), while successfully marginalising other non-commercial claims to spectrum. Following on the forms of alienation produced by the 1912 acts, in the 1920s, the department of commerce placed a further limitation on amateurs, not only consigning them to particular regions of the spectrum, but also forbidding them from broadcasting "weather reports, market reports, music, concerts, speeches, news of similar information and entertainment." This was coupled with further regulations that ordered all amateurs to cease broadcasting at 833.3 KHz (the wave currently assigned for that purpose) (Benkler, 1998, p.20). This limited amateurs to radiotelephony and telegraphy in frequencies above 1500 KHz, once more considered a useless reserve given the technological constraints of the period.

4.4.2 The Radio Acts of 1927 & 1934

It is necessary here to go through the Broadcasting acts that effectively separate amateurs from transmissions and give precedence to commercial incumbents. In section 4.3, we showed how the introduction of the 1912 Radio Act effectively produced the juridical foundations for an enclosure of spectrum. Adopting the spatial metaphor we might say that similar to the enclosure of land in Sixteenth Century England, 1912 erects boundaries in the frequency continuum. However, it does not yet separate the general public from the means of wireless communication. Access to the territory of the airwaves is still framed as a common right as opposed to a selective privilege conferred by a state authority or secured through market advantage. While the 1912 act regulated spectrum, therefore, stations could continue to broadcast as long as they procured a license from the secretary of commerce. This license dictated the frequency allocated, the geographic location and very soon, the time of day in which transmissions could take place. However, licenses in this period were "more like registration receipts than permits" (Marcus, 2004, p.5); the conditions of 1912 did not confer rights to exclusion, long term possession or transfer and at the same time the secretary had no authority either to refuse applications or to detract existing licenses (Benkler, 1998).

The rise of broadcast details a series of controversies that see the introduction of de facto property rights in spectrum. This was a significant shift in the commercial script of radio from a point-to-point medium for security and logistics towards a one-to-many form of mass media. Economic decisions motivated by a discourse of scarcity start to come to the fore alongside broadcasting. The rise of one-to-many transmissions multiplied signals, but this was not accompanied by a corresponding increase in available spectrum, leading to a perceived shortage and to high levels of interference (Benkler, 1998; Corbett, 1996). At first, the secretary of commerce assigned a single frequency to broadcast (833.3Hz/ 360 metres). As time passed, other bands were made available, culminating in the release of the 500-1500 KHz band for broadcast in 1923. Despite this expansion of the broadcast band, the number of stations still grew in excess of available channels and by 1922 there were 576 broadcast stations in operation throughout the United States (Douglas, 1989, p.293). In response to this issue, the Department of Commerce sponsored a series of four annual radio conferences running from 1922-1925 (Streeter, 1996, p.88). These brought together industry representatives, members of government and public citizens to determine the future regulation of radio. Most significantly they attempt to advocate a "public interest' standard for licensing (op. cit, p186).

The situation highlighted tensions in the political economy of radio. On the one hand, legacy belief in the 'public' and communal nature of the spectrum resource cultivated by amateurs meant that a degree of openness and inclusivity remained in place for a time. On the other, the enclosures of 1912 already conferred an advantage to powerful commercial interests who now argued that their initial investment deserved reasonable protection from interlopers. Commercial operators as such advocated for the institution of a small number of official stations to serve the needs of the nation in place of the current situation of general authorised access (Streeter, 1996).

As a result of these pressures, the secretary attempted to withhold and selectively assign licenses. Two cases would be decisive in pushing forward the privatisation of the airwaves: the Intercity case of 1923 and later the Zenith corporation case of 1926.

A 1923 federal case *Hoover vs. Intercity*[92] denied the secretary the right to withhold licenses, but reaffirmed the right to allocate wavelengths, times and locations so as to minimize interference. A resulting 1926 case of the *United States Vs. Zenith Radio Corporation*[93] further denied the secretary the ability to regulate licenses. The outcome favoured Zenith, the court again denied the secretary the right to regulate licenses and this time – contrary to Intercity – explicitly denied him juridical discretion over wavelength and temporal assignments also. For a brief period in history, the federal government had no authority to define any rights to spectrum (Benkler, 2008; Marcus, 2004).

President Hoover ceased trying to regulate spectrum altogether and instead issued licenses to all applicants. The result is often described as 'a chaos of the airwaves'; stations could choose whatever frequency, amplification, broadcast schedule and geographic location they wanted. For some historians this period represents a tragedy of the commons (Coase, 1959; Hazlett, 2008), and for others, a deliberate crisis cultivated to justify the nationalisation of the airwaves (Marcus, 2004).

The right to *deny* access to spectrum is formalised in the 1927 Radio Act. Unlike the 1912 Act, which presumed that all citizens had a right to a license, the 1927 Act emphasised that broadcasting was a privilege given to individuals based on their commitment to "public interest, convenience and necessity" (FRC, 1927). The 1927 Act also brought about the existence of the Federal Radio Commission (FRC),

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[92] The Intercity case of 1921-23: The radio station Intercity built a high-powered radio telegraph station and situated it in Lower Manhattan. It completely wiped out radio reception in most of the city. In May 1921, the Commerce Department revoked Intercity's license on the grounds that it was interfering with ship-to-shore traffic. Intercity appealed and on November 17th 1921, the department was ordered to issue a license on the grounds that the act of 1912 gave the secretary new discretionary power to renew a license.

[93] Zenith case of 1926: The Zenith Corporation owned and operated WJAZ, located on the Edgewater Beach Hotel outside of Chicago. In May 1924, the station was sold to WGN, owned by the Chicago Tribune, who asked and received permission to retain license for the new station. However, they warned that the available frequencies were already assigned and that they would have to make time-share arrangements with other stations. They agreed and asked for the wavelength 322.4 metres. When told that this would bring them into interference with near lying stations (WSAI in Cincinnati and KOA in Denver) they assured the committee that this wouldn't be an issue as they planned to broadcast for only two hours between 10-12 once a week. They received the license asked for, authorising the station to broadcast at the wavelength of 322.4m (930 kHz) for the two hours specified. However, following the sale of part of the station WJAZ to the Chicago Herald Examiner controversies arise. WJAZ Started to exceed the time and frequency limits of its license, effectively challenging the authority of the department to assign wavelengths. In January 1926, WJAZ shifted its frequency to 329.5 metres (910 kHz) a frequency then in use by seven stations in Canada. The resulting case *United States Vs. Zenith Radio Corporation* called the secretary's powers of allocation and assignment into question.

shifting the responsibility of regulation from the secretary of commerce to five appointed commissioners. The core elements of the present radio regulation system in the US were formally set in the Radio Act of 1927 and have not changed since (Benkler, 1998). A large portion of the available spectrum was reserved for government use, while other parts of the spectrum were regulated by the Federal Radio Commission (later to become the Federal Communications Commission). The commission, among other things, was required to classify radio stations; prescribe the nature of the service and assign wavelengths; determine the power and location of the transmitters; regulate the kind of apparatuses used; and make regulations to prevent interference (Benkler, 1998, Coase, 1959, p.6). The 1934 Radio Act further consolidated this position and introduced conditions for transferability of the license, the implications of which will be discussed in chapter five.

4.4.3 Corporate Liberalism in the Public Interest

While the Radio Acts are established in an ostensible 'public interest', the regulatory approach would be to alienate public and non-profit broadcasters while conferring increasing advantages to powerful commercial stations. As such, a number of historians of early broadcast media have identified a 'corporate liberal' strategy in these early stages of broadcast regulation (Slotten, 2000; Streeter 1996). This describes a situation where an economic elite performs an ideological opposition between corporate interests and those of the state where in reality there is symbiosis. Much like the relationship between the church and the feudal system, the influence of the state attempts to reconcile free enterprise and strong individualism with a corporate capitalist demand for order, stability and social efficiency. Emphasising first one then the other the state worked to regulate the corporate economy through the agencies of government, through private associations like Chambers of Commerce and trade organisations, and through technocratic agencies (Streeter, 1996, p.35). But perhaps more significantly, in producing a false dichotomy between the interstices of public property and private property, the corporate liberal system obfuscates the proposition of a 'third way' of regulation centred on the commons.

Questions of the public interest are reframed at this time, away from an approach centred on the protection of a natural resource belonging to all humanity that justified the radio act of 1912, towards a reconciliation of the social good with

economic interests (Corbett, 1996). For example, in a crucial address at the start of his term, Hoover maintained:

> The ether is a public medium, and its use is for public benefit. The use of a radio channel is justified only if there is public benefit. The dominant element for consideration in the radio field is, and always will be, the great body of the listening public...whatever other motives may exist for broadcasting, the pleasing of the listeners is always the primary purpose...public good must overbalance private desire (Hoover, 1925).

What this quotation demonstrates is that in the early stages of regulation, public interest is positioned *against* the burgeoning commercial interest broadcasting. However, it gradually becomes aligned with a corporate liberal policy. This is particularly obvious in the development of advertising revenue for public broadcasting. In suggesting that the public good is the primary concern for broadcast regulation, the committee was not attempting to remove the spectrum from commercial control. Rather, the public interest has arguably become a rhetorical strategy in the development of broadcasting as a commercial institution where recourse to the social good rationalises and legitimises the integration of everyday life into the corporate order. Initially the government (through the representation of the secretary of commerce) had relied heavily on the rhetoric of the public interest to justify enclosure (Corbett, 1996; Smythe, 1952). However, from 1922 onwards, this program gave precedence to one-to-many broadcasting techniques over many-to-many wireless telephony that amateurs had cultivated; to commercial broadcasters over educational and religious broadcasters; and to large commercial entities over smaller interests. Gradually stations emerged that were "highly sophisticated in a technical sense; well funded by radio manufacturers, newspapers or department stores with which they were associated; and transmitting on clear channels allocated to them by the department of commerce" (Aitken, 1994, p.696). This was in stark contrast to amateurs, who had been limited to radiotelegraphy in a useless band and forbidden from broadcasting altogether (Benkler, 1998). In effect this produces a strong division between the commercial broadcaster as incumbent and the general public as audience.

4.4.4 Commercial Broadcasting

The development of broadcasting charts not only the progression of new technical systems in radio, but also the harnessing of the new forms of networked sociality cultivated by amateurs in the interests of capital. As such, the development of radio as a commercial broadcasting medium describes a system of accumulation founded on the control of transmissions by corporate liberal interests and the extraction of value through the unremunerated work of the audience. This anticipates the rise of new productive relations closely associated with the general intellect: work that involves attention and response to commercial messages, communication and cooperation. Once the amateurs were alienated from the means of independent transmissions, in other words, these productive capacities can be put to work for capital.

Alongside the global regulation of wireless communications and the introduction of corporate advertising as the primary revenue model for broadcasting, therefore, we can identify a new technical composition of labour centred on public engagement with mass media. This political economy has two broad perspectives. On the one hand the corporate control of mass media content produced a powerful ideological force over the collective consciousness, normalising and habituating these new relations of production and consumption (Adorno & Horkheimer, 2007). On the other, the enclosure of communications was part and parcel of a general alienation of the worker from their capacities for communication and cooperation. Aside from industrial and manual labour, audiences become a new labour force and their labour as attention, taste, opinion and consumption is expropriated by licensed commercial operators and subsequently leased to commercial advertisers (Smythe, 2001).

From the early decades of the twentieth century, advertiser-revenue had become an important business model for the press, and as Douglas (1989) observes, between 1914 and 1919 alone, advertising expenditures in newspapers and magazines doubled. For many publications, profits accrued through advertising began to outpace those accrued from direct sales. It almost goes without saying that this in turn had a significant effect on the content of mass media publications; offending advertisers or criticising corporate America was no longer advisable (p. 251). Shortly after the 1927 Radio Act, commercial radio shifted towards an advertiser-supported model, making station operation the leading business of radio (Benkler, 1998). There

had initially been some discussion about how to fund radio, described by Hoover. RCA director David Sarnoff suggested indirect subsidies from radio equipment manufacturers as a possible form of revenue, while Hoover initially suggested funding radio programming through an indirect tax (Benkler, 1998, *supra* note 58). By the 1920s, however, the use of advertising had become a significant means for radio stations to generate income.

There was a degree of initial resistance to the proliferation of commercial messages over the airwaves, or at least the appearance of a certain reluctance. In his opening address as secretary, Hoover claimed that it was:

> inconceivable that [the regulators] should allow so great a possibility for service, for news, for entertainment, for education and for vital commercial purposes to be drowned in advertising chatter. (Hoover, cited in Streeter, 1996, p.44).

As such, any benefit that was derived by advertisers was to be "incidental and entirely secondary to the interest of the public" (op. cit, p.103). Despite such claims, however, advertising was gradually incorporated into regulatory policy. Following an alliance of public interests with economic gains, advertising was justified because it cultivated a strong commercial system. At Hoover's urging, the 4th radio conference resolved, "the excellence and public-service value of radio programs is increased by the support of those seeking appropriate publicity" (Hoover, 1925). By 1929 the FRC could present advertising as an integral part of the broadcasting model stating that:

> [T]he commission must...recognise that, without advertising, broadcasting would not exist...If a rule against advertising were enforced, the public would be deprived of millions of dollars worth of programs which are being given out entirely by concerns simply from the resultant goodwill which is believed to accrue to the broadcaster or the advertiser by the announcement of his name and business in connection with programs (FRC, 1929).

Throughout the 1930s executives cooperated with advertisers to promote the use of direct advertising. In turn, advertising agencies not only acquired control of policy, but also of program content. By the mid 1930s, virtually all sponsored on-air programming was both developed and produced by advertising agencies (Douglas, 1989). Commercial corporate radio quickly grew to dominate broadcasting, such that by 1937 almost 93 percent of all broadcasting stations in the United States were

controlled by an "oligopoly" of networks (Streeter, 1996, p38). Between 1927 and 1937, networks such as AT&T, GE, RCA and Westinghouse established a pattern of dominance through the nation with local stations functioning as hubs within a vertically integrated system of program production and distribution (Douglas, 1989, Streeter, 1996).

The rise of broadcasting sees the intersection of new forms of enclosure with new systems of accumulation. The possibility of a radio set in every home presented new opportunities for integrating everyday life into commercial control (Streeter, 1996, p. 86). Commercial mass media represented an opportunity to perform ideological work on a burgeoning audience of potential consumers while at the same time putting that same audience to work attending and responding to commercial messages (Smythe, 2001).

Raymond Williams (1985) has observed that it wasn't until the middle of the twentieth century that the term 'consumer'[94] passed from specialised use to more general parlance; its predecessor 'customer' implied a different set of relationships based around a local and ongoing relationship to a supplier. Consumer, on the other hand, suggests a more generalised and 'abstract subjectivity operating within a more abstract market' (p.46); it is at once more obscure and more pervasive. Williams in turn links this transition to the production of large-scale industrial capital markets such as those associated with the Fordist economy. In the early decades of the century, many corporate and government interests aligned themselves with Henry Ford's view that higher wages and shorter working hours for the labour force could potentially create new markets for mass-produced goods purchased in their leisure time. As Hoover argued:

> The very essence of great production is high wages and low prices, because it depends upon a widening range of consumption only to be obtained from the

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[94] Williams charts how the term consumer was used from the fifteenth century onwards where it possessed largely negative connotations as an action 'consumption' or subject 'consumer' that exhausts, wastes or uses up a resource, exemplified by the sickness 'consumption' that wastes the human body. From the 18th century onwards, however, it comes to be employed in relation to a bourgeois political economy. In the emerging organised market, activities such as making and using goods and services were gradually reconceptualised in relation to the dichotomy of production and consumption. In the mid twentieth century, we witness a transfer of the term to general and popular use in line with the decline of the term 'customer'.

> purchasing power of high real wages and increased standards of living. (Hoover cited in Streeter, 1996, p. 43)

In short this is an economy where manufacture is not only tailored to the supply of known and already existing needs (which terms such as customer or user signify) but to the ongoing production, not only of material goods, but needs and desires and commercial ways of satisfying these. Alongside this formula of shorter hours/higher wages, the coordinated advertising of mass-produced consumer goods towards a mass public formed part of this economic strategy.

Other strategies at the time involved the improvement of social services such as healthcare, housing and education, to cultivate new domestic relations centred on the nuclear family, wage-earning husbands and unpaid home-making housewives. And this project is also bound up with early broadcasting, where the new labour of consumption – attention and affective response to advertising - becomes part and parcel of domestic work in the home. These messages infiltrate the domestic space through the medium of commercial radio. This is just one situation where we can trace the initial breakdown of divisions between productive and reproductive labour discussed in chapter two (Hardt and Negri, 2009). While it operates within a broader societal structure, broadcast media is nonetheless central to this project. As well as providing a medium for commercial messages and advertising, radio also ideologically affirmed the new capitalist order. As Ewen (1976) argues, while reducing the economic trauma of capitalist overproduction by increasing and regulating consumption, advertising was also seen as an advocate for a new way of life, educating the public in new habits of thought and action associated with domesticity, consumer spending and corollary apolitical visions of the self.

4.4.5 Summary

The situation described in this section sketches the beginnings of the audience commodification described by Dallas Smythe in chapter three (2001), where rent is extracted through the enclosure of the broadcast audience. We can therefore understand this as an antecedent of the forms of accumulation operating in network media today.

Section 4.5: Conclusion

This chapter analyses the foundations of the enclosure of electromagnetic spectrum. This is the enclosure of wireless communications that are in turn re-provisioned to users/workers/audiences in ways that are productive to capital. Specifically this chapter described how competing commons-based and proprietary understandings of radio were gradually enclosed in a system that puts audiences to work in commercial radio broadcasting.

Enclosure is two things, both the development of an informational milieu and the organisation of workers within it. The main contribution of this chapter explored how in order for spectrum to be enclosed, first it had to be produced as a tangible resource thought to be in want of regulation. Where spectrum is a relational artefact between communicating individuals/devices, it had to be made to appear as a tangible resource subject to scarcity and necessitating enclosure. This chapter traces the methods, at turns discursive, material and juridical, that produced the electromagnetic spectrum as such a rival good.

Where these processes produced legally enforced boundaries within the frequency continuum, the second stage of enclosure involves the separation of everyday users from these electromagnetic frequencies, which is to say, from the means of wireless transmission and communication, reducing them instead to a captive audience carefully insinuated within an ethereal reserve. This was detailed alongside the corporate liberal development of a commercial broadcasting model that extracted income from the commodification of radio audiences' cognitive, affective and attentive work.

Following on the discussion of rent in chapter three, it should be clear that this enclosure forms the techno-material basis for the extraction of rent. However in the 1920s and 1930s its operation is still quite limited, both because it operates on a singular facet of cognition and does not support forms of feedback, and as we will see in the next chapter, because the operation of rent is still limited by state intervention and an attendant economic policy that limits rent-seeking activity.

The next chapter looks at the operation of rent in the present day. This is not only to fully explore the operation of rent in electromagnetic spectrum, it is also to identify and analyse the antagonisms that come to the fore in the operation of rent, where the

forms of enclosure and artificial scarcity necessary for the operation of rent, and detailed in this chapter, coalesce and compete with the necessary fluidity required for social production in the digital commons.

Chapter Five: Antagonisms in the Political Economy of Spectrum

Section 5.1: Introduction

Following on chapter four's analysis of the foundations of enclosure, this chapter looks at the contemporary accumulation of surplus from wireless networks, demonstrating that this corresponds to the value theory of rent identified in chapter three. This chapter has two points of focus: the first analyses the operation of rent over spectrum; the second identifies antagonisms emerging between, on the one hand, the necessary enclosures structuring this system of accumulation, and on the other, the economic resocialisation necessary to social production.

As discussed in chapter four, this thesis identifies three stages in the development of cognitive capitalism. The first stage was detailed in chapter four, involving the enclosure of wireless communications and the tentative beginnings of a system of accumulation centred on the broadcast audience. This was theorised as a foundation that produces the conditions necessary for the extraction of rent. The second stage, detailed in this chapter, analyses the operations of these enclosures in a contemporary economy. While the regulatory underpinnings are roughly the same in both stages, we observe a vast escalation of spectrum-based technologies and wireless networks from the 1930s to the present day. So too, this develops alongside an economic intensification of value extraction from the centralised audience commodity identified by political economist Dallas Smythe in the 1950s, towards the accumulation of ubiquitous production and consumption within totalising mobile networks (Manzerolle, 2010; Smythe, 2001). This stage corresponds to an advanced capitalist society in which information, knowledge and cultural work are now hegemonic, where "producing increasingly means constructing cooperation and communicative commonalities" (Hardt and Negri, 2000, p.302).

In this second stage in particular, we can identify overlapping, fragile and sometimes-conflictive alliances operating between the proprietary enclosure of network media and the necessary autonomy required for cognitive and cooperative forms of production. This second stage appears to rest on potentially contradictory alliances between a strong consolidation of oligopoly networks operating in tandem with a re-composition of productive relations requiring fluid access to information

and communications. As such, in many ways it appears as though this is an unstable period in which either the productivity of the commons reveals itself to be excessive to the constraints of a neoliberal economy, or in which the mechanisms of enclosure reconfigure to adapt to and manage the necessary openness required for social production through digitally networked media. These conflicts are arguably leading to a third stage in the development of cognitive capitalism, the outcomes and particulars of which are still unclear. Where this chapter describes the conditions and antagonisms that produce this third stage, chapter six will try to speak to and explore its possible trajectory.

In order to explore the antagonisms between the enclosures of spectrum and the new forms of value capture and accumulation, it is necessary to gradually move forward in time and technical complexity from the early history of broadcast towards the conditions structuring the present day wireless economy. Where we finished in chapter four, the operations of a market in spectrum were still heavily regulated by state interventions designed to limit rent-seeking activity. Throughout the 20th century, however, we encounter a significant increase in market activity in spectrum. This manifests as an intensification of property rights in the spectrum; a conflation of the public interest with the economic interest; and a gradual deregulation of spectrum away from exclusively command and control towards license assignment through shadow markets and spectrum auctions (Corbett, 1996). This progresses and advances alongside a strong material intensification of spectrum-based networks. Instead of state-controlled broadcasting networks operating in an ostensible 'public interest', we now have a proliferation of different network topologies and business models, including radio and television broadcast, cellular communications, and more recently, the mobile Internet, wireless sensor networks, and machine-to-machine communications. This also means that the work of the audience is similarly intensified, to include not just reception and response to commercial messages but active production: incorporating all spaces, all kinds of data and all qualities of action and interaction (Manzerolle, 2010).

To understand the dynamics of rent accumulation in spectrum it is necessary to bring these two elements - market intensification and technical intensification - together. On the one hand this requires a more detailed exploration of the various rights and property relations associated with spectrum than the previous chapter afforded. It

also requires a more rigorous examination of the operation of rent over spectrum than chapter three's description of mobile networks allowed for, identifying a number of different streams where possession of a license to spectrum allows for the extraction of value external to production. This overview of the current dynamics of rent accumulation in spectrum is provided in section 5.2.

However, more and more we see that the organisation and extent of production in mobile networks produces a corresponding demand for bandwidth. This produces antagonisms, where the consolidation of spectrum as exclusive and alienable property is in conflict with the access to communicative resources necessary for social production. In spectrum this has led to what is sometimes termed a 'spectrum crunch', where mobile network operators are now unable to provide adequate bandwidth for their services in the current proprietary consolidation (Chen, 2012b; Goldman, 2012). Section 5.3 explores this antagonism, with a particular focus on the relations between regulatory enclosure, rent and the production of artificial scarcity in spectrum.

There has been wide ranging controversy surrounding the scarcity of spectrum in recent years, where growing predictions of a severe deficit in available spectrum intersect with criticisms concerning the inefficient management of this resource. Spectrum, many argue, rather than being a naturally scarce resource, has been managed into scarcity by rent-seeking activities that frame episodic restrictions as permanent barriers[95] (Benjamin, 2002, 2003; Benkler, 1998, 2001; Weiser & Hatfield, 2007). As such, many different factions now call for a reorganisation of spectrum away from exclusive licensing towards more spectrum efficient sharing techniques[96] (Forge et al., 2012; PCAST, 2012; Thanki, 2012).

Section 5.4 steps back and analyses the implications of this specific controversy with reference to broader theorisations of the antagonisms at play in cognitive capitalism. How do the forms of contention we can now identify in spectrum regulation compare

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[95] See: Baran, 2009; Benjamin, 2002, 2003; Benkler, 1998, 2001; Chrisholm, 2013; Faulhaber & Farber, 2003; Freyens, 2009; Lehr & Crowcroft, 2005; Weiser & Hatfield, 2007; Werbach, 2003, 2011.

[96] See: Ballon & Delaere, 2009; Baran, 1995; Benkler, 2004, 2012; Buck, 2002; Cave, 2012; Chen, 2012a; Cochrane, 2006; Doyle, 2011; Forde, et al., 2011; Forge et al., 2012; Lehr & Crowcroft, 2005; Noam, 1997, 1998; PCAST, 2012; Sandvig, 2006; Thnaki, 2012; Weinberger, 2013; Werbach, 2003, 2004, 2011

and contrast with non-empirical accounts of a crisis in cognitive capitalism by theorists of social and biopolitical production? What do they suggest in terms of the future development of rent and/or possibilities for a communality of network resources?

Section 5.2: The Operation of Rent in Wireless Networks

5.2.1 Introduction

So far this thesis has identified and explored three necessary conditions in cognitive capitalism: a re-composition of labour around social production through information and communication technologies; a system of value accumulation based around surplus produced through this form of online work; and the necessary foundations of enclosure through which this value is extracted. Here it is necessary to rehearse the operation of these in contemporary wireless networks and spectrum-based technologies. This is a) to provide a better understanding of the operation of rent in spectrum so that b) in the future we might begin to theorise possible forms of resistance to this process.

We begin by looking at the expansion of markets in spectrum from the period following broadcast regulation in the 1930s through to the legitimisation of spectrum auctions and tradable rights in the neoliberal economy. Following the enclosures performed by the 1927 and 1934 Radio Acts (4.4), the operation of markets in spectrum was still constrained by state regulation and a Keynesian economic policy designed to limit rent-seeking activity (Keynes, 1936)[97]. However, deregulation in the 1980s and the introduction of spectrum auctions facilitated the expansion of

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[97] Keynes called for the euthanasia of the rentier, understood not simply as a property owner, but as one who lives on the interest income (rent) received in compensation for the loan of property held in the form of money. Today the term designates the owner of any debt obligation, public or private that returns periodic amounts of interest over a long term. Here Ricardo's 19th century position that the interests of the landlord were inimical to the requirements of industrial expansion was replaced by a Twentieth Century Keynesian critique of the position of the rentier as a fetter on capitalist production (Ricardo, 1971; Keynes, 1936). Keynes' theory focused on the advantages that rentiers would find in holding liquid assets rather than in financing employment-creating investment in periods where they felt threatened by uncertainty over the future value of their income and capital. Investment would have to compete with the rentier's preference for liquidity, creating rates of interest far in excess of what entrepreneurs could pay from the expected earnings of productive investment. Further, rentier preferences might be so strong as to render the monetary authority powerless to reduce interest rates to stimulate activity. Keynes thus advocated a policy of direct intervention through the socialisation of investment, accompanied by low stable rates of interest that would eventually eliminate the power of rentiers to hinder policies for full employment (1936).

markets in electromagnetic spectrum. So too, the development of new forms of wireless networks in cellular communications and the mobile Internet advanced alongside deregulation, transforming the political economy of the network (Hazlett & Leo, 2010; p.5).

Here we briefly analyse the different ownership models, rights and privileges currently associated with spectrum licenses and assess their role in the extraction of surplus value from these converged wireless networks. The previous chapter detailed the emergence of audience commodification as the primary locus of value for broadcast networks (Smythe, 2001). Today, with the juridical and techno-material intensification of spectrum-dependent networks, this system is much more total and immersive, producing a variety of different spaces and strategies for the extraction of rent. The different channels for rent accumulation are detailed in this section. This analyses how spectrum is currently monetised in advanced capitalist societies, identifying rent as the primary operator in the extraction of surplus value.

5.2.2 But Not the Ownership Thereof: Deregulation and Market Expansion

As discussed in chapter four, the Radio Acts of 1927 and 1934 solidified a 'Command and Control' (CAC) regulatory system in electromagnetic spectrum. An appointed commission conferred a license to spectrum by administrative fiat (Benkler, 1998; Cave, 2012)[98]. Applications were reviewed by the regulatory authority, and, in the case of competing interests, allocations were informed by comparative hearings (sometimes known as beauty contests), or in later decades, through a lottery system (Corbett, 1996; Benkler, 1998). This arrangement remained in place from 1927 through to the early eighties, when the neoliberal shift towards market deregulation impacted spectrum licensing (Hazlett & Leo, 2011). While these licenses conferred a temporary right to exclusive use of a frequency channel, this did not constitute a state of absolute possession of the resource (Corbett, 1996). Instead, the 1927 act declared the radio spectrum to be the property of the state[99] and

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[98] Until 1981, comparative hearings were the only assignment tool used. At that point, faced with the task of allocating licenses to cellular telephony, the commission prevailed upon congress to allow lotteries to be used in the place of comparative hearings (Hazlett, 1998a).

[99] There are four different types of property: open access property that is non-excludable and available free of charge to all of humanity (i.e. air); private property that is the exclusive possession of an individual or group of legal owners such as a private residence; public property or state property that is in principal the possession of all citizens but regulated in their interests by a central authority, such as a nature reserve; and common property, owned and managed by a collective.

classified licensed broadcasters as 'trustees' as opposed to economic beneficiaries of this public good, dedicated to acting "in the public convenience, interest and necessity" (Radio Act of 1927, cited in Smythe, 1952, p.105).

The 1927 Radio Act specifically included a non-ownership waiver, which explicitly conferred to the licensee "the use of such channels [...] but not the *ownership* thereof" (Radio Act of 1927, ch. 169, 44 Stat. 1162, my emphasis). Furthermore, the clause emphasised the temporary nature of the license, stating, "[n]o such license shall be construed to create any right, beyond the conditions and periods of the license." Finally the non-ownership waiver specified certain constraints over transfer, declaring that licenses to broadcast "shall not be transferred....to any person, firm, company, or corporation without the consent in writing of the licensing authority" (ibid).

The senate also included a draft of what became known as the 'bare-bones theory'. Popular in the twenties, thirties and forties, this approach attempted to address the ambiguities between the operations of the state and the market in broadcasting (Warner, 1941). In effect, 'bare-bones' tried to preserve the public character of the resource by aligning value with the tangible 'resource' and away from the ephemeral license. Regulators were eager to produce an obvious distinction between private property and broadcast licenses. The guiding principle was that if licenses did not constitute property rights but were conferred as a privilege in recognition of a public commitment, then broadcasters in receipt of such licenses should not profit from their transfer. Following the tenet that a network's transferrable value should reside in tangible assets such as real estate and technological infrastructure, the Senate prohibited license transfers:

> If the consideration be greater than the reasonable value of the apparatus for which said license had been issued, and said exchange value shall in no case exceed the original cost of the apparatus. (FCC, 1988, p.6504)

'Bare-bones' appears to have been an attempt by the state to maintain spectrum as an economic tangible and reduce its value as an intangible asset.[100] As it became

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[100] As one American Civil Liberties Union (ACLU) representative argued in the Senate: "Secretary Hoover's signature in New York City sells for $150,000 to $200,000, and the applications are now being picked up as for sale...you should prevent the sale above the cost of the equipment or the cost of the plant." (Warner, 1941, p.586)

increasingly clear that stations were still exchanged in excess of their tangible assets, the commission attempted to describe these intangible assets in terms of perceived future earning capacity, established reputations and network affiliations; anything, basically, but the possession of a license to broadcast information to a national audience (Streeter, 1996, p.238). Bare-bones, therefore, can be understood as a concerted effort to limit rent-seeking activity in spectrum, where economic policies of the time understood such activity to be a parasitic fetter on the good productive instincts of capitalism. As such the state intervened to limit the extent of speculative activities and the exercise of patrimonial property by licensed incumbents.

Shadow Markets In Spectrum

Clearly licenses were not to be construed as a juridical property right; they conferred the right to use, economically benefit from and exclude the activity of others in a particular frequency band but not to unmitigated transfer (Coase, 1959). Secondly, possession was temporary; existing licenses and investments were not to confer a future claim on spectrum, potentially limiting the economic value of a license (Corbett, 1996; Streeter, 1996). Despite the mandates of the non-ownership waiver, however, the majority of historical commentators accede that, in spite of gestures to the contrary, exclusive channel allocations came to comprise a de facto property right for incumbents and oblique transfers between corporations a 'shadow' market in these same rights (Coase, 1959, p.27). The market value of broadcasting stations rose significantly following formal regulation in the 1920s; existing title to spectrum was generally understood to embody a future claim[101] (Corbett, 1996, p.645); and transfers were common at prices far in excess of the tangible resources associated with a broadcast station (Streeter 1996, p. 230[102]). The overwhelming majority of transfer applications were approved at this time, and for prices far in excess of tangible assets (Coase, 1959; de Sola Pool, 1984). Furthermore, the majority of broadcasters achieved their licenses, not through formal allocation by the Federal

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[101] According to a number of historians, State regulation appears to have provided an informal guarantee that licenses would be renewed beyond the initial license period of three years and would not be revoked (Corbett, 1996).

[102] As Streeter (p. 230) argued, "[t]here is no doubt that the policy of using licenses to create and protect transferable stations has had the effect of establishing the broadcast spectrum as its own kind of real estate."

Radio Commission, but through purchase in a secondary market (Aitken, 1994; Coase, 1959; De Sola Pool, 1984; Streeter, 1996)[103]. In 1959, economist Coase observed "the extraordinary gain accruing to radio and television operators as a result of the present system of allocation frequencies becomes apparent when stations are sold" (1959, p.23). While strictly all that might be economically apportioned was the station and its organisation, when transfers took place it was evident that a significant percentage of the purchase price represented payment for exclusive use of a frequency band (Aitken, 1994, p.713).

We can deduce that anti-ownership legislation such as the proposed 1927 waiver and the bare-bones theory do not indicate an anti-commercial sentiment on the part of the regulatory authority, so much as the need to maintain some measure of state control over the medium and associated market activity through regulatory intervention[104]. In other words, they should not be mistaken with any genuine desire on the part of the state to uphold the communality of spectrum so much as the establishment of a regulatory quid pro quo between regulators and incumbents, where broadcasters exchanged a degree of state intervention in the market for efficient barriers to competitive entry (Benjamin, 2002, pp. 49-50; Hazlett, 1998, p.541).

Arguments for the Establishment of Property Rights in Spectrum

From the mid twentieth century onwards, a number of economists have repeatedly argued that juridical property rights should be established in spectrum, effectively replacing the command and control model with a market[105] (Coase, 1959; Hazlett, 1998a, 1998b; Herzel, 1951; Kwerel & Williams, 1993). This began in the 1950s

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[103] Aitken argues that occasionally when a station is sold it is possible to glimpse this shadow market in licenses at play. While strictly all that may be economically apportioned is the station and its organisation while the frequency remains private property and the grant of license confers to lasting rights to it as such, when transfers take place there is no doubt that a significant percentage of the purchase price is payment for exclusive use of a frequency band. Similarly, Pool has summarised:

> In fact...there is a market in spectrum... the government initially gives away licenses for free; these are then sold in a second hand market. What is excluded from market allocation is only the initial grant of a frequency by the government to its first owner. Today as in the 1920s, the regulatory authority must approve license renewals and license transfers, and this introduced some small uncertainty into the transaction. But in the overwhelming majority of cases, renewals and transfers are routine (De Sola Pool, 1984, p.139).

[104] A number of theorists have argued that the 1927 Act was established to suppress a system of private property rights developing naturally in spectrum[104] (Coase, 1959; Hazlett, 1998a).

[105] Coase, 1959; Herzel, 1951; De Vany, 1998; Faulhaber & Farber, 2003; Hatfield & Weiser, 2005; Hazlett, 1998a, 1998b; Hazlett & Leo, 2011; Kwerel & Williams, 1993; Rand, 1964; Weiser & Hatfield, 2007.

with economists Leo Herzel (1951) and then Ronald Coase (1959) arguing for the establishment of auction-based property rights, progressing to ongoing campaigns for the introduction of liberal spectrum assignments and auctions by theorists such as Kwerel (1985, 1993) Hazlett (1998a, 1998b, 2008) and Hatfield & Weiser (2005, 2007). The introduction of a market system proposes that, instead of allocation through a state-defined regulatory body, spectrum should be bought or sold like any other commodity, with governments issuing property rights that corporations might trade, combine or otherwise modify. Auctions would be used to assign and efficiently distribute these rights (Coase, 1959).

Spectrum property rights theoretically produce freely tradable rights, created in courts under tort law and resembling those applied to land (De Vany, 1998; Werbach, 2003). Spectrum is zoned like real estate across a plane of access bisecting the physical geography of space and the artificial geography of electromagnetic frequency[106]. It follows that incumbents would be conferred rights similar to those involved in the ownership of land: the right to control the use of a property, to exclude use/trespass by others and to exercise free discretion in acquisition and transfer (Corbett, 1996). In turn the law underpins these rights: spectrum owners could sue anyone who interfered in their territory, produce injunctions and collect damages, or, in some cases, prosecute for trespass (De Vany, 1998; Hatfield & Weiser, 2005).

In 1951, a law student at the University of Chicago, while commenting on the allocation of VHF frequencies for colour TV argued that auctioning frequencies to the highest bidders would be more efficient than the established methods of allocation through command and control. Herzel wrote:

> [t]he most important function of radio regulation is the allocation of a scarce resource of production – frequency channels. The FCC has to determine who will get the limited number of channels available at any one time. This is essentially an economic decision, not a policing decision (1951, p.809).

This proposal to lease frequencies to the highest bidder was supported by another economist Coase in his article 'the Federal Communications Commission' (1959). Drawing on the 'chaos of the airwaves' theory, described in the advent of

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[106] For a detailed discussion of the implementation and jurisdiction of property rights in spectrum see De Vany et al. 1999 and Doyle and Forde, 2007.

government regulation of broadcast (section 4.4), Coase would be among the first of many economists to cast this period of confusion as a consequence of the absence of a firm market or pricing system for spectrum. Coase goes on to present an argument for an efficient market-based system, allocating the use of a band to the highest bidder and leaving the subdivision of the use of frequencies to secondary market transactions. For Coase, such a system foregoes the necessity of government regulation beyond the establishment of a legal system to define property rights and arbitrate disputes where necessary.

Herzel and Coase argued that the market improved on government allocation for a number of reasons, but these largely converge around the informational role of market dynamics of supply and demand to effectively manage resource scarcity. As Coase would argue, "[s]ince it is generally agreed that the use of private property and the pricing system is in the public interest in other fields, why should it not also be in broadcasting?" (p.40). A government was thought to lack the precise monetary measure of benefit and cost provided by the market. A regulatory body could not be in possession of all the relevant information pertaining to the commercial application of radio, consumer demand and possible modes of production. Here, the lack of existing property rights was thought to constrain possibilities for rapid transfer and technological innovation, and lead to dangerous trends such as political lobbying and state censorship of media. The 'invisible hand' of the market, conversely, was framed as a neutral arbitrator.

Taking up this argument, economic as opposed to regulatory decisions, many economists argued, would help to direct communications to where they delivered the highest social gains (Coase, 1959; Hazlett & Leo, 2011)[107]. The neoliberal argument at play claims that market-based solutions are inherently more socially valuable, equating public interest with economic gain. Economists even argued that open-access spaces could be adequately provisioned within a market regime, in much the same way public parks may be provisioned within the context of proprietary

[107] "Exclusive ownership rights help direct spectrum inputs to where they deliver the highest social gains, making exclusive property rules relatively *more* socially valuable." (Hazlett and Leo, 2010, p.1037).

development (Hazlett & Leo, 2010)[108]. Unlicensed bands of spectrum for general authorised access figured as a highly regulated public-access sphere operating within a broader economic geography of constraint.

Deregulation & the Telecommunications Act of 1996

Ultimately the shift to such a market-based approach was a subspecies of deregulation and these approaches gained a new currency alongside the rise of neoliberal policies in the US and UK. In the late 1970s and early 1980s, the notion of property rights in spectrum, after stagnating for several decades, took on a new legitimacy, emerging as a major force in policy. Regulatory bodies relaxed restrictions on market trading, making the secondary transfer of licenses easier while also strengthening broadcasters' proprietary claim in spectrum (Corbett, 1996). As Reed Hundt, FCC chair from 1993-1997 boasted, "[w]e totally deregulated wireless" (1999, p.98). The introduction of lottery systems was the first applied step towards deregulation, and in 1981, Congress gave the Commission authority to award licenses by random selection (Corbett, 1996, Faulhaber & Farber, 2003). Thus lotteries had the effect of making licenses less like government sanctioned privileges and much more like resources that could be freely traded in a market (Corbett, 1996 p.636).

Deregulation, with its goals of increased competition and decision-making based on market criteria, forced recognition of broadcaster's roles as marketplace competitors, as well as public trustees. Market-based allocation via auctions was suggested in 1985 and adopted in 1993[109] (Benkler, 2002, p.27). Auctions began in July 1994 and quickly registered over $20 billion in receivables for the U.S. Treasury (Hazlett, 1998). Since their introduction, auctions have played an increasing role in spectrum policy in both the US and Europe and recently achieved significant revenue through the sale of prime spectrum 'real estate' for next-generation mobile networks (Thomas, 2012).

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[108] "Indeed" Hazlett and Leo argue, "exclusive frequency rights are so broadly accommodating that they efficiently supply "spectrum commons," just as public parks are most productively provided within the context of private ownership of real estate." (Hazlett and Leo, 2010, p.1038).

[109] This 1993 experiment with auctions became mandatory policy in 1997. There were a number of limitations placed on the auctions. First, only subscription-based service licenses, such as wireless data transfer, mobile telephony and satellite services, were to be auctioned, omitting broadcast services such as radio and television. A second restriction was that they should only apply to new assignments and not to license renewals (Hazlett, 1998).

The formal introduction of auctions was part of a second wave of deregulatory reforms that occurred in the 1990s, when the Clinton administration declared that the private sector should lead in building what was called the 'National Information Infrastructure'. The legislation billed itself as a major policy shift away from regulation in favour of market competition (Benkler 2001, p. 15). This directive reached its peak in the Telecommunications Act of 1996, a series of policy shifts concerning physical infrastructure that emphasised the private provision of communications infrastructure through markets (Benkler, 2001, Sakolsky & Dunifer, 1998)[110].

It is worth identifying that deregulation and market expansion also followed closely on the introduction of new forms of spectrum-based networks. The commercial introduction of cell phones nicely coincided with the rise of neoliberal policies (Goggin, 2011, p.13) and the deregulation of telecommunications licenses. This is a topological shift, expanding the one-to-many networks of broadcast towards a centralised topology that permits one-to-one communications through mobile telephony. Mobile networks also initially adopted a subscription-based revenue plan as opposed to the advertiser-based revenue model that dominated radio and television and would once more become significant alongside mobile user-generated content and the mobile Internet. To an extent this approach formally nullifies the concept of the licensee as a trustee of the public good, recasting the relationship between incumbents and users as a commercial contract between service providers and subscribers/customers (Hazlett, 1998; Tideman, 1991).

As such, following on the introduction of auctions, the 1996 Telecommunications Act helped to further solidify property rights in the spectrum, shifting the role of the incumbent from public trustee to market competitor. Section 201 presents the mobile incumbent as a holder of a property right that can be exchanged with the FCC in a market-like transaction (FCC, 1996). It also significantly expands the incumbent's current license terms, appearing, in one commentator's opinion to offer "an unprecedented longevity for broadcasters' current rights to use the airwaves and to transform [what was] a temporary and conditional broadcast license into one of

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[110] As McChesney (1998) described it: "the overarching purpose of the 1996 Telecommunications Act is to deregulate all communication industries and to permit the market, not public policy, to determine the course of...the communications system."

virtually permanent duration" (Corbett, 1996, p.611). The Act also relaxed its public interest mandate, no longer requiring broadcasters to operate in the public interest and no longer formally approving format changes (section 204). According to a number of accounts, the Act solidified control of networks with a few economic elites, leading to significant merger activity and increased concentration (Sakolsky & Dunifer, 1998). Furthermore, it was a law that had global consequences, permitting US transnational media and communications to grow through merger and acquisition with little risk of regulatory intervention (op cit p.24).

5.2.3 Property Rights in Spectrum

If spectrum was increasingly consolidated as a kind of property, what kinds of rights were associated with the possession of spectrum? Such an enquiry is necessary in order to a) understand how value is extracted from the enclosure of spectrum and b) analyse potential antagonisms that inhere in spectrum enclosure when we explore this in section 5.3. Although aspects of property, law and enclosures have been discussed in chapters three and four of this thesis, to undertake this analysis it is necessary to segue briefly into a more detailed investigation of the nature of property rights than we have had the opportunity to perform so far.

Property rights define a relationship between individuals with respect to goods, resources and services (Demsetz, 1967). These rights enforce possession or title, allowing an owner to exercise choices over the good in question. Property is often so naturalised that it obscures not only other possible social and material relations towards resources, but also the complex bundling together of different facets of possession, enclosure, use and exclusion that are constituted through the property relation as it is embedded in the law (Hatfield & Weiser, 2005, p.44). We can therefore recognise property as a whole bundle of rights and not a singular privilege. Harold Demsetz described property as a social contract between individuals that is upheld by juridical apparatuses for the enforcement of that right; for the production of actions for trespass and infringement of that right; and for the production of injunctions to prevent these from occurring (1967). These rights produce two levels of provision: The first concerns all delimitation of use, rights to income and enjoyment of fruits and alienability of assets. The second level consists of the conditions for the definition, execution and enforcement of regulations concerning those rights (Moulier Boutang, 2012, p.99).

Typically property rights today include:

- Control of use
- The right to any benefit
- The right to transfer and to sell the property
- The right to speculate and leverage value from
- The right to exclude others

But don't usually include:

- Uses that interfere with the property rights of other private parties
- Uses that unreasonably interfere with public property rights such as public health, safety, peace and convenience (Callies, 2000).

Moulier Boutang argues that the conflation of different rights into a singular property relation is socially constructed; in other periods of history property rights admit some of these benefits but not others (2012, p.115). As such the consolidation of property rights listed above is heavily associated with the formulation of bourgeois private property. This mutability of property rights at different moments in history will be significant when we discuss transformations that are occurring in spectrum rights in chapter six.

Furthermore, as discussed in section 2.2, the rights associated with intangible and tangible property are different. To briefly revise this distinction, tangible property is by nature:

- Rival: its value depletes through use or over time; the consumption by one individual prevents consumption by another; or the marginal production costs exceed zero i.e. it costs more to supply the good to each subsequent individual
- Divisible: it can be broken into smaller increments easily and therefore can match commodity values
- Excludable: it is straightforward enough to control access, enforce exclusion and the costs of this do not exceed the social good of the property itself.

In a price system, tangible goods are typically 'sold' or, if the contract is temporary, 'leased' or 'rented'. Generally speaking, ownership of a tangible asset allows for full control of property rights.

Intangible goods are typically:

- Non-rival or imperfectly rival: they do not decrease with use, they allow for multiple simultaneous uses and they may be freely reproducible, having zero marginal reproduction costs
- Indivisible: the essence of their value resides in some aspect that exceeds material segmentation
- Non-excludable: it is difficult to exclude others from their use (Benkler, 2006).

This makes intangibles much more difficult to corral as property and as a result the property rights associated rely on heavily legislative frameworks to enforce rights. If you permanently transfer an intangible you typically 'assign rights' as opposed to selling that property and to temporality confer the rights you license those. When rights or licenses have been assigned the licensor may impose restrictions over what the licensee can and cannot do with licensed material (Bocti & Casuccio, 2005).

Spectrum as License & Property Right

If property is indeed a bundle of rights, what kinds of rights are specifically associated with the possession of spectrum? And do these rights refer to a tangible or intangible form of property? As previously discussed (chapter four), these questions are not straightforward. The electromagnetic spectrum has a spectral relationship to property; it is at once tangible and intangible. As a form of property it functions neither like property in land (material property) nor property in the intellectual or creative content of a commodity (immaterial property), and yet retains some of the characteristics of both. As also discussed in chapter four, it therefore requires a concerted and tension-ridden effort to corral spectrum as something resembling tangible property. In many ways the intangible continuum of radio frequencies resists this qualification. Again, such an enquiry is significant to an analysis of the operation and antagonisms of a rent theory of value as it applies to mobile networks.

IMF papers on the treatment of mobile phone licenses in national accounts concludes that today there are *two* assets involved with spectrum licenses: *the spectrum* itself, owned by the state and classified as a tangible non-produced asset, and the *license* to that spectrum which is sold or leased to the incumbent as an intangible asset (Dippelsman & Maehle 2003, p.6; SNA, 2008). In its current configuration,

electromagnetic frequencies, which occur in nature and are therefore non-produced, are corralled in the material, technical and juridical ways described in section 4.3 in order to produce spectrum as a tangible asset. In essence, this underlying tangible asset is then partitioned and the economic dimensions of particular zones rented or sold[111] as an intangible asset[112] to commercial incumbents, understood in international accounting standards to be a "*construct of society*" (SNA 1993, p.373, my emphasis)[113].

In this case the persistence of the tangible asset represents ongoing access to a non-produced condition, means or element of production: the available electromagnetic frequencies, while the intangible asset relates to the value of what can be produced through the use of spectrum, or spectrum-based technologies. The relationship between these two is significant. Where the tangible resource is rarefied and consolidated in exclusive ownership, the intangible is provisioned to customers and users in the form of network services. The persistence of a tangible right allows an owner (state or commercial incumbent) to continue to exercise a degree of choice or

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[111] Depending on the nature of the contract between state and incumbent, the acquisition of a license is characterised as purchase or rent (Dippelsman & Maehle, 2003, p.11). Rights to transfer are key in this distinction, as are economic responsibilities.

[112] The spectrum has a potentially infinite life as a tangible asset, but its economic value as an intangible is always contingent at any time on its potential future use. (Dippelsman & Maehle, 2003, p.7).

[113] The 1993 System of National Accounts (SNA) defines a tangible non-produced asset as those "that occur in nature and over which ownership rights have been established" (1993 SNA 13.53). The category of tangible non-produced asset was changed to simply "natural resources" in the 2008 SNA (2008 SNA, xlviii). The spectrum resource, irrespective of licenses or future economic potential, is classified as such when the IMF argues that the physical and measurable aspects of the spectrum indicate that it should be regarded as a tangible asset analogous to "land and subsoil assets" (Dippelsman & Maehle, 2003, p.4 supra note 3). Despite the murky physicality of spectrum, the primary argument against understanding radio frequency as an intangible is that it is not a construct of society. The treatment of the sale of *licenses* in the electromagnetic spectrum, on the other hand, *has* been classified as an intangible asset (Dippelsman & Maehle, 2003), understood in accounting standards to be a '*construct of society*' (SNA 1993, 13.53, p.373). As discussed in chapter two, intangible assets emerge from the expropriation of the cultural commons, the 'informational and cultural content of the commodity' (Lazzarato, 1996) that is socially produced. The accounting treatment of assets previously called "intangible produced assets" and now labeled, more descriptively, "intellectual property products" has been clarified and expanded in the 2008 SNA. Many of these assets, often seen as a hallmark of the 'new economy', are associated with the establishment of property rights over knowledge in one form or another. These assets are further split into research and development; mineral exploration and evaluation; computer software and databases; entertainment, literary or artistic originals; and other intellectual property products. They consist of patents, leases and other transferable contracts and purchased goodwill. Such assets are evidenced by legal and accounting actions, "such as the granting of a patent or the conveyance of some economic benefit to a third party. Some entitle their owners to engage in certain specific activities and to exclude other institutional units from doing so" (SNA 1993, p.368).

control over spectrum, such as who to confer certain privileges to, or in the case of auctions, to extract direct revenue from the sale of licenses. The intangible asset on the other hand, allows an incumbent to build, scale and control network resources and provide infrastructure, services and platforms in order to extract value. Users are given access to these network services but not to the proprietary spectrum.[114]

In an arrangement that is common in the political economy of networks, the persistence of a tangible substrate helps to exercise a degree of economic control over a spatiotemporal topology that operates beyond the powers of direct command (Terranova, 2009). This appears to be an organisational form that captures value from social production without having to directly intervene in its organisation. These operations should become gradually clearer as we look more closely at the dynamics of rent accumulation in spectrum.

5.2.4 Spectrum and Rent

Now that we have explored the different property rights associated with spectrum we can investigate how these might be leveraged to accumulate income. Throughout the twentieth century, a number of theorists working across economics, law and policy have recognised that legal title to use, hold or transfer licenses to spectrum has facilitated the extraction of rent (Bazelon, 2011; Manzerolle, 2010; Metalitz, 2001; Smythe, 1981, 1987; Streeter, 1996). We have touched on this when rent and mobile networks were discussed in section 3.3, but here the concept will be refined and discussed in greater detail.

To briefly recapitulate the different forms of accumulation described in section 3.2, profit is understood to be the internal character of capital with respect to production. In profit, therefore, capitalists purchase labour power (pay wages) and the means of production (raw material etc) in order to produce commodities that are sold in the market with the expectation of producing a profit that is partly reinvested in the production process. As such, profit it thought to play a positive role with respect to production, operating against scarcity and investing in the ongoing development of productive forces (Hardt, 2010; Marazzi, 2010; Pasquinelli, 2008; Vercellone, 2008,

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[114] Excepting examples of unlicensed spectrum, which will be discussed in greater detail in chapter six.

2010). Profit therefore implies a strong organisational role on the part of capital with respect to production.

In a rentier economy, in contrast, capitalists enclose previously common resources and control access to these. As such, rent is described as the surplus that is extracted through the ownership of a resource that confers the privilege to extract value from a position external to production. In turn, where profit is thought to operate against scarcity, the production of artificial forms of scarcity is a core tenet of rent, extracting surplus not through a direct command over labour but through command over markets and the manipulation of conditions relating to supply and demand (Marazzi, 2010; Vercellone, 2010).

Theorists now argue that alongside transformations to the relations of production in a Post-Fordist economy, rent acquires a new hegemony with respect to accumulation (Vercellone, 2008, 2010). While there are a number of controversies circulating around this theoretical framework (Ahn, 2012; Caffentzis, 2013; Fuchs, 2009), arguably a rent theory of value is more appropriate to describe the extraction of surplus value from the enclosure of electromagnetic spectrum than a framework that looks to profit and a labour theory of value. So too, the income accruing from spectrum is generally classified as rent by accounting standards (Dippelsman & Maehle, 2003). This rent accrues to the institutions, corporations and shareholders who have succeeded in enclosing the commons as an asset. It is collected by governments in the form of licensing fees and auction prices when channels are assigned, and by network providers as advertising revenue, service charges, or speculative returns. Here, a theory of rent allows us to analyse how surplus value is extracted from the enclosure of electromagnetic spectrum.

As such there are a variety of contemporary strata and strategies through which rent can be extracted in spectrum. Harvey's categorisations of monopoly rent are helpful here in distinguishing between these (2001). In keeping with other theorists of rent, Harvey identifies that rent arises because social actors can realise an enhanced income stream, over an extended period of time, by virtue of their exclusive control over some directly or indirectly tradable item. Harvey identifies both direct and indirect forms of rent accruing from the exclusive control of a scarce resource (p.94). As discussed in 3.3, direct forms of rent trade expressly on access to an element of production, such as when spectrum is leased to network operators. These operators

pay a licensing fee to roll out core infrastructure and services in the network. This form of rent arises when social actors control some resource, which, in relation to a certain activity, enables them to extract rents from those desiring to use it (p.94). In this case the value is considered to be a non-produced and unearned 'windfall', with a differential value contingent on technological/capital investment in the asset (Harvey, 1976, p.268).

It should be clear that, in the political economy of spectrum, this corresponds to the lease established between the regulatory body and an incumbent. Indirect rents, in contrast, result when actors trade, not on the resource itself, but on the commodities and services that may be produced or expropriated through its use, such as from advertising revenues or from speculation on future uses. In this case, the value is socially 'produced' because it is the outcome of a 'social contract' (Dippelsman & Maehle, p.5; SNA, 2003, p.373). This kind of rent corresponds to intangible assets leveraged by incumbents who have inserted themselves in a strategic position in the communications network through the enclosure of wireless communications.

These two rents display different degrees of exploitation of the commons. Which type acquires significance is a consequence of the relations of production operating within particular capitalist epochs (Harvey, 1982). If direct forms of rent are premised on the historically singular enclosure of a naturally produced common resource, indirect forms of rent appear to leverage this point of enclosure to obliquely access and expropriate value from commons-based production. Historically, such as in the development of land, enclosure involved alienation from the means of subsistence in order to extract labour power in return for a wage. This corresponds to profit. In the current configuration over spectrum, it involves an enclosure of the means of communication and cooperation to extract income from a position autonomous to production. Where labour's access to these capacities is crucial for capitalist development, these are once more 'put-out' to users, but in a configuration that now facilitates the extraction of social production in the form of attention, circulation, the production of information and so on. Harvey uses this framework elsewhere to describe how proximity to knowledge or cultural activities can be distilled through material channels in the forms of rents over urban real estate (2001). Similar conditions can be observed in spectrum.

In the early decades of radio policy, the state intervened heavily in regulation and constraints operated to limit the exercise of the market and maintain the license to spectrum as a pure element of production, a condition designed to limit rent-seeking activity and increase profit (Streeter, 1996; Warner, 1941). In recent decades, however, following the deregulation of wireless, the withdrawal of public welfare, and the re-composition of labour around digitally networked media, rent now proliferates unchecked. The relations of production developed around industrial production encountered crises and in an attempt to forcedly keep the prominence of exchange value in place and guarantee profits, capital is led to develop a rentier-logic based on the enclosure of the commons and the rarefaction of supply (Marazzi, 2010, p.34; Vercellone, 2010, p.95). Today the figure of rentier and the parasitical character of capital become associated with productive capital itself. Direct command over the production process is replaced with marketplace command, and this operates through the construction of a monopoly position that imposes itself as an intermediary between labour and the market. This is not just rent over the means or conditions of network production, but rent extracted from mobile labour in a fashion similar to the 'putting-out system' (Vercellone, 2007, p.15); access to tools and capacities are provisioned by capital to the general public, but control remains consolidated with commercial networks.

Let us look more closely at how licenses facilitate the extraction of different forms of rent. Possession of a license, including the rights to use, benefit from, hold or transfer the asset, now represents "the true currency of wireless operators" (Seybold, 2012). Accounting statistics surrounding the transfer and auction of licenses and the share value of mobile operators, media broadcasters, and Internet service providers indicate that a license to spectrum can represent as much as 80% of a company's total net worth (Dippelsman & Maehle, 2003). This value is currently amortised over a period of ten to forty years and in accordance with a calculation known as megahertz-pop (MHz-pop), representing the population in a license area multiplied by bandwidth (Bazelon, 2011; ITU, 2012)[115]. In other words, this license is thought

[115] This is calculated as follows: Price per MHzPop Multiple = Sales Price / (MHz of license x population covered) Example: PCS License is 15.0 MHz, Covers 1 million pops; Sales price is $11.4 million; Price per MHzPop = $11,400,000 / (1,000,000 x 15.0) Price per MHzPop = $0.76

to be more valuable than an operator's stations or tangible core infrastructure, and more valuable than the collective value of their paid labour force and technical support. It is a value not accurately described by either constant or variable capital. Instead, the value of the spectrum license reflects the operator's access to the communicative and cooperative capacities of a population of audiences and mobile prosumers in a particular geographic license area such as a city or a state. The represented value of this unpaid labour in turn inflates the auction value of the spectrum license itself, but also augments the value of advertising revenues that can be extracted through a license to spectrum.

Speculative Rent

One way rent can be extracted is by withholding a resource from current use and speculating on its future value (Harvey, 2001). This is rent that accrues through speculative activities, simply by possessing an unused asset and allowing value to accrue as rent on the property rights. As Batt describes it:

> [l]and rent [describing the enclosure of assets that are non-produced] is the most attractive tax base of all, as rent is not earned; it is windfall income, entirely the result of being well situated in any market of scarce natural resources and where community demand (rather than one's own efforts) leads to an appreciation of that land's price. To be sure many people have learned to position themselves in situations where a land's market value is likely to rise — indeed these people come to think of themselves as astute investors. But the fact is that that market gain is not of their own doing at all; it is the result of common enterprise creating a surplus that comes to settle on land sites. An investment in land, in any form it might take, is speculation in greater or lesser degree (2005).

The same applies here for spectrum licenses, which, as chapter four demonstrated, are treated 'more or less like real estate' (Streeter, 1996, p.230). Recently speculation has been rife concerning the value of TV White Spaces and Future Next Generation Network auctions for mobile services (PRnewswire, 2013; TVNewscheck, 2013).[116]

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[116] In 2011, in anticipation of FCC incentive auctions, spectrum speculators purchased 39 TV stations, paying nearly $345 million. The spectators are reportedly buying television stations with a view to re-auctioning the spectrum to the FCC, who in turn will auction it to wireless broadband carriers. The speculators "are no doubt counting on strong demand from wireless buyers and a valuation premium versus what they invested in the stations" SNL Kagan said (TVnewscheck, 2012). These activities have met with a certain amount of public resentment, making clear the extent of financial speculation on what is purportedly a public resource.

Property rights over future forms of revenue are bought and traded in these auctions. The money paid for a frequency license is an interest-bearing investment; it comprises a title (in the form of an intangible asset) to the future fruits of labour (Harvey, 1982, p.21). In this instance there is an intimate relationship between rent and interest, as spectrum becomes "a form of fictitious capital, in principle no different from stocks and shares, government bonds etc" (ibid). In this case, spectrum is more valuable when it is simply held by an incumbent and not used to provide a service (Hazlett & Michaels, 2003)[117].

What is striking in this instance is not just the oblique productivity enacted through the financialisation of electromagnetic spectrum. We have to look further to exactly what future value is embodied in speculative economic rents. As mentioned, the value of a license to spectrum is amortized over a future period of ten – forty years (ITU, 2012). The market value therefore reflects the rent that can be extracted, not only from the present, but from future uses and applications i.e. through estimates such as "the global Wi-Fi market will be worth $93.23 billion by 2018" (PRNewswire, 2013). The amortisation of future value in spectrum demonstrates how, through the introduction of a market system over a previously common asset, incumbents trade in the allocation of not only current, but also the *future* claim to the products of digital labour. In performing this operation they produce a long-standing debt over future social production, and in so doing, condemn labour to ever-increasing levels of exploitation. Here, value in rent is a subjective expression of future profits based on a spatiotemporal enclosure of labour power. The ownership of spectrum produces a creditor-debtor relation between the user and the owner of spectrum. And this proceeds not just through the rent from direct property, but through a dependent subjectivity in which the rationality of human capital replaces a belief in social rights and common goods (Lazzarato, 2012).

Cognitive Rent

Most significantly the ownership of spectrum represents a title to extract rent from social production in digitally mobile environments. As described in chapter four, the enclosure of the broadcast spectrum laid the foundations for the commodification of

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[117] Hazlett is particularly vocal about the negative effects of rent-seeking in spectrum: for an example see Hazlett & Michaels, 2003.

media audiences. Here, the audience performs the work of consuming and responding to commercial messages, marketing goods to themselves and to their social networks (Smythe, 2001). In a one-to-many topology, TV and radio signals infiltrated domestic, recreational and workspaces with commercial messages. The many-to-many topologies afforded by mobile communications and the mobile internet intensify this process, allowing for not only a rent applied over audience attention, but for two other processes detailed in chapter three: 1. The extraction of information *back* from everyday sites, which in turn can be fed back into the system through market research and targeted advertisements and 2. The monetisation of links and communications circulating between networked individuals (Pasquinelli, 2009; Walker, 2002). This form of rent was described in some detail in chapter three, but we will briefly revise it here.

Previously, a title to spectrum allowed a station to market an audience to advertisers. Today we encounter a significant intensification of this process. As mobile communications became more complex, incorporating voice and text but also forms of rich media content, this model adapted to incorporate aspects of user-generated content into the value chain. Early innovations involve audience commodification through SMS-based advertisements and ringtone services, but this system of accumulation does not really come into its own until social production in web 2.0 migrates to mobile contexts. With mobile convergence (Nillson et al., 2011), we have a conflation of mobile telephony with Internet protocol packet-switched networks, as mobile communications expands from voice to rich media and eventually geolocative dynamic content (Goggin, 2012). In contrast to the traditional mass media audience, users in the mobile web 2.0 era "are also content producers; through user-generated content, the users engage in permanent creative activity, communication, community building and content production" (Fuchs, 2010b, p.298).

So too, they perform these activities in everyday spaces (Kluitenberg, 2006). The expansion of these sites of extraction progress and advance alongside the multiplication of spectrum-based radio devices including cellular phones, mobile Internet devices, machine-to-machine communications, smart-grids, NFC technologies, the Internet of Things, and wireless sensor networks of all kinds (Thanki, 2012). We are no longer talking about targeting discrete sites or spaces outside of traditional waged labour, but expropriating the entire individual:

psychographic, geographic, demographic, social and even biometric data are made open to extraction (Manzerolle, 2010). As a result, advertising revenue becomes significant once more, with location-based services accounting for a significant percentage of revenue on mobile devices (The Economist, 2008, 2010b, 2011a). Leading mobile advertising companies such as Google's AdMob and Apple's iAd leverage the ability to monetise data traffic to and from personal devices (Spreeuwenberg & Poell, 2012). And as well as gathering information from multiple spaces, commercial messages are now provisioned for individuals and spaces in the form of targeted advertising and location-based services (The Economist, 2011a). This market is only growing as mobile payments and micro-billing systems take precedence (Bauwens et al.. 2012, p.49). Location based services are estimated to bring in $10 billion in revenue by 2016, according to research from strategy analytics. The biggest portion of this (just over 50%) is estimated to come from location based advertising (Kim, 2011).

From this discussion coupled with the detailed description of digital rent in chapter three, it should be clear that licenses or property rights to spectrum allow for the extraction of surplus value from mobile labour. This value corresponds to rent and not to profit because it operates through the creation of a strategic position with respect to social production in mobile networks rather than through a direct intervention in the production of information and cultural content. This value is extracted in a number of ways. For one, the social value of communication networks raises the market value of the electromagnetic spectrum, making trading, speculating and withholding supply profitable. This value accrues as rent on the spectrum license itself. Most significant however, because a license to spectrum represents an extended period of access to a population of users in a specific geographic area operating on a particular band of frequencies (MHz-pop), licenses produce rent through unremunerated labour extracted as advertising revenue, market research and mobile commerce.

5.2.5 Conclusion

It should be clear that licenses to spectrum allow for a variety of different channels for the extraction of rent: the lease of communicative and cooperative capacities back to users; the advertising revenue that can be extracted from the commodification of audiences and the expropriation of social production; and the tradable market value

of spectrum 'real estate' (Streeter, 1996) leveraged by the future productivity of mobile labour. However, as this system progresses and advances we can also see that there are potential antagonisms between a neoliberal strategy that extracts value from social production and a necessary project of economic resocialisation that cultivates the commons.

In spectrum this is represented as an antagonisms between artificial scarcity and the bandwidth required for such an intensive degree of mobile labour. This is producing an exponential demand for spectrum that is exerting significant pressure on the existing consolidation of mobile bandwidth. The next section will look at antagonisms emerging between the proprietary consolidation of spectrum as it operates beside the necessary conditions for social production.

Section 5.3: Antagonisms in Spectrum Infrastructure

5.3.1 Introduction

Moving from the historical and theoretical underpinnings of cognitive capitalism through to a specific exploration of the operation of forms of rent in contemporary spectrum-based networks, we have identified a system of value accumulation that rests on the expropriation of social production and reproduction. This at once brings the digital commons to the fore of capital, while also bringing new systems of enclosure to bear on that commons. Arguably this is not a smooth form of accumulation; instead we can identify sometimes complementary, but just as often competing operations at play in the operation of rent over the digital commons. The remainder of this chapter explores specific points of resistance between the conditions necessary for value extraction and those necessary for value production in spectrum-based networks. These realities are subsequently related to broader political theses on irreconcilable elements in cognitive capitalism.

In its most reductive form what we appear to encounter are various antagonisms between 'enclosure' (and all this term implies: exclusive property rights, alienation and rarification of resources), and disclosure (and all this term implies: open access, standards and innovation models, and a proliferation of communications). In the political economy of spectrum-based networks, this antagonism manifests itself in a number of ways:

Due to the myriad business models at play in mobile communications today, there are emergent conflicts between competing models of ownership and control of network resources. For example, the traditional circuit-switched mobile cellular networks with a legacy in telephony typically employ a classic 'walled garden' approach, with closed access; centralised control; vertically integrated resources; and a strong proprietary consolidation of infrastructure (Goggin, 2012). This is in sharp contrast to the open access models typically associated with the packet switched Internet, premised upon open standards, decentralised regulation and fluidity of resources (Baran, 1995, Werbach, 2003).

In some ways these competing approaches can be explained by the different value chains traditionally associated with them. For a business model focused on subscription-based services, pay-per-use or infrastructure-as-a-service, a closed arrangement or 'walled-garden' approach makes the best commercial sense. However, where rent is concentrated on the commodification of user-generated content produced through the resource, access above all other things becomes a priority. In the latter we encounter an inversion of the standard industrial economic narrative, where *openness* as opposed to *enclosure* is the true locus of accumulation.

There is a convergence of telephony and networked communications in mobile today. As the activities associated with the Internet migrate from the desktop to geolocative contexts, the technological script (Akrich, 1992) of mobile communications comes to more closely resemble the Internet than telephony. Rich media content, mobile applications and context aware social media now characterise the vast majority of activity on mobile networks. This sea change exerts significant pressure on traditional telecommunications providers to evolve a modular and open access framework. As telecommunications economist Jan Dawson (2011) explains, traditional telecommunications providers can no longer afford to provision mobile network infrastructure through a pay-per-use model alone because of a law of diminishing returns; instead it is necessary that they adopt a business model that not only supports social production through mobile networks, but also leverages the value of user-generated content to expand their revenue. This in turn requires evolving new approaches to the consolidation and provision of proprietary network resources.

This produces a variety of changes to ownership of the network, but in spectrum this manifests as a conflict between approaches that continue to consolidate spectrum in exclusive frequency allocations and those that petition for a much more fluid and ad hoc approach to the provision of this resource[118]. Put another way, we can say this manifests as an antagonism betweens approaches based on a rarification of supply and consolidation of property necessary for the extraction of rent, and the necessary proliferation of network connections and points of communication required to maintain a flourishing digital economy.

In the case of spectrum, an antagonism in rent concerns techniques that manufacture scarcity and prohibit access at precisely the moment when excess capacity is needed to support proliferating mobile communications. The telecommunications industry and associated regulatory authorities now identify an imminent 'spectrum crunch' where current demand exceeds the capacities of the resource in its current arrangement (Chen, 2012b; Goldman, 2012; Gompa, 2013). Mobile data traffic is now doubling every six months, as individuals use smart phones, tablets and laptops to browse, to communicate to access rich media content and to download applications wirelessly (Forge et al., 2012). According to the Organisation for Economic Cooperation and Development (OECD), the number of devices connected to mobile networks worldwide is around 5 billion today and could rise to 50 billion by 2020 (PCAST, 2012). Such astonishing growth in mobile media requires an equivalent expansion of network resources. This presents as not only a desire for bandwidth, but also a greater fluidity of resources in response to rapid fluctuations in the network architecture. The consolidation of exclusive and permanent licensing appears to be anathema to these requirements.

5.3.2 Spectrum and Artificial Scarcity

As such it seems that conditions necessary for the extraction of rent are in opposition to those necessary for the progression of cognitive capitalism. Rent is linked to the rarification of the good in question. According to Vercellone (2010), resources on which rentier appropriation is based today do not tend to increase with rent; indeed they do exactly the opposite. Rent is thus linked to the artificial or actual scarcity of a

[118] This is not the same thing as a conflict between property and the commons as both liberal spectrum licenses and unlicensed spectrum propose ways of trading and consolidating spectrum in highly fluid and transient ways.

resource, and to a logic of rarefaction, as in the case of monopolies (Vercellone, 2010, p.95). It leverages monopolistic or oligopolistic forms of property, and positions of political power that facilitate the manufacture of scarcity. Beyond the enclosure of the commons, therefore, the survival of exchange value is contingent on the destruction of non-renewable scarce resources and/or the creation of artificial scarcity where these goods are by nature non-rival, inclusive and reproducible. Scarcity in the 'intangible commons of the mind' (Boyle, 2003, p.37) is induced by a variety of juridical artefacts such as intellectual property or digital rights management in the case of digital content, and through the discursive and juridical practices outlined in the enclosure of spectrum (chapter four).

As discussed in chapter four, it follows that spectrum had to be scarce in order to bring it within a market and to justify 'economic decisions' (Herzel, 1951) concerning its provision. To do so involves proceeding from the position that there is not enough bandwidth readily available to satisfy common access[119]. This tenet allows commercial incumbents to justify enclosure of spectrum. It also allows those most powerful incumbents to consolidate their control in network infrastructure, preventing other potential competitors from inserting themselves in that commercial space. These conditions were adequately rehearsed in chapter four. Of course, enclosure by the state or the market and scarcity are connected; first because concerns surrounding the finite nature of common resources are compelling justifications for regulation and second because the types of 'exclusive' control of access associated with the property rights of one social actor assume the separation or exclusion of others from that same resource. Enclosure and scarcity, therefore, go hand in hand; there is no chronology as such. The extraction of rent is dynamic and these elements, which are separated for clarity in this thesis, are in reality entangled, imbricated and mutually enforcing.

Economics is defined as 'the study of choice under scarcity" (Boal, 2005) and thus by that definition concerns those goods that exist in quantities insufficient to satisfy the social need for them. If a good is available in abundance it is classified as non-

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[119] "The spectrum has been called a 'limited' natural resource because...there is only a finite portion available for beneficial uses at any one time. The word scarce is appropriate."

economic and thought to be better provisioned through contracts that fall outside of the market. As Coase explains:

> It is commonplace of all economics that almost all resources used in the economic system (and not simply radio and television frequencies) are limited in amount and scarce, in that people would like to use more than exists. Land, labour and capital are all scarce... (1959, p.14).

In the official history, the airwaves require regulation 'in the public interest' because electromagnetic frequencies are a naturally scarce resource (Herter, 1985, p.651). Beginning perhaps with the Malthusian thesis on overpopulation and resource management, scarcity emerges as a totalising discourse in the management of natural non-produced resources (Davis, 1955). This is a discourse in which experts define a 'problem', science and technology are invoked to provide solutions and governments and markets institutionalise fixes. If we begin with Malthusian economics and proceed to theorists such as Hardin (1968), often invoked in arguments for proprietary regulation of previously common resources, we can trace a rhetorical equation between, on the one hand, the physical reality of limitations and on the other, the issue of scarcity as it operates in political economy. But an acknowledgement of limitations or finitude and a totalising discourse of scarcity are quite different things. As Luks argues, limits might well exist, but the socially and politically relevant question is their conceptualisation as 'scarce' (Luks, 2010, p.93). Similarly, Luhmann identifies scarcity as the "social perception of restrictions...that can lead to social relations" (1944, p. 177 cited in Luks, 2010, p.95). Scarcity equates finitude with the necessity of social restrictions and economic choices. We can acknowledge that natural resources are limited and may be utilised in different ways, but when we speak of 'scarcity' we do not speak of an objective condition, but refer to something that is socially constructed. This line of thinking is particularly evident in economic discourses surrounding spectrum, where a scarcity discourse was used to rationalise the introduction of public and later market regulation.

5.3.3 The Spectrum Crunch

There has been wide ranging controversy surrounding the scarcity of spectrum in recent years, where growing predictions of a severe deficit in available spectrum intersect with criticisms concerning the inefficient management of this resource. Spectrum, many argue, rather than being a naturally scarce resource, has been

'managed into scarcity' by rent-seeking activities that frame episodic restrictions as permanent barriers[120] (Werbach, 2003, 2004, 2011).

Scarcity is an elusive concept when applied to spectrum. On the one hand, there are ultimate limits to bandwidth, described by the laws of physics: below a certain frequency communication is performed through infrared or visible light. And within these physical limits are those that are defined by the capabilities of radio technology at a given moment in history to process and individuate competing signals. However, the previous use of an electromagnetic frequency as a communications channel does not impact the fidelity of future transmissions, only those operating concurrently. This ambivalent condition means that while spectrum is a perfectly renewable resource (Benkler, 2004) and cannot be understood as scarce or degradable in any permanent sense, its capacity at any given moment in time also allows it to be managed and framed as a rival good. As such, the current spectrum deficit can be attributed, not to any endemic scarcity of the radio waves themselves, but to an economic landscape that privileges exclusive usage rights over shared and unlicensed allocations. "We don't have a spectrum crunch so much as a spectrum policy crunch" argues David Tennenhouse, Microsoft's vice president of technology policy, "the so-called 'spectrum crunch' really reflects artificial spectrum scarcity" (Talbot, 2012, p.2).

Technological capacities are a significant factor in the availability of spectrum. In this sense, the definition of a useful channel is always dependent on the threshold constrains of available knowledge, technology and legislation. "Fixed allocations cannot keep up with innovation, and no one can reliably predict in which directions and along what paths technology will evolve" (Chrisholm, 2013, p.2). Due to the available technology and expertise when wireless communications were first implemented, for example, the possibility for managing multiple transmissions and competing signals was fairly limited, and early techniques favoured exclusive access (Marcus, 2004). When Marconi conducted the first radio transmission in 1895, the energy from his spark gap transmission employed the entire usable radio spectrum. In 1901, his first radio transmission covered an area of more than 100 million square

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[120] See: Ballon & Delaere, 2009; Baran, 2009; Benjamin, 2002, 2003; Benkler, 1998, 2001; Chrisholm, 2013; Faulhaber & Farber, 2003; Freyens, 2009; Lehr & Crowcroft, 2005; Weiser & Hatfield, 2007; Werbach, 2003, 2004, 2011.

miles and yet only transmitted one bit of information every six seconds (Aitken, 1976). However, following Cooper's law,[121] wireless capacity is thought to have increased one trillion times since 1901 (Marcus, 2004). The development of a variety of non-exclusive techniques in subsequent years from spread spectrum,[122] to new forms of digital signal processing and modulation, directional antennas,[123] and various forms of cognitive and software defined radio,[124] reconfigures the geography of enablement and constraint. These techniques will be explored in detail in chapter six. For now suffice to say though frequency specific receivers produce a rival, excludable and scarce resource, other radio techniques permit a variety of cooperative negotiations between devices transmitting in the same frequency band. These pose a significant challenge to an economic construct that treats spectrum as a rival good. While some of these techniques are already implemented in the small available unlicensed domains such as the 2.4 GHz band, political lobbying by powerful incumbents, and legacy regulations from state bodies, mean they are still prohibited in licensed spectrum (Benkler, 2012). Current policy continues to give precedence to a signal processing technique that supports exclusive ownership, prohibiting the exercise of dynamic spectrum access techniques that contest exclusive use and 'manage spectrum into abundance' (Doyle, 2011; Forde et al.. 2012).

Regulatory constraint on dynamic spectrum access are the most significant, but not the only cause of scarcity. If scarcity is produced by adherence to frequency specific licensing, it is further consolidated through the scale of these exclusive assignments. As described in chapter four, current allocation divides spectrum into large blocks (bands and channels), which are assigned on a regional or nationwide basis. 'Guard bands' – empty margins around active frequency domains designed to prevent

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[121] According to Martin Cooper, the quantity of available spectrum has grown at the same pace since Marconi's first radio transmissions in 1895. The number of theoretically possible communications has doubled every 30 months. This fact has been dubbed 'Cooper's Law'.

[122] Spread Spectrum describes techniques in which a signal generated in a particular bandwidth is deliberately spread across the frequency domain, resulting in a wider bandwidth.

[123] A directional antenna radiates greater power in one or more directions, allowing for greater performance and reduced interference from unwanted signals.

[124] A cognitive radio is an intelligent device that can dynamically adapt a range of operating parameters such as frequency of operation, power, modulation scheme, antenna beam pattern, battery usage and so on. These adaptations may occur either in specific predefined ways or through pattern recognition and computer-based learning from real world situations.

possible interference between proximate operators - in turn flank these frequency channels (Faulhaber & Farber, 2003). This practice not only cedes control to economically powerful actors who can afford to invest in this scale of infrastructure, the geographic extent of current allocation techniques, coupled with highly conservative margins of unutilised bandwidth, is apt to produce an excess capacity that is left to accrete as rent on the resource (Benkler, 2004).[125]

Finally, scarcity is also performed through informational databases. An examination of the static frequency allocation charts of any first world country appears to show electromagnetic spectrum to be heavily occupied (Fig. 4.1. FCC, 2012b). Such charts, however, do not take into account ongoing utilisation, only existing allocations and assignments. Secondly, in more dynamic geo-location databases that do consider ongoing utilisation, highly conservative wave propagation models often determine what constitutes 'activity' or occupation. These may return a result of occupation in favour of the incumbent, when in reality this often fails to be the case (Marcus, 2010).[126]

Scarcity in all of these instances results from the rarification of a resource and the rent-seeking architecture of an economy that seeks returns for the owners of network infrastructure, and not, as is sometimes presumed, from the tangible constraints of

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[125] Benkler has described the relationship between granularity and shareable resources (2004). Granularity is a concept that is used to describe the scale and depth at which a resource is normally provisioned. Large-grained goods are those typically provisioned in increments that constrain individual access. Small-grained goods – such as a personal computer in the first world – are provisioned on a scale that enables individual access. For Benkler, the granularity of spectrum contributes to scarcity because the smallest increment size not only constrains bottom-up access, it also almost guarantees excess capacity in most contexts.

[126] Recently, certain national regulatory bodies are looking to make use of geolocation databases to enable access to 'TV White Spaces'. These are frequency blocks of spectrum that have come available in the global switch from analogue to digital television. Where analogue television required more spectrum for transmission and produced greater interference, digital broadcasting is more spectrum efficient, freeing up spectrum in the highly desirable 700MHz range. Recent legislations include a number of protocols for access to this spectrum, such as listen-before-talk combined with a dynamic reference to geolocation with database lookup, where a transmitting device refers to a database to determine whether a frequency is currently in use at a particular geographic location. The current databases, however, make use of a wave propagation model, as opposed to a dynamic measurement approach, to determine whether spectrum is 'available'. This model calculates whether certain frequencies are available in a specific location by measuring their strength relative to the distance from the radio. The model currently employed, according to Marcus (2010), does not take adequate account of signal attenuation, returning a result of occupation when in reality this often fails to be the case. The data model, he argues, is engineered to be highly conservative and prohibit access to unlicensed users in favour of the licensed incumbent.

the airwaves themselves. A significant number of studies comparing static tables of spectrum allocation with real-time activity return a very different conclusion. Where reference to the FCC frequency allocation chart demonstrates high levels of scarcity and full utilisation, for example, current spectrum utilisation through dynamic sensing and measurement is estimated by myriad studies to be at best 17% in urban areas and 5% elsewhere (Figs 5.1 and 5.2) (Ballon and Delaere, 2009; Forge et al.., 2012).

As such a number of critics across law, policy and economics are now calling for a fundamental reorganisation of spectrum regulation away from exclusive licensing towards more efficient methods that incorporate sharing and dynamic spectrum access (Benkler, 2012; PCAST, 2012, Thanki, 2012; Werbach, 2011)[127]. While these will be explored in detail in chapter six, it goes without saying that such a radical re-composition will have significant implications for a political economy of wireless communications, threatening the material consolidation of powerful incumbents while producing new advantages for other actors.

5.3.4 Summary

This section explored how spectrum is consolidated in forms of artificial scarcity that are antagonistic to the necessary proliferation of bandwidth for a burgeoning mobile economy. As a consequence of forms of regulation that encourage artificial scarcity, the growing demand for mobile bandwidth to support a range of network services is due to exceed the available spectrum in its current regulatory consolidation. As such there are wide-ranging discussions in regulatory policy about the future validity of exclusive licensing in spectrum, with many factions now advocating the development of shared, unlicensed or commons spectrum in favour of the existing allocations. Where the enclosure of spectrum can be identified as a basic tenet in the extraction of rent from mobile users, a crisis of exclusive rights to spectrum appears to present itself as a possible 'exploit' (Galloway and Thacker, 2007), highlighting potential antagonisms in the operation of rent that might lead to a disaccumulation of capital.

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[127] For more see: Ballon & Delaere, 2009; Baran, 1995; Benkler, 2004, 2012; Buck, 2002; Cave, 2012; Chen, 2012a; Cochrane, 2006; Doyle, 2011; Forde, et al., 2011; Forge et al., 2012; Lehr & Crowcroft, 2005; Noam, 1997, 1998; PCAST, 2012; Sandvig, 2006; Thnaki, 2012; Weinberger, 2013; Werbach, 2003, 2004, 2011.

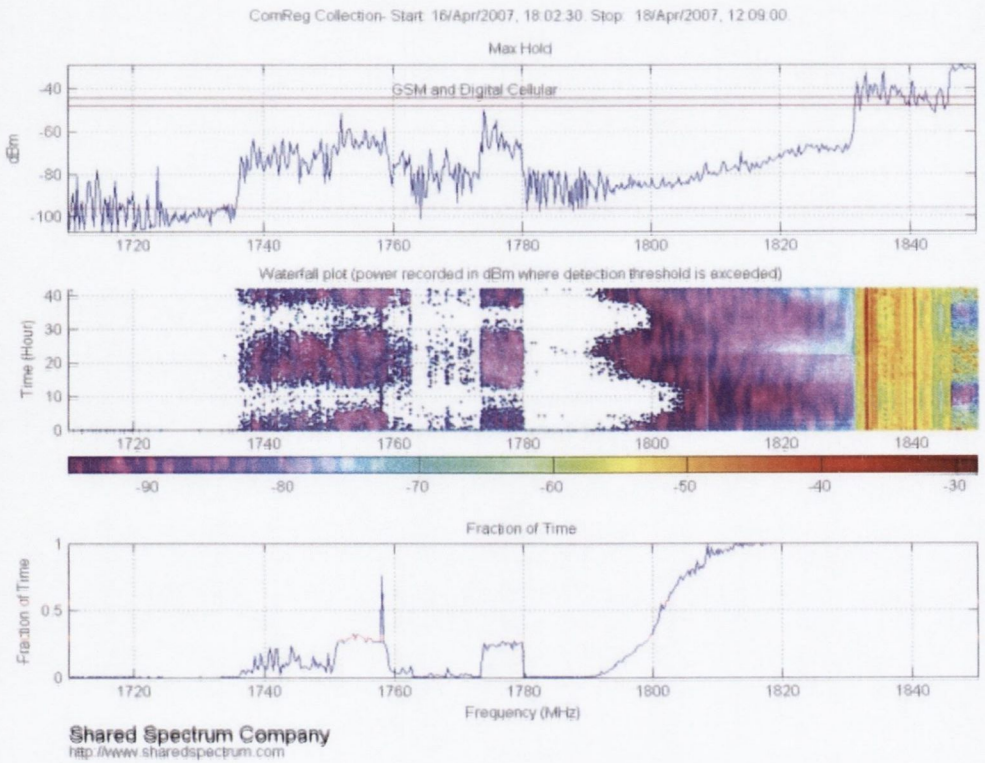
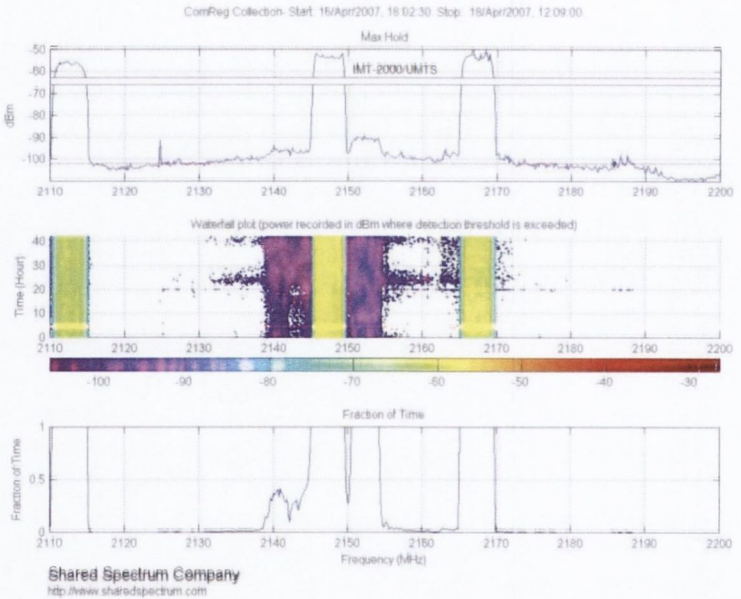


Fig 5.1 Shared Spectrum tests of spectrum utilisation in Dublin City Centre 18-04-2007 Source: [http://www.sharedspectrum.com].



5.2: Shared Spectrum tests of spectrum utilisation in Dublin City Centre 18-04-2007 Source: [http://www.sharedspectrum.com][128]

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[128] These images are measurements taken by a company called Shared Spectrum on behalf of the Centre for Telecommunications Research (CTVR), Trinity College Dublin in 2007. They show spectrum occupancy in GSM, Digital Cellular and UMTS bands between the 16th and the 18th April 2007. 40 hours of measurements are shown. Activity in the spectrum can be most clearly seen in the centre waterfall plot where white regions illustrate inactivity. Large portions of the spectrum dedicated to cellular activity are currently unused. Such measurements are site specific; however, similar plots exist for the USA and UK that were also performed by Shared Spectrum. The measurements shown are indicative of the kind of pictures Shared Spectrum found in many different locations across the USA and other places in which they conducted measurements.

Section 5.4: Antagonisms In the Dynamics of Rent Accumulation

5.4.1 Introduction

"All is not well with capital – and the traditional treatments are unable to cure its maladies" (Hardt and Negri, 2009, p. 296).

The tensions we have just explored in spectrum support the theses that there are conflictive tendencies in the political economy of mobile networks: in the relations between the products of capitalist accumulation; the composition of mobile labour; and the property relations under which that labour produces. Broadly speaking, this is a clash between the neoliberal strategy of rentier expropriation of the common and the necessary project of economic re-socialisation that cultivates the commons. These conflicts are often presented in economic and popular literature as a contradiction between the productive nature of the 'good' capitalist, as a generator of new forms of wealth, and the parasitic character of the rentier who accumulates without producing, and whose wealth, in turn, is contingent on conditions of destruction and artificial scarcity (Vercellone, 2010). However, in our analysis we want to avoid making crude distinctions between the real and the financial economy, or simply arguing that profit is productive while rent is destructive. A critique that positions profit and rent in complete opposition to each other fails to apprehend the nature of the tensions at work in the new system of accumulation[129].

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[129] As an example of this approach, various crises in Internet production and real estate market conventions in the past decade are sometimes described in relation to a crisis of capitalist accumulation, emerging as a consequence of speculative activity that proceeds unchecked. According to popular analysis, the meaning of this crisis lies in a conflict between, "on the one side, a tendency of financial capitalism towards rent, and on the other, the good productive defence of an accumulation logic that favours the production of growth and employment" (Vercellone, 2010, p.86). Here rent is understood to be orthogonal to the classic line of profit.

But as our discussion of the dynamics of rent has illustrated, the present situation is more nuanced. Firstly, such straightforward economic analyses of the return of the category of rent often neglect the broader transformations that give rise to the becoming-rent of profit, many of which have been explored throughout this thesis; for example, the technical re-composition of labour, the complexity of financial instruments and services, and the technical sophistication of mechanisms for value capture. Similarly, popular perspectives on the antagonisms of rent omit the importance of those influences and conditions that brought about a crisis of Fordist systems of production and led towards the speculative tendencies of contemporary capitalist production.

Secondly, in the Keynesian fashion, most critics continue to understand rent as external to the movement of capital and opposed to the category of profit. Likewise, financialisation is often treated as a separate system apart from a 'real' or 'material' economy, where evidently this has ceased to be

These conflictive tendencies can be identified in crises of capitalist accumulation over ICT networks. This conflict includes internal contradictions within the commercial sector between industrial telecommunications networks and the fluid business models proposed for next generation networks. It also includes tensions between forms of necessary enclosure and the relations of social production required for the valorisation of mobile networks. To better understand these conditions as they operate in mobile networks, these conflicts will be discussed alongside theoretical literature on conflict and antagonism in cognitive capitalism and the operation of rent.

5.4.2 Antagonisms in Social Production

Post-operaismo theorists understand these new systems of accumulation as destabilising to capital. This perspective is grounded in the labouring subject and theorised not as a powerful opposition, so much as the cultivation of forms of systemic production that are excessive to accumulation that may in turn produce antagonisms with social forces captured within the mechanisms of enclosure. Here the antagonisms between rent and a necessary re-socialisation of production eventually produce conditions for developing and defending the commons (Hardt & Negri, 2005; 2009, Hardt, 2010). Moulier Boutang has very succinctly described the issue at hand for capital as one that confronts the same old alternative: either to open more and potentially disclose control or to enclose further and risk stifling productivity (2012, p. 99). Here we can attempt to elaborate on this dilemma: for autonomist theory, capital requires a certain degree of control over workers, such as that produced through the subjugation of the wage relation or alienation from the means of production. At the same time, the composition of labour in cognitive capitalism requires a significant autonomy for the labour force: autonomy to produce, but also the autonomy to construct social relations and organisational forms that are potentially excessive to enclosure (Hardt and Negri, 2000, 2009).

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the case for some time. Instead, as discussed in chapter two there is no real distinction between the real and the financial economy today. In fact, Marazzi argues that it is precisely through the fluidity of previously discrete categories of real and financial, material and speculative that rent is now productive (2011)[129].

As discussed through our previous analysis of social production and rent, so much of value production today occurs outside the labour-wage relation and outside the environs of managerial command and as such appears to overflow the thresholds of political or economic control. Speaking of the re-composition of labour described in chapter two, it would seem that the measure of value today cannot be tied to the quantity of (waged) time dedicated to the necessary reproduction of labour-power as a whole or from the ensuing social order (Fuchs, 2009). Value concerns not just waged labour or even the distinct categories of domestic or reproductive labour but the stuff of life as a whole (Lazzarato, 1996, 2012), and when this is the case, 'productive' labour becomes something unquantifiable, immeasurable, overflowing the boundaries of society (Marazzi, 2007). Exploitation at this degree requires a new set of provisions: the growing autonomy of labour, the transformation of subjects through education and training in cooperation and communication and access to the means of immaterial production such as knowledge, information and communication technologies and productive networks. For theorists such as Hardt and Negri, this is precisely how capital 'creates its own gravediggers':

> pursuing its own interests and trying to preserve its own survival, it must foster the increasing power and autonomy of the productive multitude. And when that accumulation of powers crosses a certain threshold, the multitude will emerge with the ability to autonomously rule common wealth (p.311).

Theorists such as Hardt and Negri (2005, 2009) and Berardi (2009a, 2009b) believe that the cultivation of a cognitive workforce provides the necessary skills and tools of communication and cooperation to mobilise against capital i.e. that the necessary provision of cognitive facilities such as education, training in cognitive skills and cooperation and the widespread provision of information and communication technologies will also cultivate the necessary capacities required to break free of capital. Here the hegemony of the digital commons constitutes the provision of social tools and critical faculties required to mobilise the labour force gainst the mechanisms of privatiation.

Similarly, they also understand that, due to the nature of the material it exploits and seeks to transform into economic value, cognitive capitalism requires a degree of autonomy. Any attempt to organise production from an external position disrupts the forms of social production at play in the commons. "The multitude produces

efficiently, and moreover develops new productive forces, only when it is granted the freedom to do so on its own terms, in its own way, with its own mechanisms of cooperation and communications" (Hardt and Negri, 2009, p.302). This is not only the provision of necessary tools and institutions for immaterial labour, such as universal service and cheap, available communications, but also the removal of impediments to production wherever possible. Such impediments operate at different scales but might include things as broad as the reduction of property rights in favour of open access or the introduction of a basic social wage in preference to wage labour. For Hardt and Negri, therefore, "[t]he freedom required for biopolitical production also includes the power to construct social relationships and create autonomous social institutions" (2009, p.310). They understand there to be a 'threshold' to this - certain structural limits that capital encounters in the attempt to subjugate the immaterial economy to a progressive growth dynamic and a logic of commercialisation, where the principle of openness predominates, despite attempts to establish economic barriers.

However, this perspective is diagnostic, not prescriptive; the theorised forms of resistance are semiotic while the operations of power remain consolidated in material property and fully supported by the law (Galloway, 2007). Autonomist Marxism tends not to engage with the materialist dimensions of value extraction in cognitive capitalism; instead, the informational network operates more as a trope in Empire than as a material substrate with internal logics and complex apparatuses for control and subjugation. Therefore, while Hardt and Negri understand the rise of the commons and forms of commoning as contingent on ICT networks, we might argue that they nonetheless fail to engage with the politics of these networks, which are not only 'virtual' but also grounded in physical and material forms of property (Poster, 2005).

5.4.3 Antagonisms in Property

"The republic of property, however, no longer serves capital well, and has instead become a fetter on production" (Hardt and Negri, 2009, p.301)

As such, the ongoing enclosure of communicative and cooperative capacities can be figured as an ongoing constraint to such liberatory projects. Specifically, the persistence of private property in the network prevents any significant disaccumulation or redistribution of value. Only a system that prevents alienation

from being employed in the reproduction of the digital commons can hope to break with capitalist accumulation (Kleiner, 2010). For social production over digitally networked media to have any autonomy, therefore, it has to operate within a *total* system of production and not simply within a logical or immaterial layer. For example, this means not just proliferating access to tools and platforms for communications but also extending access to a material substrate in the form of open hardware, open standards and common core infrastructure (Benkler, 2001). Without a common infrastructure including an open physical layer, and open logical layer and open content, social production in the commons will always be captured by the 'owners of real property' (Pasquinelli, 2008, p.86). We see this clearly in the operation of rent over electromagnetic spectrum, where the persistence of forms of enclosure continually nullifies the possibility for an anti-capitalist common at any productive level (El Amrani, 2011; Bauwens, 2011; Burgess & Samra, 2008; Song, 2011). This is, to once again echo Virno, a communality of generalised intellect (2004, p.17), but one that is flanked by a substantial inequality in rival wealth and resources.

It is therefore worth looking beyond the ways in which the new centrality of the general intellect cultivates social and cooperative capacities, to how the hegemony of the commons might inflect the existing forms of enclosure that underpin value accumulation. Because it is here that we encounter structural antagonisms at work in the expropriation of the digital commons. This speaks to internal contradictions emerging from within the commercial sector, where new and old business models with radically different approaches to command and enclosure are in conflict. If we think back to Moulier Boutang's dilemma of enclosure vs. disclosure (2012, p.99), this can be elaborated as such: while the extraction of value requires the institution of strong property rights, the relations of production require ongoing investment in institutions of the common.

Even while openness has become the watchword of contemporary capitalism, control exerted through rights associated with private property still appears as the primary operand of accumulation. In terms specific to the consolidation of digital networks we can point to the twin tendencies in telecommunications towards, on the one hand, open standards and protocols, open source communities and open innovation and on the other, the steady consolidation of monopoly and oligopoly control in the

substrate of this network – infrastructure, processing and storage technologies and of course communication channels themselves. Google today, as the perennial example, continues to multiply its investment in proprietary infrastructure, even becoming a registered electricity provider in the US in 2011 (Fehrenbacher, 2010), while at the same time extolling the social benefits of open access to communications platforms. The big questions are if such alliances can hold indefinitely, and if not, what next? Does an end to property as we know it also signal a crisis of capitalist accumulation, or simply its reconfiguration along less familiar lines? Specifically in relation to digital networks, are certain antagonisms straining the proprietary consolidation of core infrastructure, pushing towards a communality, not only of intangibles, but of tangible property also?

Significantly, the informational and cultural content of commodities do not easily conform to traditional property rights such as alienability, division or consumption; indeed they are naturally abundant. Scarcity has to be artificially produced through measures that often constrain productivity. As witnessed in the ongoing impasse between intellectual property rights and digital rights management over networked content, while such juridical measures can provide a temporary rite of extraction, in the long run they are ineffective and even counterproductive to the new relations of production. Here, forms of regulation that attempt to stabilise and control production through digitally networked media have now become fetters on that production. As a consequence, these traditional regulatory enclosures are breaking down and transforming.

It is also worth nothing that in the digital commons this is further complicated by an incompatibility between immaterial goods that elide a strict proprietary logic and the rival goods and energetic expenditure (man power, electrical energy, fossil fuels etc) that both produce and expropriate surplus value in the commons. Take as a few examples: An article published in the Economist on February 25th 2010 argued that as information is becoming more abundant, it produces an exaflood of data that exceeds the available storage capacities of physical media. So too, data centres are set to be more significant polluters than air traffic by 2020 (Lohr, 2008). Online social media avatars now consume more electricity than the average Brazilian (Carr, 2006). This in turn is leading to a breakdown in traditional property relations as providers are forced to share excess capacity or to adapt new strategies in the face of

diminishing returns on infrastructural investment. The case of spectrum speaks to both these issues, as a resource that is naturally abundant, but juridically consolidated as a rival resource.

One thing is for certain: enclosures are now in question. The property rights established by industrial capitalism are now so many fetters on social production. Instead of private property appearing as the locus of individual and corporate freedom positioned against state control, the commons has emerged as a locus of freedom and innovation positioned against the control exerted by private property, juridical strictures and market forces.

5.4.4 Summary

This section looked at various theoretical positions in relation to antagonisms in contemporary value accumulation in order to gain further insight into the antagonisms of rent. This includes antagonisms with social production and enclosure as well as internal contradictions within the telecommunications industry. In the majority of autonomist literature, theorists frame immaterial labour as an excessive force to capitalist accumulation, arguing that the current organisation of labour through networks consolidates labour in ways that are productive to capital but also antagonistic to accumulation. While this is close to the argument put forward in this thesis, we also wish to specifically attend to the ways in which the necessary autonomy of social production might come to inflect the enclosures that condition capitalist accumulation. If labour does not do this, it simply reproduces a communality of collective intellect that is open to expropriation. As such, this section also looked to how the traditional consolidation of property rights or 'enclosure' is coming to act as a fetter on social production, especially as it occurs through digitally networked media. This is producing tensions in the business model of commercial incumbents. One example of this is the ways in which artificial scarcity produced by spectrum regulation is now constraining the necessary proliferation of mobile communications, producing a 'spectrum crunch' where supply in its current consolidation cannot provision demand. This in turn is leading to proposed transformations in the enclosure of spectrum, away from exclusive licensing towards forms of sharing and a greater communality of spectrum.

Section 5.5: Conclusion

This chapter analysed the contemporary operation of rent over wireless networks. This detailed the consolidation of transferrable rights in spectrum through deregulation and market expansion in the second half of the twentieth century and identified the various affordances associated with possession of a property right or a license to electromagnetic spectrum. This analysis is a necessary foundation for a detailed investigation of how rights over spectrum have facilitated the extraction of rent from a number of different avenues, with unremunerated mobile labour identified as the significant productive force in this arrangement.

However, there appear to be antagonisms emerging in spectrum regulation between, on the one hand, the necessary bandwidth for mobile networks and on the other, the current proprietary consolidation of electromagnetic frequencies with a select oligopoly of mobile incumbents. Many critics of economics, law and digital policy now argue that the current regulatory consolidation is producing an artificial scarcity in spectrum, resulting in insufficient bandwidth to support the growing demands of mobile data traffic. This 'spectrum crunch' as it is frequently called, is leading to proposals to radically reorganise spectrum policy away from exclusive frequency licensing towards proposals for shared assignments and dynamic spectrum access.

To make sense of these conditions, we turned to a theoretical analysis of antagonisms in the operation of cognitive capitalism. This focused on the theory that the nature of the enclosures necessary for the accumulation of rent might be orthogonal to the conditions necessary for the networked composition of labour.

As a result of these antagonisms, enclosures are now in question. In turn we wish to determine if this is suggestive of a crisis of capitalist accumulation or simply points to its reconfiguration. This enquiry will be addressed in chapter six, once more by moving between broader theoretical frameworks on rent, enclosure and opposition and more focused examples of transformations occurring in spectrum policy.

Chapter Six: The New Commons or the New Enclosures?

Section 6.1: Introduction

While chapter two identified the new relations of production that bring the digital commons to the fore and chapter three described the dynamics of rent accumulation, chapters four, five and six analysed the operation of these conditions through the lens of electromagnetic spectrum. This example allowed us to closely examine the forms of enclosure that facilitate the accumulation of surplus value as rent; to analyse the potential antagonisms arising from the operation of rent; and finally to identify the transformations that overcome or accede to these antagonisms. As previously discussed, this enquiry is broken down into three stages that correspond to chapters four, five and six. Chapter four detailed the foundations of radio enclosure; chapter five identified emerging conflicts in the operation of rent between the nature of these enclosures and the necessary resocialisation of the commons; and chapter six now analyses the potential outcomes of these conflicts.

The previous chapter demonstrated how property rights necessary for the extraction of rent coalesce and conflict with the equally necessary proliferation of communications. In spectrum this is expressed though a conflict between exclusive licensing to communications channels and the requisite bandwidth to support a growing mobile network economy. This produces mobile congestion or a 'spectrum crunch', where data exceeds the capacities of spectrum in its current rarified state (Chen, 2012b; Goldman, 2012; Gompa, 2013). In turn this crunch is leading to recommendations from a number of different factions for a significant re-composition of the property relations surrounding spectrum, marking a shift from exclusive licensing to fluid and transient ownership models or even unlicensed spectrum (Alberti, 2010; Ballon, 2009; Benkler, 2012; Cochrane, 2006; Doyle, 2011, 2012; Forde, Macaluso & Doyle, 20011; Forge, Horowitz and Blackman, 2012; Milgrom, Levin and Eilat, 2011; PCAST, 2012; Thanki, 2012; Werbach, 2011).

Throughout this thesis, the enclosure of communications networks has been presented as a mainstay of cognitive rent. So too, the separation of the user from communicative and cooperative capacities is the primary impediment to an autonomous form of social production in the network (Bauwens, 2011; Benkler,

2001, 2002b, 2003, 2006; Kleiner, 2010, the Next Net, 2011, Song, 2011). Considering the significant transformations to property relations in the network economy, here we analyse if the break down of property relations produces an opportunity for social production to break free of rent accumulation, or if these networks will continue to be enclosed through new strategies and techniques.

In this chapter, we first explore the technical and policy details of a growing number of recommendations for shared spectrum. This can be framed within broader changes to property relations in mobile networks emerging as a result of the antagonisms identified in chapter five. A greater fluidity of resources and ownership models can be observed, not just in spectrum, but in other parts of the mobile network, moving from the traditional 'walled garden' to approaches that share resources and/or cede control to end-users (Doyle, 2011, Forde et al.., 2011). From this brief overview, proposals for shared spectrum are then discussed. Specifically, section 6.2. details and analyses three high profile reports published in the last twelve months that produce recommendations for a significant increase in license-exempt and shared spectrum in terms of their implications for future spectrum regulation. This includes questions such as: where are these recommendations emerging? What are the key tenets of the recommendations? How are they proposed to be adopted? And finally, if the reports and recommendations can be said to support technical and juridical approaches that might communalise radio spectrum, what is the potential outcome of this regulatory transformation?

Synthesising these proposals and stepping back into the theoretical literature, section 6.3 analyses the broader implications of adoption of dynamic spectrum access techniques coupled with unlicensed spectrum. This details two converse perspectives on spectrum-sharing: first as a systemic rupture in capitalist accumulation that proliferates an autonomous social production, and second as a reconfiguration of the modes of capitalist enclosure designed to overcome the antagonisms of rent. If on the one hand, reports recommending license-exempt spectrum indicate the imminent possibility for a 'spectrum commons' free of commercial control and intervention, these proposals are also supplemented by a number of corresponding recommendations for new systems to regulate and monetise that commons.

These proposals will be elaborated in 6.4. To understand this new form of enclosure better, Section 6.4. moves between the available technical literature on license-

exempt regulation and new critical theory on the 'communism of capital' to begin to understand how enclosure operates beyond traditional property and through decentralised channels. To do so, this discussion blends political economy, and competing perspectives on the commons with new media theory.

By drawing on a synthesis of the material from our precious chapters and analysing these conditions, we can now answer the core questions of the thesis. Does a shift towards non-proprietary and unlicensed spectrum represent an antagonistic element in cognitive capitalism, suggestive of a crisis of property rights? Or if this new communality of network resources is not at odds with capitalist interests, how is it that accumulation continues to operate beyond traditional property regimes? What are the implications for future networks?

Section 6.2: Proposals for Spectrum-Sharing

6.2.1 Introduction

At the end of chapter five we saw how mobile congestion was leading to proposals for a radical reorganisation of spectrum, introducing dynamic spectrum access and expanding unlicensed bands. This is a significant shift from the current exclusive licensing model consolidated in command and control regulation. This section analyses these recommendations. However, the proposals for spectrum-sharing are not singular; they are situated within broader transformations to the property relations in mobile networks that see the emergence of forms of resource-sharing and redistribution in mobile core infrastructure such as small cells, shared base stations and open standards in next generation mobile networks (Bennis & Lilleberg, 2007; Doyle, 2011; OpenLTE, 2013; Thanki, 2012). We then proceed to specifically analyse the conditions that favour a non-exclusive and license-exempt approach to spectrum regulation, including mobile congestion; the global success of unlicensed innovations such as Wi-Fi; and various technical innovations that support dynamic spectrum access. Significantly, the proposals for future transformation to the regulatory framework are exemplified by three high-profile reports published in 2012 that recommend and detail a shift from exclusive licensing towards an increase in 'commons' spectrum. The salient aspects of these reports will be synthesised and analysed here, to outline the future of spectrum-sharing and to begin to identify how it might be technically and juridically implemented and regulated.

6.2.2 Property Relations Are Breaking Down in Mobile Networks

Proposals for spectrum-sharing are not singular, but form part of a broader transformation to the property rights underpinning physical layer infrastructure in mobile networks. The ownership models structuring network resources are becoming more fluid (Alberti, 2010; Arango & Kaponig, 2009; Ballon and Delaere, 2009; Benkler, 2012; Bennis and Lilleberg, 2007; Dawson, 2011; Doyle, 2007; Forde et al.., 2011, Leinwald, 2007; Paul et al.., 2011, Wang, 2009). These kinds of transformations have been occurring in the digital content layer for some time, as entertainment industries and content providers struggle to adapt to the constraints and affordances of intellectual property in network media. However, the property relations governing the physical layer are now also in question, as network providers struggle to physically support an exponential demand for bandwidth and resources while faced with diminishing returns on their investment in infrastructure[130]. Consequently, economists of telecommunications now identify a tendency to the breakdown of traditional monolithic property structures that previously structured the physical layer of communications networks, as telecommunications companies and Internet service providers now transfer, share, re-use, redistribute and otherwise deploy physical resources as needed (Dawson, 2011).

A shift towards fluid and reconfigurable networks (Arango & Kaponig, 2009), a mobility of resources of all kinds (Barker, 2007; Hindubusinessline, 2011; Rimler and Rasmussen, 2005) and a growing recognition of sharing as a modality of economic production (Benkler, 2004) are beginning to counter the 'walled gardens' and rigid economies of scale cultivated under Fordism. This sea change is particularly evident in mobile networks, which were leading exhibits of highly centralised, closed and proprietary infrastructure until very recently (Goggin, 2011, p.158). Today approaches are emerging that virtualise the network (Forde, et al., 2011); that support the concept of distributed or multiple points of connection (Doyle, 2011); that share, re-use and distribute resources (Bennis & Lilleberg, 2007);

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[130] I have analysed these transformations in detail through publication elsewhere. For further analysis see O'Dwyer and Doyle, 2012.

or that cede centralised control of transmissions from the mobile operator to third parties or even to the end user (Thanki, 2012, p.14)[131]. As Forde et al. explains:

> The early success of mobile networks was at least based in part on the ability of the various monopolistic network operators to exert total control on their resources: the phones available to customers, the [Radio Access Networks] RAN which they built out and the [Public-switched telephone network] PSTN to which, and through which, they connected their customers. But we are now moving from highly integrated architectures to one in which the boundaries between different network entities are now much more blurred and fluid; the nature of user equipment is changing rapidly, the evolution of the radio access technologies is advancing apace and the cellular network value chain is ever changing. (2011, p.337)

Here, the authors provide an analysis of the changes occurring in network property towards sharing as a modality of economic production in networks. Traditionally, mobile networks are highly insular with exclusively owned resources consolidated in monolithic property. In early cellular networks, the carrier maintained an exclusive ownership of all necessary resources, from electromagnetic spectrum through to antennae, base stations and the real estate for deployment. Next generation networks such as 4G (IMT advanced) and LTE, however, require a greater architectural fluidity compared to legacy networks such as GSM and CDMA. Often these incorporate not only cellular, but wireless LAN, digital broadcast, satellite and other

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[131] In a 2011 presentations at Emerging Communications, Jan Dawson, chief Telecoms Analyst for Ovum outlined a number of future projections for telecommunications, the Internet and mobile communications in the next decade. Key projections included a shift from communication to content, where communication diversifies and becomes free and content becomes the primary driver of value for networks; a growing mobility and distribution of networks as connectivity becomes increasingly mobile and distributed; a rise of managed device platforms and cloud infrastructure; and the rise of functionality delivered through software instead of hardware (virtualisation). Secondly, Dawson identified two distinct players in the telecommunications market – a model that extracts value from platforms and users through a managed device platform approach (exemplified by companies such as Google's Android and Amazon's Kindle) or a model focused entirely on providing infrastructure and network management in a low cost, agnostic and flexible fashion. Two competing modalities appear to be at work here. On the one hand we witness software and media conglomerates multiplying their investment in infrastructure, becoming powerful incumbents: owners, not only of intangible assets such as software, patents and other forms of intellectual property, but also proprietors of tangible resources such as energy; data storage and processing; bandwidth; real estate; hardware and cooling resources. Amazon for example, with a legacy in digital content distribution, has recently emerged as a network provider, with services not only through their managed device platform, but also through a range of cloud and hosting services, such as EC2. Specifically, this model doesn't suggest an *absence* of control, so much as a *transfer* of control of infrastructure from more traditional incumbents with a legacy in telecommunications towards software providers looking to consolidate their market position through investment in upstream traffic.

access systems connected via flexible core networks (ITU, 2003). This allows for greater structural flexibility and a variety of choices for users, but the outcome is also that many of the network components: satellites, Internet backhaul, hotspots, platforms and so on, might be separately-owned and operated, requiring coordination between discrete vendors and operators. Consequently, previously centralised network assets are now commonly distributed and owned by a variety of stakeholders. As it stands, "co-operative arrangements among different legal entities are more likely to characterise [4G] IMT advanced than overall ownership by a single enterprise" (Forge et al. 2012, p.63). Resource sharing is becoming more common between discrete mobile network operators, emerging alongside a variety of different ownership and business models around infrastructure, from managed device platforms to wholesale provision of infrastructure to virtual network operators, who own no infrastructure at all and instead rent capacity in the form of bandwidth and billing services from traditional network operators (Ballon, 2009; Cave, 2012; Forde et al., 2011).

As ownership becomes more fluid, the different components of the mobile network are also transforming from monolithic infrastructure to increasingly modular goods (Benkler, 2004)[132]. So too, resource sharing between incumbents and users is a feature of these next-generation networks, where operators cede base station control from a previously centralised point to end users in the form of small cell technologies (Thanki, 2012). These transfer infrastructure from a centralised point to the end user (O'Dwyer & Doyle, 2012).[133]

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[132] Modularity, according to Benkler is the property of a project that describes the extent to which it can be broken down into smaller components or modules that can be independently produced (2004, p.336).

[133] Cellular networks are increasingly reliant on smaller cells for operation. A cellular network is comprised of distinct geographic areas or 'cells' that are served by one or a number of base station transceivers. In a cellular network, each cell uses a different set of frequencies from neighbouring cells to avoid interference and provide the maximum bandwidth. When brought together these provide radio coverage over a large geographic area. Typically (macro-cellular) network cell sizes range from 1 to 20 km. The greater the number of cells the greater the capacity of the network; however, the core infrastructure required for the roll out of additional cells is significant, including not only base stations but costly real estate in urban areas. As a consequence, 'femtocells' or 'picocells' are an attractive option for mobile network operators. These are very small cell sizes in the range of personal, domestic and office spaces that connect to a user's existing broadband Internet connection for backhaul. They operate as an extension of the carrier's existing network, providing improved coverage in a user's direct vicinity. This being said, the current configuration or femtocells includes regulations and billing systems designed to allow a mobile network operator to remain in control despite breaking down infrastructure (AT&T, 2012).

What we see is that all kinds of resources associated with the provision of networks have become modular, and necessarily so, in order to respond to demand for multiple services and increased bandwidth. Such an increase in the modularity of network infrastructure in turn has significant implications for the property relations governing the network. The implications for individual users and small non-commercial entities is that it is now possible to access resources, where once the necessary injections in capital, and the surrounding regulations made it impossible to communalise and scale mobile networks with any ease. The implications for incumbents is that they must evolve strategies that are financially profitable while also somehow supporting a new degree of openness in their core infrastructure (Dawson, 2011; Leinwald, 2007).

Spectrum Sharing

Recognising the importance of sharing as an economic modality of production has had significant implications for spectrum policy. This is arguably reflected in the emergence of a variety of market forces that trade, re-farm and otherwise reapportion licensed spectrum, but also in the growing assertion for shared spectrum coupled with dynamic spectrum access techniques (Ballon & Delaere; Baran, 2005; Benkler, 2012; Cave, 2012; Cochrane, 2006; Forge et al.., 2012; PCAST, 2012; Thanki, 2012; Werbach, 2003). Where auctions and property rights in spectrum were long in favour (Hazlett 1998; 2008), a number of technical and economic factors now favour an unlicensed approach to spectrum regulation: the exponential demand for mobile bandwidth; the huge success of innovations in the 2.4 GHz band; and the development of a variety of non-exclusive techniques that make cooperative negotiation of the electromagnetic spectrum feasible. Today it is fair to say that the idea of shared and license-exempt spectrum has a currency beyond a core group of digital activists and long-time advocates of 'open spectrum' and common core infrastructure (Benkler, 2001; Buck, 2002; Dunifer et al.., 1998; Meinrath and Pickard, 2006; Noam, 1997, 1998), emerging also at the centre of neoliberal policies for communications. This is particularly indicated by several high profile reports published in 2012 recommending a paradigm shift from exclusive access to forms of shared[134], license-exempt, unlicensed[135] and non-exclusive regulations (Forde at al,

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[134] Shared spectrum includes all situations in which two or more users of wireless applications are authorised to utilise the same range of frequencies on a non-exclusive basis in a defined shared arrangement.

2012; PCAST, 2012; Thanki, 2012). These reports will be discussed in detail presently, but first it is necessary to look more closely at some of the factors that make sharing commercially attractive in spectrum, such as mobile congestion, technical advances and demonstrated economic success in unlicensed spectrum.

The Spectrum Crunch

Shared spectrum is a powerful solution to mobile congestion. The so called 'spectrum crunch' was discussed in detail in chapter 5, where the growth of mobile data has engendered a significant demand for bandwidth that many network operators are now struggling to provide within the current regulatory configuration (Manzerolle, 2010). The underutilisation of spectrum in exclusive licensing arrangements and the significant instances of market failure in auctions and secondary licensing schemes has led many to argue for shared assignments and an increase in unlicensed spectrum (Talbot, 2012).

Technical Advances

As discussed in chapter five, the concept of available capacity in spectrum is always subject to the technological affordances and constraints of a particular era (Werbach, 2011). Alongside the success of Wi-Fi, there have been numerous technological advances in dynamic spectrum access over the past several decades that support spectrum sharing.

These include:

The use of smart or 'cognitive' radio devices that transmit on a variety of different frequencies: A cognitive radio is an intelligent device that can dynamically adapt a range of operating parameters such as frequency of operation; power; modulation scheme; antenna beam pattern; battery usage etc. These adaptations may occur either in specific predefined ways or through pattern recognition and computer-based learning from real world situations. Cognitive radios are defined as radios that are "self-aware, user aware [and Radio Frequency] RF aware" (Mitola, 2000), able to identify available frequencies through a variety of methodologies and respond accordingly to avoid interference with other devices. These include cognitive-sensing

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[135] The terms license-exempt and unlicensed are often used interchangeably. In a US context the term 'unlicensed' is generally used as license-exempt is used to define particular operations in RF bands.

based access and/or access to a geolocation database lookup table that provides dynamic information about currently available spectrum in a specific geographic location (Doyle, 2009). As such, a cognitive radio relies on networked connectivity and codified behaviours as opposed to external regulations from a central authority. Conversely, while the growth of internet-enabled devices such as smart phones and tablets has fed spectrum scarcity, their multicore processing architectures also facilitate the introduction of dynamic spectrum access techniques (Mannion, 2013)[136]. As devices with multisensory, multiband location-aware capabilities coupled to increased memory and an ecosystem of software app developers, cognitive radios already inhere in commercial electronics.

The development of spread spectrum and sophisticated multiplexing techniques: Spread spectrum is where a signal generated with a particular bandwidth is spread or distributed in a wide frequency domain (Marcus, 2009). This allows more users to share a common band or channel, but it also requires greater swatches of unlicensed spectrum to achieve. Related techniques include frequency-hopping spread spectrum, direct-sequence spread spectrum, time-hopping spread spectrum, chirp spread spectrum and combinations of these techniques (Benkler, 1998). Each of these techniques employs pseudorandom number sequences to determine and control the spreading pattern of the signal across the allocated bandwidth. Ultra Wideband (UWB) is another modulation technique that accomplishes the same purpose, where signals are under-laid across a band of frequencies at very low power close to the noise floor, transmitting on short duration pulses (Forge et al., 2012). Spread spectrum was initially developed as a military application in the 1940s[137]. Despite this early provenance, spread spectrum techniques were not engaged for a long time, as while more efficient, they also seems to require more bandwidth, and a shared utility - ideas at odds with the mindset of both incumbents and regulatory authorities

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[136]"software-defined radios that could adapt to multiple baseband processing and modulatory/demodulation schemes were fed in part by the emergence of new multicore processing architectures with less and less power consumption – flexible front ends coupled with flexible processing architectures. (Mannion, 2013)

[137] Avant-garde composer George Antheil and actress Hedy Lamarr were granted a patent in 1942 for their secret communication system for use in radio guided torpedoes. Coordination was done with paper player piano rolls (Marcus, 2004).

(Baran, 1995). However, spread spectrum techniques are now implemented in next-generation networks.

The use of smart antennas and beamforming techniques to shape signals: Sharing intelligence can be incorporated not only into transmitters and receivers, but also into the antennas. Beamforming allows a radio to direct energy at a particular target while blocking incoming energy from other directions (Thanki, 2012, p. 93). A directional antenna radiates greater power in one or more directions, allowing for greater performance and reduced interference from unwanted signals. While a classic television aerial simply uses horizontal bars of lengths that match the periodic frequencies of the broadcast channel, electronic antennas can be designed to be highly directional, "they can even be tuned dynamically to lock on and shape a narrow directional beam to a signal, preventing it from spreading widely where it might impinge on other signals" (Werbach, 2003, p. 890).

The use of sophisticated multiplexing techniques and digital signal processing (DSP) to digitally shape signals: In chapter four we discussed the genesis of basic frequency-division multiplexing and time-division multiplexing techniques. Contemporary techniques such as CDMA and W-CDMA used in cellular networks and OFDM, used in Wireless Local area networks (WLANs,) WiMAX and 4G and COFDM are highly spectral efficient and noise immune approaches (Forge et al., 2012, p.37). As such these support dynamic spectrum access. These technical approaches all make spectrum-sharing a viable and attractive option for utilising bandwidth (Cave, 2012; Cochrane, 2006; Forge et al., 2012; Thanki, 2012).

The Wi-Fi Success Story

Demonstrated economic success in unlicensed spectrum furthers this argument. As detailed in chapter 3 when electromagnetic spectrum was first introduced as a study, a small amount of unlicensed spectrum already exists and is commonly known as Wi-Fi. Spectrum 'commons' (sharing within channel assignments) is the approach already featured in the Industrial, Scientific and Medical (ISM) bands (Weiser and Hatfield, 2005). In 1985, the FCC authorised the use of these ISM bands for low powered communications devices on a license-exempt or unlicensed basis. The regulation did not specify too many details, but instead prescribed particular limits

on the maximum power output of any device operating in the band[138]. This ISM band in turn gave rise to wireless protocols such as Wi-Fi (IEEE 802.11b) Bluetooth and Zigbee (IEEE 802.15)[139]. When viewed historically, the development of common property regimes in radio gains its precedent from amateur radio, the maritime mobile service and similar historical innovations in spectrum commons. Nonetheless, license-exempt spectrum was considered radical in the context of regulatory norms[140].

The often recounted success story of technical and commercial innovation in these unlicensed bands provides a persuasive argument for the long-term economic value of license-exempt spectrum. In particular, Wi-Fi has led to countless technological advances in consumer electronics; has restructured domestic, work and institutional spaces (Ito, Okabe and Matsudo, 2006); and provided access to network services in areas where the roll out of costly core infrastructure remains an economic impossibility (Meinrath, Losey and Pickard, 2010; Song, 2011). This includes the development of a sharing culture in network resources, exemplified by a number of large-scale community-based mesh-networking projects. There are many of these, but the most famous include the GUIFI network in Spain and FON, a global sharing Wi-Fi network that allows its users to access Wi-Fi from FON hotspots all around the world in return for provisioning shared access to their own personal network (FON, 2013; Forge et al., 2012; GUIFI, 2013).

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[138] The general rules of a license-exempt spectrum commons are more straightforward than those of licensed spectrum, tending to allow what is not expressly prohibited where the inverse is often the case for licensed spectrum:

- No assigned channels and no exclusivity in channel use
- Equal rights presumed among all users
- Technical specifications are detailed including power transmit/signal strength and bandwidth to mitigate against interference
- A degree of tolerance for interference; while no agent should deliberately cause interference, if interference occurs, each user must adapt and deal with the situation to the best of their abilities.

[139] Wi-Fi occupies five channels in the 2.4 GHz band. Spectrum assignments and operational limits are not entirely consistent worldwide: most of Europe allows for an additional two channels beyond those permitted in the US for the 2.4 GHz band (1-13 vs.1-11).

[140] As Forge et al. claim "Analogies with the internet have been suggested, and this is no coincidence: Paul Baran, who was the first to articulate "open spectrum" policies in the 1990s, was also responsible for "packet switching", the technique that makes the internet resilient and efficient without any centralization of traffic control. Baran's research suggested that the basic concepts of packet switching should work whether a network is wired or wireless, so he proposed internet-like rules for the regulation of radio" (2012, p.31).

Furthermore, as mobile network traffic has expanded, Wi-Fi now functions as a significant externality for mobile network operators who utilise the benefits of unlicensed spectrum to offload data from their congested networks (Benkler, 2012; Forge et al., 2012, Juniper, 2013). While the role of Wi-Fi not only as the foundation of community-based mesh networking projects, but as a powerful externality for commercial networks is not much explored in the political economy of communications, it deserves attention here. Far from discouraging the introduction of open networks, Mobile network operators now recognise a tighter integration between licensed and unlicensed spectrum as a way to gain benefits from open access while socialising some of the risks of investment in core infrastructure. As Benkler (2012) argues:

> Wi-Fi offloading is fast becoming a critical component of the way in which even the organizations most clearly orientated towards the exclusive licensing model, cellular carriers, handle the fast expanding demand for broadband data carriage (p.75).

Today, mobile incumbents strategically offload whenever possible. When data from the initial influx of smart phones and tablets congested major networks in the US, it was to Wi-Fi and not to secondary markets in property-like spectrum that incumbents turned to for a solution (ibid). Juniper research found that 63% of traffic by smart phones and tablets is currently carried over Wi-Fi networks, projecting that this figure "may be close to 90% by 2015" (Juniper, 2013). Comscore supports this statistic, reporting that 40% of all mobile data is currently carried over Wi-Fi, and 92% of tablet data. A large percentage of this is thought to rely on offloading to home and personal networks as opposed to hotspots (Cisco, 2011). This utilisation of unlicensed spectrum at 2.4 GHz and 5 GHz is only expected to increase in the coming decade due to the rise of smart phones and tablets and an "'exaflood' of data transfers and offloads from cellular networks to Wi-Fi" (Forge et al., 2012, p.46).

Furthermore, we can identify specific instances of offloading partnerships by commercial incumbents such as British Telecom, Deutsche Telekom and Softbank onto the communal FON network[141]. In March 2013, Deutsche Telekom announced that it would partner with FON in providing 2.5 million hotspots by 2016. As

[141]FONs partners include Belgacom (Belgium), BT (UK), Hervatski Telekom (Croatia), KPN (Netherlands), Oi (Brazil), MTC (Russia), Netia (Poland), SFR (France), SoftBank (Japan), Telekom (Germany) and ZON (Portugal) (FON network, 2013).

Deutsche Telekom CEO Rene Obermann observed, "[t]he partnership with FON sits perfectly with Telekom's network expansion strategy. Wi-Fi and hotspots can be used to divert heavy data traffic to fixed-line networks and this reduces the load on mobile networks" (McGrath, 2013).

This Wi-Fi offload strategy is in keeping with many of the large telecommunications operators, who are producing 'hybrid networks' comprised of small cells[142], Wi-Fi networks and macro cells. The only disadvantage of Wi-Fi offloading, from the perspectives of Mobile network operators, is the significant danger of losing revenue streams through users replacing cellular communications with 'free' over the top Voice Over Internet Protocol (VoIP) services or community networks. While Wi-Fi is a useful externality, therefore, it also threatens to escape the revenue stream of mobile incumbents.

However, the demonstrated social and economic value of Wi-Fi as an innovation emerging from such a small swathe of license-exempt spectrum has fuelled numerous arguments favouring an increase in the amount of spectrum not subject to proprietary control by one or two powerful incumbents (Benkler, 2004, 2006, 2012; Cochrane, 2006; Milgrom, Levin & Eilat, 2011; Rheingold, 2002; Sandvig, 2004; Staple & Werbach, 2044; Weiser & Hatfield, 2005). This is particularly prescient, because Wi-Fi, while hugely successful, is also subject to scale and capacity limitations due to its frequency propagation characteristics and conservative power-transmit regulations (Thanki, 2012). As such a number of factions argue for the introduction of unlicensed spectrum bands in the valuable Ultra High Frequency (UHF) or Very High Frequency (VHF) bands such as TV White Space (Karimi, 2011; Thanki, 2012; Werbach, 2011).

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[142] Another option for offloading occurs with small cell technologies such as femtocells and picocells. Alongside Wi-Fi, these are often presented as a solution to mobile network congestion, allowing for the re-use of frequencies in a geographic area. Reducing cell size produced greater efficiency. Femtocells are designed to boost coverage in a user's office or domestic space. They utilise the user's own Internet access to provide backhaul (Meinrath, S. In conversation with the author, March, 2012).

TV White Space

Following the global transition from analogue to more spectrum-efficient[143] digital television, bands of spectrum, particularly in the 50 MHz and 700 MHz range, were freed for use. This is known as TV White Space. White Space has been the subject of significant controversy, with many incumbents arguing that the newly freed spectrum should be auctioned to the highest bidder and others arguing that it provides the ideal ground for testing and implementing the new dynamic spectrum access and cognitive radios (Shadowace, 2008; Thanki, 2012; Werbach, 2011). There have already been a number of tests using White Space Devices (WSDs) coupled with geolocation databases in these bands. In December 2012, the FCC recommended that researchers and companies be allowed to access the frequencies that been reserved for radar systems (2012a). Companies such as Spectrum Bridge, Telcordia and Google have already tested and started operating White Space networks (Brodkin, 2013a; FCC, 2011, 2012a, 2013; Google Inc., 2013).

All of these factors: mobile congestion, technical advances and the demonstrated success of economic innovation in unlicensed spectrum, have led to increased proposals for spectrum sharing in the past few years.

6.2.3 Summary of Three Reports in Favour of Spectrum-Sharing

2012 saw the publication of three high profile reports that recommend a paradigm shift from exclusive access to forms of unlicensed, license-exempt, light licensing and shared access spectrum in Federal and TV White Space bands respectively (Forge et al., PCAST, Thanki). Economists, theorists, corporations and advisors to regulatory committees across the UK, EU and the US propose a reconfiguration of the regulatory model away from static and exclusive allocations towards the use of dynamic spectrum access techniques; suggest changes to licensing to enable flexible and shared assignments; and discuss the introduction of new systems for negotiation and enforcement that adequately respond to these dynamic systems. The salient recommendations of these reports will be analysed and synthesised here.

The final report for the European Commission on 'Perspective on the Value of Shared Spectrum Access' provides an outline of the socioeconomic value of shared

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[143] Digital can use adjacent channels, however, analogue cannot. Digital signal processing is also more efficient.

spectrum and responds to the '[European] Commission's recognition of the need to move away from exclusive and persistent channel assignments...reflected in a growing emphasis on shared spectrum access, which our findings support" (Forge et al., 2012, p.12). Published in February 2012, this document was influential to a subsequent report published by President Obama's Council of Advisors on Science and Technology (PCAST) in July 2012, entitled 'Report to the President Realising the Full Potential of Government-held Spectrum to Spur Economic Growth'. The council, which includes Google chairman Eric Schmidt and Microsoft chief researcher and strategy Craig Mundie, proposed radical reform to the federal spectrum. Most significantly, PCAST suggests that "the norm for spectrum use should be sharing, not exclusivity" (2012, p.vi). A third report also published in the summer of 2012 was produced by Richard Thanki, an economist with Ofcom and entitled 'the Economic Significance of License-Exempt Spectrum to the Future of the Internet'. Thanki identified similar concerns, with a significant emphasis on the necessity of shared-spectrum as opposed to auctions in the recently vacated TV White Spaces. All three reports represent significant policy reconfigurations and provide detailed recommendations for the implementation of this new regulatory architecture. These include a greater fluidity in allocations; an increase in shared as opposed to exclusive channel assignments; a significant increase in unlicensed spectrum; and the introduction of cognitive radios and dynamic spectrum access techniques to realise these reforms.

Thanki: The Economic Significance of License-exempt Spectrum to the Future of the Internet

Richard Thanki's report entitled 'The Economic Significance of License-exempt Spectrum to the Future of the Internet' focuses on the importance of sharing in Sub 1GHz spectrum and identifies an overwhelming need for enabling license exempt spectrum in TV White Spaces. For Thanki, "the technical and commercial innovation found in license-exempt spectrum has the potential to play a vital, if not predominant role in meeting [current] connectivity challenges" (p.6). Thanki argues that current models that promote artificial scarcity in spectrum, coupled with the growing demand for spectrum for cellular operations, is leading to oligopoly ownership of the most valuable spectrum. Similar to the PCAST report, Thanki argues that the risks of regulatory and market failure are great when allocating TV White Spaces and urges

caution in response to incumbent requests for exclusive use licenses in these bands (p.20). Instead, Thanki identifies license-exempt models as a solution to future requirements for cellular networks, for machine-to-machine (m2m) communications and for the mobile Internet.

Thanki identifies the significant role already played by license-exempt spectrum in core areas such as broadband connectivity, m2m connections and developing robust and adaptable networks, but equally observes that the socioeconomic possibilities of open access spectrum are severely constrained by regulatory protocol. To this effect the economist largely focuses on the limitations to existing license-exempt spectrum (Wi-Fi) in terms of power-constraints and the propagation characteristics of higher frequency spectrum. Because Wi-Fi is located at higher frequencies, this limits propagation to tens of metres indoors and hundreds outdoors. Producing equivalent unlicensed bands in TV White Spaces, which are sub 1GHz, removes these constraints. Sub 1GHz spectrum, on the other hand, has low power requirements and excellent penetration, allowing broadband links to extend for many hundreds of metres in cities, and kilometres in less densely populated areas, even without a clear line of sight. These qualities would enable large mesh networks to form easily and scale robustly.

In light of this, Thanki identifies the need for a new regulatory standard, shifting away from the command and control model of spectrum as a "finite natural resource' towards a more nuanced approach that adopts dynamic spectrum access as the norm (p.14). TV White Space is presented as the obvious starting point for this transformation. In response to warnings of a 'tragedy of the commons' scenario, Thanki points out that this has failed to come to pass in existing license-exempt bands, which already dynamically share and utilise spectrum with success (p.93). Unlicensed spectrum in TV White Space "would allow a large number of license-exempt architectures to be constructed in a bottom-up fashion enhancing both the robustness and adaptability of communications networks. (p.90)"

Forge, Horowitz and Blackman: The Final Report for the European Commission on Perspective on the Value of Shared Spectrum Access

The report for the European Commission providing 'Perspectives on the Value of Shared Spectrum Access' identifies the socioeconomic value of shared spectrum access, focusing on its impact on "competition, innovation and investment"(p ii).

This enquiry was addressed through a "scenario analysis of the wireless industry to 2020 combined with economic modelling"(p.7). As such it includes a survey of current industry developments and a survey of 27 EU member states on the current use of shared access for wireless broadband. The report explores three different sharing scenarios: No sharing; modest sharing; and a sharing economy implementing dynamic spectrum access technologies and new regulatory frameworks, and concludes that the sharing economy produces the greatest social and economic benefits.

As well as indicating the scale of the added value of shared spectrum access to the EU economy, the report explored concepts such as Authorised Shared Access (ASA) and Light Licensing, highlighting the technical challenges, costs and incentives for incumbent users to adopt these approaches. As central transformations to the normative regulatory framework, both of these concepts require further elaboration:

Light Licensing was defined in the ECC Report 80 as:

> ...a combination of license-exempt use and protection of users of spectrum. This model has a first come first served feature where the user notifies the regulator with the position and characteristics of the stations. The database of installed stations containing appropriate technical parameters (location, frequency, power, antenna etc.) is publicly available and should be consulted before installing new stations. If the transmitter can be installed without affecting stations already registered the new station can be recorded on a database. New entrants should be able to reach an agreement with existing users in case interference criteria are exceeded (ECC, 2006, p.11).

Authorised Shared Access is an authorised scheme proposed by Qualcomm and Nokia in a joint response to the RSPG consultation on cognitive technologies in January 2011. ASA uses dynamic spectrum access techniques to enable one or more new licensees to opportunistically exploit spectrum previously assigned to one incumbent exclusively when that spectrum is not in use. This is a model of sharing that concerns existing incumbents.

President's Council of Advisors in Science and Technology: Report to the President Realising the Full Potential of Government-held Spectrum to Spur Economic Growth

The PCAST 'Report to the President Realising the Full Potential of Government-held Spectrum to Spur Economic Growth' is influenced by the Thanki and EC reports on shared spectrum, but takes these proposals even further. The PCAST report concludes that the command and control practices that have dominated regulation, coupled with current market strategies for auctioning spectrum are inadequate to the current demand for mobile bandwidth. As a result the advisory committee recommends that, taking both the current situation and the advancement in dynamic spectrum access techniques into account, that future US government policy should be to "share underutilised spectrum to the maximum extent consistent with the Federal commission" (p.iii). The focal point of this recommendation concerns the identification of 1,000 MHz of underutilised federal spectrum within which to implement spectrum-sharing pilot schemes. A presidential memo published in 2010 and entitled "Unleashing the Wireless Broadband Revolution" required that the federal government "make available 500 MHz of spectrum for both mobile and fixed wireless broadband use by commercial users within ten years" (The White House, 2010). The PCAST report now responds to the numerous developments in policy and technology that have occurred since this memorandum was issued.

The essential argument contained within the report proposes that "a significant policy change can be made to move spectrum availability from scarcity to abundance" (p.6). To achieve this, the advisory committee recommend that the norm for spectrum use should be "sharing rather than exclusivity" (p.73) and call for the government to "immediately identify 1,000 MHz of federal spectrum in which to implement the new architecture and thereby create the first shared-spectrum superhighways"(p.vii).

Developing on the 2010 memorandum, which primarily concerns sharing between commercial incumbents, and the two-tiered ASA model discussed in the EC report (Forge et al., 2012), the report proposes a *three-tiered* spectrum architecture, adding a further dimension of *public* access. This includes provisions for primary access by federal users, secondary access for license holders and general authorised access for all other users, including the general public. Primary users have the highest priority,

secondary licensees are required to register deployments and use a database and receive some protection against interference and general authorised access users are allowed opportunistic access to the identified spectrum in a specified area and time period, provided they don't interfere with licensed incumbents and that the band isn't currently in use.

The advisor committee identify a number of structural changes necessary to regulatory policy in order to implement the shared model. In brief they propose:

- That the president immediately issue a memorandum that states it is the policy of the US government to share underutilised federal spectrum to the maximum extent possible, implementing a substantial reorganisation of the management of spectrum.
- That future decisions to enable commercial access take a longer view that speculates on their impact on innovation and economic growth in wireless devices as opposed to the direct revenue considerations associated with spectrum auctions.
- That regulatory authorities significantly transform the management of spectrum. Alongside the three-tired sharing model already discussed, these changes include:
    - Allocation and Assignment: The report proposes a re-examination of spectrum partitioning in consideration of emergent technologies for dynamic spectrum access, in particular modifying FCC rules to allow for general authorised devices to operate in two bands, specifically the 3550-3650 MHz (radar) bands and another to be determined by the NTIA and FCC (p. xiv). This shift to dynamic spectrum access also requires a number of other regulatory configurations, such as the reconfiguration of spectrum allocations to produce wide bands dedicated to spectrum sharing (p.17); the production of substantial frequency blocks that are "agnostic" (p.101), meaning that the technologies and services deployed would not need to be specified in advance; and the implementation of methods for spectrum management that take into consideration, not only radio transmitters, but the behaviour of radio receivers (p.17).
    - Management Systems: The report proposes new means for managing dynamic shared access through the implementation of a Shared Access

System (SAS)[144] to act as an information and control clearinghouse (p.vii). The existing White Space device systems currently being developed and deployed by the FCC and other third part operators in the TV bands are put forward as a model to be implemented elsewhere. In light of this they recommend the nomination of a test city and related mobile test service to trial shared spectrum (p.135).

6.2.4 Analysis Of the Three Reports

While these three documents vary in terms of the proposed extent of spectrum sharing and the proposed expansion of license-exempt bands, there is also a high degree of consensus that allows us to briefly extrapolate the salient implications of the 2012 reports here.

All reports identified the economic or socioeconomic benefits of the spectrum-sharing approach. This considers not only the greater efficiency of dynamic spectrum access approaches, effectively solving current issues in mobile congestion, but also the benefits to commercial innovation that unlicensed spectrum is thought to afford. As the PCAST and the EC report both identify, this is a conceptual shift from a short-sighted focus on the value of direct revenue produced through spectrum auctions and secondary markets, towards a longer-term consideration of the economic benefits of commercial innovation and research in unlicensed bands that would be accumulated in a different way. The demonstrated economic success of innovation in the ISM bands is presented as a case in point to support this theory (Forge et al.., p.31; PCAST, p.3).

To implement a sharing approach, all three reports proposed the expansion of current unlicensed bands from the constraints of 2.4 and 5 GHz unlicensed spectrum towards UHF or VHF bands that afford advantages in power and scale. This expansion would be produced by clearing currently occupied but significantly underutilised bands in TV White Space or Federal Spectrum. All proposed the implementation of dynamic spectrum access techniques to manage and accommodate sharing, as well as the implementation of test-beds to experiment with these approaches[145].

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[144] The SAS database that holds information about what spectrum is occupied.

[145]All reports recommend a shift from exclusive assignment and allocation of licenses in favour of various modalities of shared assignment in which channels are occupied by multiple users. This

Furthermore, the adoption of a sharing approach proposes a fundamental reconsideration of the property rights associated with the possession of a spectrum license. Spectrum licenses would becomes more transient and easily transferrable, but most significantly, possession of a license would no longer afford the exclusion of that resource from others (PCAST, 2012). However, this transformation to the property right produces the least consensus among the three reports. By far the most significant point of contention concerns the issue of 'exclusive sharing' versus 'general-authorised access', with factions split between a two-tiered and three-tiered sharing model. To recapitulate the two-tiered model, proposed by the EC report and supported by mobile operators such as Qualcomm, Nokia, T Mobile US and other incumbents implements exclusive sharing for "a discrete, identifiable group of operators" and would allow "a licensed network operator to tightly manage access to the ASA spectrum…in order to provide users with a reliable quality of service, with all proven interference management/mitigation/cancellation techniques available in today's licensed mobile broadband technology" (Qualcomm, cited in Dano, 2013) while the three-tiered model, proposed by PCAST and supported by companies such as Google, largely recommends the introduction of general-authorised access (Dano, 2013). Consequently, while a two-tiered model maintains the status quo and extends the benefits of sharing to an exclusive consort of mobile incumbents, the three-tiered model allows for new commercial entrants into the market and also affords a degree of access to the general public.

While the Thanki and EC report are more speculative in the nature of their proposals, producing recommendations that will be taken under consideration by the regulatory authorities in Europe and the UK, the PCAST report is directly implicated in current changes to US digital policy under the Obama Administration. Since its publication, The Federal Communications Commission have indicated their intention to implement the initial stages of the PCAST proposal. In a memorandum "Expanding

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ranges from various forms of unlicensed access to licensed but underutilised spectrum in federal and non-federal bands, through to the removal of licensed bands altogether in favour of commons spectrum. Licenses themselves also become more fluid, operating across different time-frames, permissions and territories and facilitating access to spectrum on both an episodic and a spatially modest scale. Finally, regulations would be lighter – built around the assumption that anything not explicitly forbidden is permitted, as opposed to the legacy principle that everything is forbidden beyond what is expressly permitted by the regulatory body.

America's Leadership in Wireless Innovation", issued on the 14th June 2013, President Obama instructed federal agencies to use their allocated spectrum more efficiently and to make it easier for these frequencies to be shared with other carriers.

> Where technically and economically feasible, sharing can and should be used to enhance efficiency among all users and expedite commercial access to additional spectrum bands, subject to adequate interference protection for federal users, especially users with national security, law enforcement, and safety-of-life responsibilities (The White House, 2013).

Furthermore, the FCC announced in September 2012 that it will 'initiate formal steps to implement the key recommendations of the PCAST report". The first step concerns freeing 100 MHz of spectrum in the 3.5 GHz band for small cell use (Brodkin, 2012a).

These reports, while welcomed by many in the industry, have also lead to accusations of a creeping communism on behalf of the Obama administration (Brodkin, 2012a, reader comments). In the coming sections we will see that while critics may be misguided in their understanding of the broader intensions of this shift toward sharing as a modality of economic production, they are not entirely wrong in their identification of an increased communality within capitalism.

6.2.5 Summary

This section analysed transformations to property relations in mobile networks, focusing specifically on proposals to implement sharing in spectrum. Three reports published in 2012 exemplify the proposed transformations to regulatory policy and their recommendations were analysed in detail. It would seem that these reports indicate a shift in spectrum policy from exclusive possession towards a significant communality of spectrum. How this will be implemented and regulated and who specifically it will benefit is not yet clear. Where the enclosure of spectrum in exclusive property rights has been identified as a primary operand in the extraction of rent, this has significant implications for the future of value accumulation in spectrum. This will be explored in detail in the coming section.

Section 6.3: Analysis of the Implications of Spectrum Sharing

6.3.1 Introduction

The success or failure of these recommendations, many of which have yet to be implemented, are difficult to unpack. What are the implications of a greater communality of network resources? To analyse the broader implications means attending to the social and juridical possibilities of a greater communality of network resources, but also understanding how such a communality might be situated within a broader project that emerges in response to an impasse of neoliberalism. The former perspective understands a crisis of property as a 'sabotage' (Pasquinelli, 2008, 2010a) or 'disaccumulation' of rent, while the latter understands a crisis of property as producing a reconfiguration of capital in which the commons plays an increasingly significant role in accumulation.

In this section, therefore, we explore two competing perspectives on the communism of capital. One perspective, exemplified by theorists such as Hardt and Negri (2009), identifies a crisis of property as an outcome of the incompatibility between the potency of social production through digitally networked media and the paradigm of capitalist growth. This crisis is thought to destroy accumulation and proliferate the commons. In a similar vein, Berardi argues that the network economy is challenging the proprietary principle that has ruled modern capitalist society, producing the "final collapse of a system that has lasted for five hundred years." (2009b, pp.1-2). A second perspective, promulgated by commons theorists such as Caffentzis and De Angelis, takes a less optimistic perspective on the communism of capital, understanding the emergence of communality as part of a 'commons fix' (De Angelis, 2013) designed to re-establish growth and accumulation that does not proliferate any permanent material equality. Both of these proposals will be explored in this section through the lens of future regulation.

6.3.2 A Sabotage of Rent: Anti-capitalist Outcomes from Spectrum-Sharing

We begin by identifying the positive social, economic and juridical implications of a communality of spectrum.

Proposals for shared and unlicensed spectrum do seem to suggest a decomposition of the property relations previously governing common core infrastructure. Where

property rights normally involve a triadic privilege including possession, exclusion and benefit (5.2), all of which are necessary for the extraction of rent, shared spectrum dissolves this alliance in a situation where licenses now represent an "exclusive right to actual use, but not an exclusive right to preclude use by other…users: (PCAST, 2012, p. 23). As such this has significant implications for the consolidation of network control through exclusive property. At the very least, property starts to mean something quite different, and this difference produces possibilities for new forms of resistance or systemic exploit (Galloway and Thacker, 2007).

It is necessary to stress that the openness we identify here is something different to the forms of selective access already identified in social production in online environments. While a degree of openness and access is de rigueur in the philosophies of web 2.0 production, manifesting as open APIs, open source software and free platforms and content, this generally only extends to the content layer and selective aspects of the logical layer of the network. The physical layer infrastructure, such as processing and storage resources and the 'channels' themselves, tend to consolidate in exclusive property. As such, providing open access to the "only privileged protocol" (Galloway, 2004, p.11) of communication and cooperation and not just some higher layer service or platform that is made 'open' to extraction, could have significant implications for social production in digitally networked environments. Communality appears to inflect *all* layers of the network and undermine the necessary forms of enclosure that form key preliminaries for the extraction of rent. Where mobile operators leverage their exclusive control of spectrum to implement services and extract rent from mobile labour, the dissolution of property rights in spectrum poses a significant threat to their market position.

Pasquinelli understands a 'sabotage' of value accumulation over the commons as the only available political gesture of the multitudes against the anonymous and impersonal dimension of speculative rent (2008, p.48). Sabotage engages approaches that selectively destroy or contaminate the channels of rentier accumulation, perhaps by proliferating goods that capital has artificially made scarce or by identifying and exploiting possible limits to digital enclosure. As such, the introduction of dynamic spectrum access techniques, coupled with an increase in license-exempt spectrum, appear as a direct sabotage to the rent applied over wireless networks, destabilising

the proprietary channels that are a necessary accompaniment to the 'open' spaces of cognitive production. In a poetic correspondence, the metaphor of 'squatting' is sometimes invoked by telecommunications engineers to describe situations where unlicensed users opportunistically access licensed spectrum, directly evoking the disruptive potential of dynamic spectrum access techniques to licensed incumbents (Doyle, 2009, 2011; Safire, 2000). Through such a configuration, dynamic spectrum access is an enemy of rent.

These transformations might gesture towards a decomposition of information capitalism towards its inherent contradictions, as recent alterations to the technological composition of capital destabilise the economy of infrastructure. This in turn has social and juridical implications for the producers of online culture, potentially facilitating the development of communications channels free from commercial expropriation or sovereign intervention. For example, shared spectrum has positive implications for the development of a fully distributed, decentralised network (The Next Net, 2011). Not only an increase in unlicensed spectrum, but also a greater fluidity and transience in licensing, is conducive to smaller scale operations, nonmarket collectives and less economically powerful actors. Long term advocates of open spectrum argue that such transformations condition the growth and scale of community-owned networks that were previously constrained by the limitations applied to unlicensed spectrum (Bauwens, 2011; Burgess & Samra, 2008; Forge et al., 2012, Song, 2011). For example, the operation of an open source GSM network such as OpenBTS is currently prohibited because of the proprietary consolidation of the GSM spectrum bands. Should those bands become unlicensed, these inexpensive networks could be legally implemented, bypassing the commercial constraints of licensed incumbents. So too, wireless mesh networks that rely on the affordances of current license-exempt spectrum are currently constrained in their scale by the power-transmit regulations governing Wi-Fi. If other bands with better propagation characteristics such as sub 1GHz were to become available to unlicensed use, these networks could potentially scale and expand.

And yet the implications of a shared infrastructure are still very uncertain. If it is clear that we are seeing a dissolution of property as we know it, it is unclear whether a breakdown of traditional property is suggestive of an overall crisis of the logics of enclosure (and subsequently of rent) or simply indicative of its re-composition

through new channels. Just as there are possibilities for potential anti-capitalist commons in the new regulations, we can also identify possibilities for the failure of any lasting communality of spectrum, or indeed, other resources necessary for social and material reproduction.

6.3.3 Possible Failures of Spectrum Sharing

We can identify three possible scenarios that constrain any lasting communality of the network. While these are couched in the proposals for shared spectrum, they are also broadly indicative of three different outcomes for property rights in the future of capitalist ICTs.

Scenario One: The crisis is countered by an even stronger consolidation of property in spectrum and proposals for an increase in unlicensed spectrum are ignored or poorly implemented.

One obvious failure of the commons occurs where these recommendations for shared spectrum are rejected in favour of a continuation of direct revenue-producing auctions and secondary markets as a solution to resource scarcity, or where the benefits of 'sharing' are closely restricted to a select few incumbents. As discussed, there have been significant objections to the three-tiered access proposal by mobile operators who stand to forfeit market command with the introduction of sharing initiatives. As such the FCC has also agreed to seriously consider recommendations for the two-tiered (ASA) sharing structure proposed by Qualcomm, Nokia, T Mobile US and other US-based MNOs (Brodkin, 2012a). This is not sharing so much as a strategic fluidity of resources between collusive networks.

Scenario Two: Widespread or Modest Sharing is technically introduced but constrained by highly conservative regulations.

Another possibility for failure occurs where the three-tiered model for shared spectrum *is* tentatively introduced, but various forms of political or market-based lobbying produce unfavourable conditions for widespread adoption or general unlicensed access to spectrum. These might include conservative restrictions on the use of cognitive radios required for shared spectrum such as overly stringent power-transmit regulations or the introduction of highly politicised spectrum access systems

that favour powerful incumbents at the expense of general authorised users (ECMA, 2012; Marcus, 2010; Musev, 2013)[146].

These first two scenarios try to maintain exclusive resource control for a privileged oligopoly of powerful actors. However, in many ways proposals that adhere to exclusive licensing are not economically productive in the long run. A number of network theorists insist that reactionary approaches that cling to traditional property rights – through digital rights management, anti-piracy legislation, intensified intellectual property or a 'walled-garden' approach to networked management – all have a limited future (Berardi, 2009b; Kleiner, 2010; Moulier Boutang 2012). As demonstrated in chapter five, it is increasingly difficult to exercise property rights over digital networks. It is not only that an intensification of property rights over the commons is antagonistic to principles of justice, democracy or morality. Of course, the heavy imposition of technological surveillance and commercial interventions *is* understood to conflict with civil liberties and a generally understood Magna Carta, but the main conflict for *capital* resides in the "operating material of the accumulating regime of cognitive capitalism" (Moulier Boutang, 2012, p.107), where freedom, cooperation and multiplication are necessary ingredients for productive innovation. Because of the nature of what it exploits, production today must develop unhindered. As such it is unlikely that a complete absence of sharing or a tightly insular and controlled distribution of resources will be productive in the long term.

Scenario Three: Sharing is adopted, but with new enclosures.

The most likely possibility, then, is that open spectrum is widely implemented, but the technological apparatus transforms in such a way as to still produce effective forms of enclosure that operate *beyond* the property relation. Some early technical innovations in the management of license-exempt and shared spectrum seem to suggest that the emergent modes of accumulation may produce no necessary contradistinction between 'the commons' and 'the market'. As previously discussed, this alliance is already well observed at a content level, where open standards and open innovation are the locus of production for software development and social

[146]As Marcus (2010) has discussed, the models used in geolocation database lookup tables for opportunistic access to White Space are often highly conservative, returning results of occupation and access when in reality this fails to be the case.

media. From the PCAST and EC reports, it now appears that communality is beginning to inflect the physical layer also. This is perplexing, because until this point it appeared as though accumulation in cognitive capitalism has been based on fragile alliances between the old enclosures of material property and the new modes of value extraction from immaterial production. If these alliances break down – ceding to forms of openness not only in digital content, but also in the proprietary infrastructures that previously facilitated accumulation – how is that forms of accumulation might continue to act over the digital commons? In other words, how is such a privileged position produced, if not through proprietary enclosure? We need to tease out how this might play out, both theoretically and practically.

6.3.4 A Neoliberal Plan B

We will explore how this operates through network media in section 6.4, but first it is theoretically useful to situate our analysis within a set of strategies that appear to emerge alongside a broader crisis of neoliberalism. This brings us to the second perspective on the crisis of property as producing a necessary 'commons fix' (De Angelis, 2013). As De Angelis describes it:

> Nowadays the mainstream paradigm that has governed the planet for the past thirty years – neoliberalism – is at an impasse, which may well be terminal. There are signs that a new governance of capital is taking shape, one in which the "commons" are important. (De Angelis interviewed, An Architektur, 2011, p.1)

Commons theorists such as Caffentzis and De Angelis are beginning to sketch a regime that emerges from an impasse of neoliberalism as we know it (Caffentzis, 2010, De Angelis, 2013). However, instead of understanding this impasse as "the final collapse of a [capitalist] system" (Berardi, 2009b, p.1) like many of their autonomist contemporaries, these theorists identify the re-emergence of sentiments and behaviours appropriate to the commons as part of a new regime in the governance of capital, where both the question of the commons, and that of enclosures are drastically reconfigured in order to overcome the structural antagonisms emerging in contemporary capitalism.

For these theorists, an identification with the commons becomes a way to apprehend the crisis and internal limits of neoliberalism. In order to re-establish growth and accumulation, capital must transform the governance of social relations. To illustrate this shift, Caffentzis has traced the re-theorisation of the commons within

conventional economic wisdom (2010). Earlier neoliberal policy deliberately removed the commons element from material reproduction. For example, efforts to decommunalise land in Africa expressed the aims of the World Bank and other global planning agencies to "refuse all collective solutions to the problems of production and reproduction of the economy" (2010, p. 27). This perspective is the same theoretical approach put forward in Hardin's 'Tragedy of the Commons' (1968), and became the conventional wisdom of the World Bank, the IMF and development experts in the 1970s and early 1980s. Largely as a result of resistance, however, a decisive turn occurred in the ways in which the commons was conceptualised. For Caffentzis this is evident in the 1992 World Development Report where the authors for the first time defended to a limited extent the African commons. What we see here is that the commons is no longer exclusively the ideology of the left but becomes a mainstay of an emergent form of governance. Here the commons becomes "a political position to evade the antagonistic responses to the privatisation of land when they become powerful and aggressive" (p.29). This demonstrates that the emergence of this sentiment predates web 2.0, forming part of a broader strategy as opposed to an isolated response to issues with the digital economy. Caffentzis' focus is labour antagonisms that manifest in refusal and struggles over material resources, but the same framework applies to antagonisms emerging in information/computational manifolds where antagonisms between the necessary conditions for social production clash with network enclosures.

For Caffentzis, neoliberalism therefore requires a 'Plan B' that accepts the commons and understands that it might happily coalesce with the market in certain mixtures and regimes. Here Ostrom's theorisation of common property regimes or Benkler's descriptions of sharing as a modality of economic production have particular traction (Benkler, 2004; Ostrum, 1990). Both use a liberal economic framework to understand how rational agents can regulate resources through common property as opposed to public or private property relations. In such an arrangement the commons does not require the cultivation of anti-capitalist or even anti-individualist behaviour on the parts of its commoners. There is no necessary conflict with capitalism – or at least no inherent conflict that cannot be overcome through being changeable and adaptable. As Caffentzis describes it:

> the apparent triumph of neoliberalism with its aim to totalise the reign of capital has created its own reaction, that is, the conviction that there is a necessary 'commons' to capitalism itself. Thus the notion of 'social capital' and the importance of 'community' and 'trust' have been brought to the fore at the very moment of the so-called triumph of the market. In fact, this led to a re-recognition of a social ur-level before contract and 'the market' that structures them... and is a *sine qua non* of capitalist accumulation (p. 31).

To understand this distinction, Caffentzis theorises two different types of commons, respectively termed 'capitalist' and 'anti-capitalist'. At first blush, such a distinction appears crude, as recent controversies have shown us that the recognition of positive or negative affects on accumulation is far from straightforward. This said, the distinction is also useful, in that Caffentzis explores how forms of commoning (Linebaugh, 2004) that are not productive to capital (that escape circulation) must be effectively brought inside the market to maintain the accumulation process. In this fashion Caffentzis appears to theorise the capitalist commons as something that emerges like a spectre in the place of a pure unmediated social production. In many cases, however, Caffentzis acknowledges that it is "not often clear when a commons mixes in such a way with markets that it has positive or negative effects on accumulation"; just as capitalism co-opts the fruits of social production, workers can also fall back on 'ancient rights and liberties' as well as modes of reproducing struggle (p.37).

To be clear this re-emergence of the commons is not a rejection of neoliberal economic principles in favour of communism, but a methodological move intended to save it from its own internal antagonisms and from the external antagonisms of anti-capitalist resistance. The brand identity of corporations such as Google is a perfect example of this, as a company who pay so much lip service to openness and reflexivity, fully support open standards and personally cultivate a variety of open research and development projects such as Google's 'Summer of Code' and the 'Coder Dojo' (Bazzichelli, 2010). These approaches are not designed to altruistically disclose resources, but to socialise the risks and costs of digital labour while successfully enclosing the benefits. In other words, the aim is not to proliferate a permanent and perfect commons. As De Angelis argues, the current crisis requires a new designation of class/power relations and new systems of governance over social relations in order to recover growth and accumulation and the commons is at the

centre of this strategy (De Angelis, 2013). Caffentzis makes similar observations of the Obama administration, arguing they recognise the neoliberal Plan B as a "necessary intermediary between a stalled and a successful neoliberalism" intended "to return the economy back to its pre-crisis state of minimal state intervention" (p.37).

In summary it is necessary to stress that what Caffentzis describes appears to be something different to the commons/property relations already identified in social production in web 2.0. While the commons is significant for both, this is no longer so much about the dialectic between the commons and proprietary enclosures as the commons coupled to a new form of enclosure that produces less antagonism to its reproduction.

6.3.5 Summary

This casts the PCAST report in a different light. As previously mentioned, the report to the US president, when first published, was criticised by commercial detractors for its intimations of a 'creeping communism' on the part of the Obama Administration (Brodkin, 2012b, reader comments). While the implications of this creeping communism might not be what critics suggested -- the production of constraints on free market activity in favour of a return to state socialism - there is still some truth in the suggestion that a form of communism is coming to operate in the impasse of neoliberal governance. These reports recommending shared spectrum *do* bring the commons to the fore and they *do* suggest a communality of spectrum. Not as a project intended to proliferate a mobile commons, however, but as a 'commons fix' designed to overcome the antagonisms produced through rent.

This section explored the proposal for a spectrum commons from two different perspectives. First we identified the significant social and juridical benefits that a communality of core infrastructure is thought to produce while also threatening the consolidation of powerful incumbents. In this vein, the return of the commons is framed as a consequence of a systemic rupture in cognitive capitalism that produces a disaccumulation of capitalism. We then explored a different reading of the return of the commons that frames this as part of a post-neoliberal strategy in which the commons is an increasingly central but not necessarily contradictory element in capitalist accumulation. And yet, capitalism still needs enclosures. If we are seeing a

break down of property in favour of the commons, how does an acquisitive logic continue to operate? The next section will address this question.

Section 6.4: Networked Enclosures

6.4.1 Introduction

We are still faced with the following question: if the return and proliferation of the commons does not suggest a disaccumulation of capital, how might accumulation continue to operate in the network, seemingly beyond traditional property rights? Capitalist growth still requires some species of enclosure (De Angelis interviewed, An Architektur, 2011), so what forms do these new enclosures take? These are the questions we wish to tease out in this section.

Similar to the other core sections of this chapter, which have moved back and forth between technical literature on the future regulation of spectrum and theoretical literature on the communism of capital, this section will draw on critical theory as well as specific examples of proposed regulations for license-exempt spectrum in order to synthesise and speculate on the future operation of enclosure in digitally networked media. This approach is reflexive: it applies a theoretical framework on forms of modulating control to proposed commons regulation in order to tease out the broader implications of these for the future political economy of mobile networks. Equally, it synthesises technical proposals for the control of newly unlicensed spectrum to speak to burgeoning theories of the new enclosures.

This begins with a critical foundation of the transformations in property relations, and then proceeds to an analysis of the proposed regulatory approaches for dynamic spectrum access in the newly unlicensed bands (CSMAC, 2012; ECMA, 2012; Ofcom, 2011; PCAST, 2012; Webb, 2012). Where these regulatory approaches rely on forms of control immanent to the network architecture as opposed to external property rights, these are related to theories of network control from new media theory (Galloway, 2004) arguing that this is an appropriate framework for the forms of management proposed for the new spectrum commons.

6.4.2 Beyond Property

Before looking at the operation of forms of enclosure over dynamic spectrum access in newly unlicensed spectrum, we will briefly synthesise theory on new forms of enclosure thought to emerge from an impasse of neoliberalism/rent.

Previous discussions of the 'neoliberal plan b' suggest that there is not an absence of enclosure following antagonisms in value accumulation so much as a break down and reconfiguration of the property relation, and an attendant shift in terms of the kinds of property that are significant. What follows? The nature of bourgeois private property was explored in chapter five, identifying it as a historically contingent bundling of rights to use, benefits and exclusion of a resource that took substantially different forms in other historical eras (Moulier Boutang, 2012, p.99). So too, Marx reminds us that "[i]n every historical epoch, property has developed differently and under a set of entirely different social relations" (Marx, 1920, p. 154). The suggestion, therefore, is that traditional property relations are now undergoing transformation.

The antagonisms of rent explored in chapter five appear to arise from a burgeoning conflict between 'old' property relations consolidated in industrial capitalism as they interact with 'new' systems of accumulation peculiar to cognitive capitalism. Where there were fragile alliances established between these for a time, these are now breaking down, ceding to other forms of enclosure and control. This perspective draws on Moulier Boutang, who in the past has proposed that cognitive capitalism operates on fragile alliances between competing epochs (2012, p.112).

Drawing on the antagonisms in private property we can argue that these alliances have reached an impasse and we see the emergence of a new property relation. In acknowledging this condition, anti-capitalist factions are faced with two challenges. The first challenge is to minimise to the best of our abilities the phase during which cognitive capitalism and industrial capital can build tactical alliances between old forms of property and new forms of accumulation. The second challenge is to try and recognise the developments and relations of the new enclosures. This second challenge is the focus of our enquiry here.

In teasing out transformations to enclosure we can identify how, depending on the system of accumulation in operation, the emphasis falls on different types of

property (immobile; mobile, material; immaterial etc) and therefore on different types of commensurate enclosure (land, mobile property, the subjugation of the wage relation, debt etc) (Hardt, 2010). In the 'Common in Communism', Hardt traces a shift from immovable to mobile forms of property in the transformation from a mercantile to an industrial form of property (ibid). Similarly, in the transformations from industrial to cognitive capitalism, he emphasises a shift from material to immaterial commodities. Reductively we might draw on Hardt and theorise this as a shift from value accumulation operating over land, to accumulation through the production of commodities and finally accumulation through the social production of information, with attendant systems of enclosure that can be theorised as a progression from the walls and hedges that enclosed commons land, through to the factories that corralled industrial labour, towards the network as the site of enclosure operating over social production in the contemporary operation of capitalism. As previously discussed in chapters three and four, the network requires a different type of enclosure, involving more than simply the separation of labour from the means of production, moving instead towards attempts to provide open access to tools in a mediated space that organises and encloses labour productively, only not too much. As the shifting forms of regulation in spectrum should go some way to demonstrating, this model is still being modified and tested out.

So too, depending on the system of accumulation in operation, the emphasis falls differently on specific aspects of the property relation. Just as Moulier Boutang identified the socioeconomic construction of bourgeois property rights in the seventeenth century, conditions now points towards a break down of the previous connections between use, benefit and alienability, particularly in the domain of information and communication technologies, with the new regimes favouring some, denying others or otherwise reconfiguring the balance of these properties (2012, p.115). We see this clearly in proposals for sharing in the 2012 reports, but also more generally in changes in the network that dissolve different relations of property into their productive and possessive components or also appear to selectively leverage one or other aspect of these at different times. The most significant tendency in this respect is a burgeoning emphasis on the property rights arising through the *use* of a resource as opposed to those arising simply from possession and *exclusion*. In such

an emphasis, openness can become a positive modality in economic production because disclosure affords opportunities for accumulation at an expanded level.

A number of theorists make oblique suggestions that, while enclosure is the *sine qua non* of value accumulation, the nature of those enclosures is transforming from property as we recognise it (Hardt, 2010; Moulier Boutang, 2012; Pasquinelli, 2008). As such this section argues that we are not seeing an absence or break down of enclosure, so much as a reconfiguration of property specifically away from a relation that proceeds on the basis of a necessary opposition between the commons and accumulation towards a modality that produces no necessary friction between the two. So what does this enclosure look like? The following conclusions are tentative, but they include a transformation in enclosure from those that operate over space to those that operate over a spatiotemporal relation; from enclosures that are static to those that are modular; and from enclosures that are externally imposed to those that are immanent to the subject of the network.

Pasquinelli has used the work of Italian economist Enzo Rullani to theorise the ways in which private property in cognitive capitalism does not disappear, but instead is subject to a new logics of diffusion (2008). In effect, Rullani argues that due to the nature of immaterial production, a proprietary logic is no longer based on the space and objects of production, but on the time and speed of diffusion. As Pasquinelli describes it:

> In his book *Economia della Conoscenza*, Rullani discusses how easily reproducible cognitive products must immediately undergo a process of diffusion in order to maintain a degree of control or ownership. Since an entropic tendency affects any cognitive product, it is not recommended to invest in static proprietary rent. In actuality, there is a rent produced on the multiplication of uses and a rent produced on the monopoly of a secret. These are two opposite strategies: the former is recommended for cultural products like music, the latter for patents (2008, pp. 96-97).

Pasquinelli uses this framework of diffusion to describe how rent is today applied along temporal coordinates; for example, being the first to colonise a space, or capitalise on an innovative idea. Instead of rent as a technique of extraction maintained by persistent and static forms of property, rent is contextualised as a situation based on competition and speed. As such, Pasquinelli goes some way

towards demonstrating how rent in ICTs can be extracted along very mobile and temporary micro-monopolies, often bypassing the limits and constraints of existing property regimes in favour of very temporary and fragile insinuations between labour and the market.

According to Pasquinelli, a good example of this in action can be found in the business model of an advertising revenue based company such as Google (Pasquinelli, 2009). Google has positioned itself as an ongoing supporter of free culture, and in particular open spectrum because it requires the maximum access, participation and productivity for the indexing and aggregation of social production in online environments. In such a business model, the focus is less on the defence of intellectual and material property, therefore, than the production of a monopoly on human attention as the primary scarce commodity produced by the information age (Dean, 2012; Pasquinelli, 2008).

Pasquinelli's analysis is intriguing to a discussion of new forms of enclosure, if at times problematic. Where Pasquinelli theorises this as a form of accumulation that bypasses the usual interstices of material and intellectual property, he conveniently disallows the significant weight of intellectual property surrounding Google's own software algorithms, to say nothing of the extent of material infrastructure (labour power; real estate; storage, processing and cooling resources) required to maintain such a competitive position in the digital economy. With this said, however, Pasquinelli is still correct to make a distinction between the dynamic role of property in the extraction of rent for the new software conglomerates such as Google and the more traditional property relations, associated with, for example, a standard PPU model. To reiterate, it is not that a proprietary logic disappears, but that it succumbs to a much more rapid modulating form of control that is about being able to 'let go' at the right moment (Kelly, 1997) and equally consolidate a proprietary position when necessary.

6.4.3 Networked Enclosures for Shared Spectrum

Given the brevity of the literature, this analysis only takes us so far. Theoretically this is also quite abstract; therefore, we will now return to an analysis of spectrum, detailing the proposed forms of regulation for dynamic access to shared spectrum. Here we will see that the emphasis revolves from a centralised regulatory authority

that performs enclosure through external juridical control of the resource towards modulating forms of control that operate through the network.

To demonstrate this fully it is necessary to analyse not only the proposals for sharing (explored in section 6.2) but also to attend to some of the emerging proposals for regulating and monetising unlicensed spectrum. This introduces some new technical literature; along with the reports detailing proposed shared access to spectrum are a number of others outlining the new forms of regulation and automated management considered appropriate to a spectrum commons (CSMAC, 2012; FCC 2012a; PCAST, 2012). These largely focus on the exercise of distributed forms of self-regulation through a networked system.

While there is not a lot of literature on this yet, and therefore proposals for the future regulation of spectrum are tentative, these proposed systems take much of their direction from the regulatory protocols designed for use with TV White Space devices (ECMA, 2012; Karimi, 2011; Ofcom, 2011; Webb, 2012)[147]. Early proposals for unlicensed access to White Spaces suggest coordination through geolocation with database lookup: using dynamic spectrum access techniques, White Space devices are equipped with location-aware technologies such as GPS and connected to a centralised database detailing the incumbents (TV stations) operating in the surrounding electromagnetic frequencies and geospatial area (Ofcom, 2011). Regulatory authorities are currently in the process of establishing third party companies to coordinate the operation of these databases with license exempt radios (White Space devices). Companies such as Spectrum Bridge, Telcordia and Google have already tested and started operating White Space networks (Brodkin, 2013a; FCC 2011, 2012a, 2013).[148]

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[147] As previously discussed, 'White Space' is the sub 1 GHz spectrum (the UHF bands primarily between 50 – 700 MHz) made available by the switch to digital broadcasting.

[148] As technology journalist Jon Brodkin (2013) observes, such testing does not necessarily indicate a future in wireless networks using TV White Space spectrum, although Google already has a small legacy as an Internet Service Provider in Mountain View and a small portion of NYC. Public knowledge senior Vice President Harold Feld indicates that Google may have strategically applied to become a database provider to offset threats posed by other companies controlling infrastructure:

> "my belief has always been that Google applied primarily to cover its rear end and made sure that—however they ultimately ended up monetizing the TVWS [TV White Spaces]—they didn't need to worry about someone else having some kind of control over one of the key components (the database). So it is not … that this demonstrates any specific plans about

The first priority for such a system is to protect incumbents and existing licenses from harmful interference; the second priority is to coordinate opportunistic access by license-exempt devices as efficiently as possible (ECMA, 2012; Ofcom, 2011). These systems use a centralised database to gather information about devices (Webb, 2012). White Space devices contact the database periodically and provide their location. The database then returns information about start and end frequencies for any available bands and indicates whether there is any requirement for dynamic sensing (Ofcom, 2011, p.8). Such a database needs to dynamically reconfigure and may need to service millions of requests per day, requiring significant resources for data processing and storage (op cit, p.9).

Proposals brought by the US Commerce Department's Spectrum Management Advisory Committee (CSMAC) published similar recommendations for unlicensed spectrum in Federal bands in July 2012. These included the introduction of 'tethered' or 'connected' radio devices in all federal bands that might be made available for shared access and in all newly-created unlicensed bands. The cognitive radio in question has a form of networked connectivity that allows it to negotiate spectrum access in a dynamic fashion, accessing locative information pertaining to frequencies that are occupied or off-limits in particular geographic territories. However, this connectivity also allows a device to be controlled and accessed remotely. This facilitates a shift from autonomous radios, operating through juridical regulation to one in which some central authority has the power to remotely monitor or even temporarily or permanently disable a consumer device. This potential is engineered into the device itself.

As the CSMAS report argues, all devices for unlicensed access should be:

> connected devices, which are required to call home periodically [contact a spectrum management database] to renew authorization to operate in a band and obtain firmware updates (p.3).

The commission recommend the control and management of such systems through a Spectrum Access System (SAS) database such as those already in operation in White

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what it wants to do in the TVWS, it just means that Google doesn't want anyone to be able to mess with them once they launch whatever they are going to do" (Brodkin, 2013).

Space. The CSMAC report also discusses the possibility to de-activate devices that are deemed to be 'noncompliant' through the operation of "mitigation steps when interference occurs, including the possibility of automatic shut off or losing access to particular frequencies" (ibid). While this noncompliance primarily relates to 'interference', the report also proposes further discussion of a motion concerning intentional interruption of a wireless service by government agencies for the purpose of ensuring "public safety and law enforcement" (p.7)[149].

Furthermore, CSMAC outlines the possibility to leverage the power of the network to report or inform on noncompliant devices, proposing to deputise these tethered consumer devices to report back violations by neighbouring radios or to facilitate in the aggregation of network content. This is maintained through:

> The establishment of a voluntary clearinghouse website to leverage the power of crowd sourcing by creating a tool for consumers or government operators to file reports of interference to create a snapshot of where such incidents may be occurring and when (p.9).

The PCAST report also discusses the integration of Digital Rights Management capabilities into connected devices, in order to provide 'security and reliability' for transmission requests and permissions sent between devices and the spectrum access system (2012, p.104). However, this is also an extension of the existing managed device platforms and cloud architectures produced by companies like Apple and Amazon, and therefore can also facilitate automated control in accordance with not only FCC regulations but also third party intellectual property rights. In reality, the possibilities for action at a distance are endless in this scenario because agency is abstracted from the user to a remote hub, controlled by a centralised authority. The user no longer follows rules as external directives; instead, these are simply engineered into the technical system and codified through forms of automated management (Kitchin, 2005; Kitchin & Dodge, 2011). Finally, the CSMAC report

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[149] The quotation in full states that the committee will "explore though legislation, regulations or industry/government agreements, the ability of the Federal government to expand its enforcement of spectrum interference rules, especially as it may relate to public safety and law enforcement" (p.7).

proposes the hegemony of this connected approach through the gradual phasing out of all unconnected devices, or through their restriction to legacy bands of spectrum:

> all future unconnected devices should be restricted to legacy bands of spectrum where they are already prevalent. Policy makers should consider whether such devices should be even further restricted in the future, phasing out their access to very high-quality bands over an appropriate time period (2012, p.8).

In short, these are proposals to remove the traditional command and control forms of regulation in favour of immanent forms of control built into the mobile device itself. Existing un-tethered devices will be phased out in favour of software-defined radios.

Future Monetisation of Spectrum

The revenue model for shared spectrum is a significant concern for both national regulatory authorities and mobile network operators. Though not expressly outlined, this tethered system also produces the possibility for new forms, not only of surveillance, but monetisation and billing of users. As discussed in chapter five, there are two different forms of rent extracted from spectrum: direct rent over spectrum as a means or element of production, where spectrum is utilised in the development of new communications networks and indirect rent over services and commodities produced through the utilisation of the resource such as access to user data now and into the future. The shared spectrum property relation has implications for the progression of both. For direct forms of rent, the majority of projections suggest a shift from direct revenue procured through auctions and secondary markets in spectrum towards 'spectrum usage fees' or leasing arrangements to priority access to unlicensed that produce ongoing revenue (PCAST, p.vi). Like the auction value of a license, this leasing structure would be evaluated through the MHz-pop equation operating on the perceived future value of spectrum as a resource. The ability to transfer and reapportion spectrum would be much more straightforward allowing for a greater speculation on the resource, producing value for the incumbent greater than what can be produced through use or speculation alone. For indirect rents, the situation is more tenuous, particularly for mobile network operators who stand to potentially lose their monopoly position in the network if sharing is introduced. For example, if users can make use of alternative open access structures for

communications, particularly voice over Internet Protocol (VOIP)[150] services, it is not clear how mobile network operators may continue to maintain a privileged position to extract revenue from user-generated content. However, this appears to be largely based on a principle - already in practice in the wired Internet - that an open model will cultivate future innovation and productivity that can be captured and monetised elsewhere. In the case of spectrum this includes possibilities such as control through database management (ITU, 2012 p.18), control through managed devices and control through advertiser-revenue based services.

As previously discussed, this is a shift in emphasis from leveraging the value of alienability towards the value of use in the property right. This is the model that advertising revenue based companies such as Google adopt: advocating a spectrum commons because the locus of accumulation in the advertising revenue model is centred on access to rather than enclosure of communications. By inserting itself as a database manager for example, a company such as Google can proliferate access to wireless networks while still strategically inserting itself in the value chain through the spectrum access system or through platforms, services and software in mobile networks (Brodkin, 2013a; Google Inc., 2013; ShadowAce, 2008). We are still left with a 'license exempt' structure, but with a much more totalising regime that routes around the traditional notion of property and enclosure, where every aspect of our internet enabled devices are made over to extraction from an external authority, be it the state or the corporation.

Here we encounter a commons with a new kind of networked enclosure. The frequency band becomes comparatively 'open' to forms of generalised access, but multiple operations at the level of the network architecture continue to regulate activity, at possibly a more deeply embedded and subjective level. It might seem, therefore, as though we are not witnessing any 'disaccumulation' of network infrastructure, but a modulation of control along a new metrics of speed and diffusion. And these forms of 'free floating' control are resonant with the characteristics of networked information technologies. Networked media facilitates the forms of distributed organisation associated with 'openness', 'freedom' and

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[150] For example new mobile applications such as viber and whatsapp make use of VOIP communications to bypass mobile network operators call and service charges, making use of services operating over unlicensed spectrum.

socialised 'peer-production', while at the same time they equally facilitate an immanent surveillance, aggregation and control of distributed 'free' agents. Similar to the open access models employed in the wired Internet, therefore, it seems as though the transformation of spectrum points towards a new phase in the monetisation of mobile networks. This is based not so much on the exclusive or static ownership of a resource but on the financialisation of that resource combined with opportunistic forms of collaborative sharing (Botsman & Rogers, 2011) by powerful incumbents. It involves enclosing when necessary and equally ceding control when this is commercially advisable.

6.4.4 Protocol

It is useful here to consider the work of media theorists who have identified forms of modulating control in software and networked media (Fuller, 2008; Fuller & Goffey, Galloway, 2004; Galloway and Thacker, 2007; Kitchin, 2005; Kitchin and Dodge, 2011). Galloway's 'protocol' in particular has been instrumental in bridging political philosophy that addresses regimes of modulating and immanent control with the technical dispositif of communication networks (2004). Biopolitics and biopolitical production are particular significant to Galloway's theoretical framework, where a general synthesis of autonomist theories of power and counter power - 'Empire' and 'Multitude' (Hardt and Negri 200, 2005) - are coupled to a specific analysis of Foucault's theories of security in biopolitics (1998, 2009, 2010) and Deleuze's expansion of these through 'societies of control' (1992). To be reductive, all of these figures theorise the emergence of immanent, decentralised and flexible forms of control emerging in the latter half of the twentieth century.

While there is a universal acknowledgement that such regimes progress and advance alongside the development of information and communication technologies, the majority of political philosophy does not directly engage with a theory of the new media or indeed, anything much in the way of empirical analysis (Poster, 2005). Instead, the 'network' is frequently employed in the literature as a metaphorical trope for fluid forms of organisation, sociality, discipline and insurgency seemingly unconnected to a techno-material substrate (Thacker preface to Galloway, 2004).

For theorists such as Galloway, Thacker and Mark Poster, this position is problematic, because "you have not sufficiently understood power relationships in the control society unless you have understood 'how it works' and 'who it works

for'" (Galloway, 2004, p.xviii). As such, Galloway's *Protocol* argues for a "methodological shift" from a generalized understanding of networks (as a diagram for forms of organisation in social and technical systems) towards a materialist understanding of how protocological systems in the Internet operate as what Foucault termed "political technologies" (ibid). In Galloway's work, this theoretical framework is adapted to a deep technical consideration of protocols, standards, institutional histories and instances of hactivism and tactical media (Lovink, 1997) in the Internet, exploring how "power relations are in the process of being transformed in a way that is resonant with the flexibility and constraints of information technology" (p. xix).

In his analysis, Galloway specifically references the logical architecture of the fixed Internet, analysing the competing dynamics of distributed end-to-end principles (TCP/IP protocol) as they interact with hierarchical systems such as the Internet's domain name system (DNS). This framework is therefore very appropriate to an analysis of the relationship between, on the one hand, proposals for highly distributed license-exempt mobile devices and on the other, the centralised access systems (SAS databases) proposed to dynamically control and regulate their activity in everyday spaces. As such, this framework elucidates the implications of the future governance coordination of open spectrum and merits expansion.

It is first necessary to briefly rehearse the theoretical underpinnings of Galloway's protocological logic because these derive not only from the post-operaismo theoretical framework used throughout this thesis, but also a Foucauldian approach which, for the purposes of a focused enquiry, has not been thoroughly engaged in this thesis[151]. Foucault identifies a shift from sovereign to disciplinary societies, developing in the eighteenth and nineteenth centuries and coming to fruition in the early twentieth century. This historical shift from sovereign to disciplinary power is developed throughout Foucault's writings, particular in *The History of Sexuality,*

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[151] This thesis draws on an autonomist theoretical framework grounded in the general intellect. While a biopolitical framework is also useful to explore the transformation from command and control regulation towards a commons, many of the core tenets of Foucault's analysis of liberal economics do not directly confer with those of an autonomist perspective. For the purposes of a coherent thesis argument, therefore, the autonomist framework is chosen and a Foucauldian framework, while informing exploratory research in the subject, is necessarily limited. However, where Galloway's protocological approach synthesises both of these theories in an analysis of networked command, it is necessary to introduce this theory here for explanatory purposes.

Volume One, which introduces the concept of biopolitics for the first time and later in his Paris lectures on liberal economy (1998, 2010). Deleuze expands tenets of this in 'Postscript on Societies of Control' (1992).

The disciplinary society "initiate[d] the organization of vast spaces of enclosure" , "organising major sites of confinement" (Deleuze, 1992, p.3) that were exemplified by institutions such as the family, the school, the barracks, the prison and the factory. For Deleuze, the ideal project of these closed environments correlates with the environs of the factory: "to concentrate; to distribute in space; to order in time; to compose a productive force within the dimension of space-time whose effect will be greater than the sum of its component forces" (ibid). This disciplinary model (and its attendant institutions) undergoes a crisis in the post-war era, resulting in what Deleuze identifies as a general breakdown of all the sites of confinement by the closing decades of the twentieth century. What emerge are 'societies of control', characterised not so much by static enclosure as by "ultrarapid forms of free-floating control that replace the old disciplines operating in the time frame of a closed system" (p.4).

Where the disciplinary societies applied rigid 'molds' as forms of confinement to the individual, the societies of control are characterised by immanent and automated forms of control that reduce society to what Deleuze describes as 'dividuals' (p.5), numerically reducible identities that are codified by multiple datastreams and data shadows: biometric, psychographic and demographic data "giving the position of any element within an open environment at any given instant" (p.7). To make this distinction, Deleuze compares the role of the signature as a guarantee of identity in the disciplinary society with the regulatory role of the password in the societies of control. As briefly identified in chapter two, money too differentiates the two forms of society, where disciplinary societies correspond to "minted currencies that locks gold as a numerical standard, while control relates to floating rates of exchange, modulated according to a rate established by a set of standard currencies" (p.5).

But perhaps most relevant to its application here is the strong distinction Deleuze makes between the technological substrate of these two societies, illustrated by a shift from manual thermodynamic machines towards information and communication technologies. Just as the steam engine or production line is emblematic of a certain labour relation particular to industrial capitalism,

information technologies and their attendant topologies reflect the new cognitive capitalist division of labour, a shift identified in chapter two. This distinction is not supposed to be determining, but rather to identify how technologies "express those social forms capable of generating and using them" (p.4). Computational machines and the attendant development of epistemologies such as cybernetics and cognitive science are thought to be historically concurrent with the advent of societies of control. So too the topology of the distributed network replaces that of the disciplinary panopticon as the architecture of control with what is sometimes called 'sousveillance', describing immanent forms of control (Kitchin, 2005). Galloway extends this discussion to the wired Internet, exploring how Internet protocols manifest the modulating forms of control identified with this society (2004). Notably, Galloway writes of a confluence of competing dynamics within the protocol stack, where horizontal and distributed logics operating alongside vertically integrated and highly stratified spaces make a seemingly autonomous agent 'open' to control at a deeper subjective level.

Principally, the questions of agency, power, control and enclosure operating in network media are reconfigured in Galloway's analysis. The discussion of antagonisms in rent in chapter five identified a fundamental antagonism in the political economy between opening the relations of property more and potentially losing control of accumulation or alternatively enclosing more and stifling productivity. A protocological approach does not recognise any necessary contradistinction here, presenting an architecture that is neither formally open or closed, but continually modulated (Deleuze, 1992; Galloway and Thacker, 2007, P.125). The very concept of the Internet demonstrates this capacity on any number of levels; "In fact, the various Internet protocols mandate that control may only be derived from such a distributed architecture" (Galloway, 2004, p.25). This provides a framework for understanding how enclosure can continue to operate in the absence of a tightly consolidated or exclusive property relation. As Thacker describes:

> The Internet is not simply "open" or "closed" but above all a form that is modulated. The very concept of packet-switching demonstrates this on several levels, from the efficiency standards of routing during a download, to the ways in which each individual datagram is tagged for delivery to your email account or hard drive. Information does flow, but it does so in a highly regulated manner. This dual

> property (regulated flow) is central to Protocol's analysis of the Internet as a political technology (Thacker preface to Galloway, 2004, p.xix).

As a techno-material embodiment of principles of the societies of control, Galloway (p.82) describes protocol as follows:

- Protocol is a system of distributed management
- Protocol facilitates peer-to-peer relationships between autonomous entities.
- Protocol is anti-hierarchy and anti-authority
- Protocol engenders localised decision making, not centralised
- Protocol is robust, flexible and universal
- Protocol can accommodate massive contingency
- Protocol is the outcome (not the antecedent) of distributed behaviour

We reproduce the defining characteristics of protocol in their entirety here as they strongly conform to the technical specifications of the new spectrum access database systems that are proposed for dynamic spectrum access. Instead of command and control through a centralised juridical authority, control is a distributed modulation that facilitates autonomous interactions between network devices; engenders localised decision-making and is ultimately adaptable, robust and reconfigurable. While the SAS system still reproduces the authority of the national communications regulatory authority, this authority is engineered into the mechanics of the system, forming part of a transparent automated management system (Kitchin, 2005; Kitchin & Dodge, 2011; Thrift & French, 2002).

This is a shift not only from 'discipline' to 'control', but also from 'enclosure' towards what Deleuze describes as a 'modulation':

> Enclosures are molds, distinct castings, but controls are a modulation, like a self-deforming cast that will continuously change from one moment to the other, or like a sieve whose mesh will transmute from point to point (p.4).

Much like Rullani identifies a property relation established upon the metrics of speed and diffusion (cited in Pasquinell, 2008), Deleuze appears to suggest that rigid and static enclosures are replaced by a new speed and temporality, characterised by 'short-term' operations and "rapid rates of turn-over" (p.5), that are continuous and without limit, an enclosure of 'time and subjectification'. Deleuze argues that "man is no longer man enclosed, but man in debt" (p.6).

What is the difference between the old forms of 'private property' and a system of enclosure configured through the modalities of 'debt'? We can take this condition of indebtedness literally, as it refers to the intensification of financial economics and creditor-debtor relations in the societies of control that Deleuze has identified throughout his postscript. But we can also further abstract the condition of debt and the figure of 'indebted man' to use Lazzarato's phrase (2012), as the broad condition and subject of the new enclosures that follow on from a crisis of property relations in the network. Here we are speaking not only of spatial enclosures but also of the spatiotemporal, both in the pervasive quality of the new enclosures but also in their micro-temporal qualities as enclosures that continually reconfigure according to a set of variable conditions moment to moment.

6.4.5 Summary

Through an analysis of recent reports and government issued memorandums, this chapter indicated that dynamic spectrum access and unlicensed spectrum is both a viable and likely future for regulation. The communality of spectrum appears to emerge through an impasse of rent. This in turn might represent opportunities for resistance and sabotage (Pasquinelli, 2010a) through the breakdown of property relations substantially producing the network. However, through an analysis of the proposed regulations accompanying spectrum-sharing, it seems as though enclosure does not disappear, but simply undergoes a transformation from the property relation as we recognise it towards an immanent and self-regulating modality. This in turn allows for a greater control and monetisation of users, but one that does not substantially interfere with the relations of production governing the network. While access to electromagnetic frequencies is socialised. control is increasingly abstracted from the user through new modalities of enclosure immanent to the network. As such, the new enclosure produces no antagonisms with the commons; instead the commons plays an increasingly central role.

Section 6.5: Conclusion

Synthesising the arguments from previous chapters, this chapter asked if a crisis of rent produces a disaccumulation of capital or simply its reorganisation through new systems of enclosure in which the commons is destined to play an increasingly central role.

Through a synthesis of three government commissioned reports, section 6.2 demonstrated that a shift from command and control licensing towards dynamic spectrum access in license-exempt spectrum is indicated for the future. While the various reports differ in the extent of the sharing proposed, they all indicate a reconfiguration of the regulatory apparatus from the exclusive licensing model that structured the past 100 years of radio regulation towards a new property relation. This change was probably best summarised by PCAST's statement "the norm for spectrum use should be sharing, not exclusivity" (2012, p.vi).

Bearing in mind the core enquiry of the thesis, this was then assessed from two different perspectives: Does a communality of network resources suggest a disaccumulation of capital through structural contradictions in the operation of rent? And if not, how does an acquisitive logic continue to act, seemingly beyond the environs of the traditional property relation?

In section 6.3 and 6.4 we saw that while open spectrum presents possibilities for the scale and development of autonomous networks in theory, in practice new forms of regulation performed by centralised network databases actually produce a greater and more immanent form of enclosure over the network than the juridical property right. This observation can be positioned within what commons theorists such as Caffentzis and De Angelis respectively call a 'neoliberal plan b' (Caffentzis, 2010) or a 'commons-fix' (De Angelis, 2013), describing a set of commons strategies for the neoliberal economy to recover from an impasse of rent.

Section 6.4. goes some way towards identifying the shape of the new enclosures, making reference to the technical literature on database regulation and situating this system of automated management within new media theory that identifies forms of modulating and 'protocological' control (Galloway, 2004). This is a system of networked enclosure that operates outside of the recognisable property relation but instead within the metastable conditions of the network itself. This analysis suggests that, far from proliferating a permanent and total commons, new enclosures are in operation in the seeming communality of network resources. This marks a shift from enclosure that is performed through property as a static and juridical relation towards what we can broadly describe as a form of 'debt', referring to a modulating and spatiotemporal enclosure that is immanent to the subject of the network. Rather than suggesting a breakdown of control in the network, therefore, the questions of control

and the conditions structuring access to network media have never been more significant.

In the early stages of spectrum regulation analysed in detail in chapter four, we first identified the emergence of a new information milieu (Terranova, 2009). The 'ether' was quite unlike the productive spaces that characterised industrial capital, gesturing towards another system of production and accumulation in which immaterial production and forms of action at a distance would take precedence. So too, this productive space cannot be regulated in the same way, it resists authority that stifles the necessary openness for production. In the early stages of radio regulation we can identify attempts to manage the productivity of this space through external forms of state regulation and juridical command. Such techniques are not appropriate, however; they require a different system of enclosure.

With the emergence of a neoliberal economy (corresponding to the deregulation of spectrum in the 1980s and 1990s) we can identify the emergence of an approach that produces temporary alliances between these old forms of regulatory enclosure of this space and the new forms of networked production now taking place. The antagonisms discussed in chapter five appear to suggest a structural impasse in this alliance and the old 'sites of confinement' (Deleuze, 1992, p.3) are breaking down and reconfiguring. As Terranova identifies, the network requires an attendant control that is not exercised though external regulation or command, but instead must come to operate within the natural modalities of that system (2009). Control must shift from external regulation towards an immanent and modulating command that can account for and adapt to the unstable co-causality of the milieu while also making it productive to capital (p.243).

Chapter Seven: Conclusion

Section 7.1: Introduction

It is still difficult to say what the effects of a reconfiguration of property relations are for the future of communications networks in particular and social production more generally. However, any efforts to disrupt the current systems of enclosure accumulation must first proceed through such an enquiry. Developing a strong understanding of how concepts such as openness, the commons and enclosure are critically reconstituted is a crucial step in this process. If we grasp the new relations between the commons and enclosure, we are less likely to naively equate forms of oblique socialisation or crude communism with a radical liberation or autonomy. We are also more likely to be able to theorise or enact appropriate strategies of resistance or refusal at some point in the future.

Section 7.2: Summary of the Thesis

The key tasks set out in the thesis were first to trace the tenets of the new system of capitalist accumulation operating over social production in digital networks and then to identify and attend to the antagonisms emerging through the dynamics of this system.

First we had to demonstrate that the relation between the commons and capital was reconfiguring in some vital way, as a series of transformations to the economy dissolved the previous oppositions between social production and capitalist accumulation. This involved debunking a popular 'ideology of free culture' that understands social production through digitally networked media as inherently nonmarket and anti-capitalist. Consequently, chapter two analysed how, through a series of economic transformations following on a crisis of Fordist accumulation, capital reconfigures, expanding further outwards to the expropriation of a 'diffuse intellectuality' operating at the heart of social production (Vercellone, 2010). This in turn transforms the relations of production away from those typically associated with organised and subjugated work towards conditions in which the social and the economic conflate. Work now describes a pervasive form of production. This relation is pervasive in the sense that work now escapes the traditional environs of waged-time and the factory, coming to inflect times outside of salaried work and

beyond the conditions of the present moment. But it is also 'pervasive' because 'work' now calls on the whole individual to produce and reproduce the self. So too, the technical and material composition of this labour, while no longer organised by managerial command remains loosely composed through the topology of the network. Consequently, the relations of production assembled around online activity are conducive to those under which labour must now produce. The modes of autonomous production associated with the operation of free culture are ideal to the functioning of cognitive capitalism. As such, 'free culture' does not represent an anti-capitalist mode of production so much as the ideal composition of labour under cognitive capitalism.

Chapter three identified the dynamics of accumulation that operate over social production. Drawing on a post-operaismo value theory, rent was put forward as the key mechanism for value capture, merely expropriating value from a privileged position in the network without directly intervening in or attempting to organise commons-based peer production. In turn the privilege of the rentier is produced through a series of operations that enclose the commons and substitute direct command over labour and investment in production for command over markets and the production of artificial scarcity. Where the core enquiry of the thesis concerns value accumulation in digital networks, rent is identified as the primary mode of accumulation in digitally networked media. Digital networks today provide a variety of different channels through which to extract rent. So too, they facilitate the recursive accumulation of forms of attention, information and cultural content, and sociality produced by individuals and collectives.

After identifying the different forms of value that individuals produced and analysing the role of networked media in aggregating, assembling and circulating valorising information, chapter three then analysed how a strategic rentier position is produced and maintained with respect to autonomous social production. This introduced the concept of digital enclosure. In the operation of rent over digitally networked media, this was shown to involve the enclosure of communicative and cooperative capacities, which are appropriated, filtered through administrative channels and once again distributed to labour as part of the tools necessary for the production of the immaterial. This enclosure is not just an alienation from cooperative tools and capacities, therefore; it also involves the production of a mediated topology where

these capacities are re-provisioned in arrangements designed to be productive to capital.

Chapters two and three addressed two core enquiries of the thesis, identifying the conditions that bring social production to the fore of the contemporary economy and introducing the system of accumulation that attends the communism of capital. This produced the necessary critical base for a more focused analysis of the dynamics of rent accumulation in digitally networked media. Further enquiry concerned the antagonisms emerging through rent and their potential outcomes. To tease these out required a closer analysis of how a rentier position is produced through enclosure and artificial scarcity; of the antagonisms thought to inhere in such a dynamic; and finally of the potential outcomes of antagonism in terms of a disaccumulation or necessary reconfiguration of capitalism. Spectrum was introduced and identified as a lens for this focused analysis, not only because it allows for an in depth study of the dynamics of rent accumulation that positions this process as part of a complex liberal historical trajectory, but also because the controversies currently surrounding spectrum regulation produce an ideal lens to tease out conflicts emerging alongside rent.

Chapter four tackled the first point of further analysis, identifying the initial work required to produce a rentier position with respect to wireless communications. In the enclosure of spectrum, this was shown to involve a tension ridden abstraction, where the electromagnetic channel - in effect a relational artefact that does not exist irrespective of pair-wise communication – is transformed into a kind of rival spatial resource subject to scarcity and thought to require regulation by the state or the market. This chapter identified a range of different processes, at turns discursive, technical and juridical, that performed this enclosure. This involved first transforming spectrum into some *thing* that could be subjected to a property relation and then looking at how, through this necessary foundation, access to wireless communications could be separated from the general public. Instead through enclosure this public is corralled as an audience commodity for commercial broadcasting. This marks the development of a commercial broadcast system that extracts rent from the unremunerated labour of the broadcast audience and as such is identified as a foundation of the contemporary system of accumulation in digital networks.

Chapter five therefore explores the operation of rent in contemporary spectrum-based networks. Where this history concerns the dispossession of the resource in the early 1920s, a number of significant transformations in terms of deregulation and market expansion occurred from the 1970s onwards, producing spectrum as a market good, subject to increasingly proprietary and speculative operations. As well as adopting the core tenets of a neoliberal agenda, this system progresses and advances alongside the technomaterial intensification of spectrum-based networks from simple one-to-many broadcast topologies towards complex and ubiquitous networks capable of extracting surplus value from a continuum of social production. As such this chapter analysed how property rights in spectrum are currently leveraged to extract different forms of rent from mobile communications.

From here the chapter progressed to the second focused enquiry of the thesis and analysed the potential antagonisms produced by the dynamics of rent accumulation. Through an analysis of the controversies surrounding spectrum today, these were theorised in terms of conflict between the forms of artificially induced scarcity necessary for rentier accumulation over networks and the socialisation of network resources necessary to support a growing mobile economy. As such the system of enclosure developed in the early part of the twentieth century is identified as inappropriate for the long-term extraction of rent. It appears as though the alliance between industrial property relations and cognitive accumulation is now dissolving. As chapter five demonstrated, this conflict has resulted in arguments for a radical reconfiguration of spectrum, away from exclusive property towards forms of shared and commons licensing that would afford general authorised access.

This allowed us to pose our final focused enquiry in chapter six, and ask what the implications of such antagonism might be. If property relations underpinning the operation of rent are now breaking down, does this represent a disaccumulation of rent as it succumbs to internal conflict or simply its necessary reconfiguration in the face of a temporary impasse between old and new systems of accumulation? Certainly open spectrum and digital activists have been arguing for an increase in commons spectrum for decades, where common core infrastructure is thought to pose a direct sabotage to the stranglehold of powerful incumbents over mobile communications. From this perspective, a communality of spectrum represents the possibility to build and scale fully autonomous networks that are no longer subjected

to the sovereign or economic control enforced by the property relation. However, this chapter also drew on commons literature that frames the return of forms of communality or socialist incentives on the part of neoliberal governments as a cynical plan designed to save neoliberalism from its inherent conflicts.

To try and distinguish between these two positions required not only attending to the new communality of resources, but also asking what capital now produces in the place of a juridical license or property right. We can agree that capitalist accumulation requires some species of enclosure (De Angelis interviewed in An Architektur, 2011). Do commercial proposals simply suggest opening spectrum to all kinds of commercial and non-commercial activity? Or are new forms of control coming to the fore in the place of the property relation that has structured radio regulation for so many decades? An analysis of the available technical literature on the automated management of cognitive radio networks seemed to suggest the emergence of a form of enclosure immanent to the network and operating irrespective of external property rights. Largely this concerns the development of centralised access databases controlling the operations of all future radio devices and in turn operating under the control of commercial third parties such as Google, already a White Space database provider (Google Inc., 2013).

In turn this species of networked enclosure appears to allow for much more draconian intense exploitations and control. The networked enclosure does not necessarily disrupt the mechanisms of rent accumulation, but simply requires commercial interests to become more dynamic in their operations, no longer relying on a static relation but instead on a modulating form of control. Where traditional mobile incumbents look like they might not be able to adapt to this system comfortably, other conglomerates such as Google and cloud infrastructure providers look set to thrive in such an environment. If anything, therefore, this future condition produces an even greater consolidation of economic control with powerful incumbents, but one that arguably does not produce any necessary antagonism with the commons.

Section 7.3: Analysis

The conclusions drawn from this analysis of spectrum regulation are broadly generalisable for those of mobile digitally networked media. Spectrum is implicated

in the operation of all wireless communications, and wireless communications in turn are necessary for all forms of pervasive connectivity, making spectrum a lens that can speak to the most ubiquitous and commercially valuable networks in operation today. So too supplementary research detailed throughout the thesis identified similar antagonisms operating in the property relations of other network resources (section 6.2). As such, while there are peculiarities to spectrum because of its liminal status as both a tangible and intangible good, the conclusions drawn from the shifting property relations in radio spectrum can be applied to other forms of network infrastructure that support the circulation of content. However, further research is required to identify if the conclusions drawn from this thesis can be applied outside of the domain of social production in digitally networked media.

In the introduction to this thesis, the nature of enquiry was described as a 'reflexive analysis', whereby the burgeoning theoretical frameworks from the communism of capital allowed us to think critically about the future of spectrum regulation, while at the same time the peculiarities of spectrum regulation allow us to critically reflect on this burgeoning theoretical framework.

Following from the analysis performed in chapters four, five and six, it should be clear that a dissolution of traditional property relations in network resources does not necessarily present the possibility to proliferate any permanent or anti-capitalist commons for wireless communications. While access to electromagnetic frequencies is socialised, control is increasingly abstracted from the user through new modalities of enclosure immanent to the network. Points of entry abound, but the ability to exercise choices and decisions or to withdraw from a broader topology of enclosure - these choices are all abstracted from the user. Consequently, this does not suggest any necessary break or rupture within cognitive capitalism. Instead, following on theorists such as Caffentzis and De Angelis, this communality is a 'commons fix' for a temporary impasse of rent. The re-emergence of sentiments and gestures appropriate to the commons is not thought to produce any lasting rift. This conclusion has implications for those of us concerned with the future autonomy of communications networks. It suggests that we must look further than a question of resource ownership to also identify how forms of struggle or individuation can be identified from an active engagement with protocological command.

Secondly, we might ask what an analysis of spectrum can contribute to the development of a theoretical framework for the communism of capital. In chapter six we identified two conflicting viewpoints emerging from a Marxist analysis of the communism of capital. One positioned the centrality of the commons as a potentially liberatory force, provisioning the necessary tools for species of resistance and cultivating social capacities that are excessive to accumulation. The other position understands the centrality of the commons to be a temporary state of re-socialisation that operates within a broader stabilisation of the new systems of rent accumulation.

A close examination of the operation of the new forms of enclosure in spectrum regulation appears to substantiate the latter perspective, suggesting that control continues to operate, because the technicity of the network allows for micro-delineations between the conditions necessary to access and those that proliferate agency (Simondon, 1980). As such the post-operaismo perspective on the emancipation of the multitude needs to consider the materiality and function of networks. This thesis has suggested on more than one occasion that a lack of focused engagement with the material substrate of the network in favour of a more abstract reading of the network as a trope for forms of sociotechnical organisation produces a degree of myopia in post-operaismo critique as it applies to information and communication technologies. However, this is a specific critique of the application of critiques of immaterial labour to networked media and should not be construed as an overarching critique of the theoretical framework. Instead this calls for a greater engagement between new media theory as it intersects with political economy and political philosophy. In this regard, theorists such as Pasquinelli, Terranova and Galloway and Thacker have much to offer in the way of future analysis. As such, the thesis concludes that a communality of spectrum does not necessarily support autonomous social production and so too, a liberatory perspective on the communism of capital requires a closer engagement with the concatenations of the digital network.

Section 7.4: Further Work:

Several conclusions drawn from the thesis reveal future avenues of research. Consequently these are explicated together in the conclusion.

From Property to Debt

A key outcome of the thesis enquiry is the recognition of shifts in property relations governing the network. As we have seen, there has been a shift from static forms of property and the very strict juridical institutions that identify and enclose the institutions of the common towards much more temporally and spatially diffuse arrangements. For example, in spectrum instead of an external injunction – operating through the property relation, and the external threat of prosecution, litigation and exclusion that implies - we now have an immanent command, where exclusion is engineered at the level of firmware and proceeds through opaque processes that are totally abstracted from the user.

Through a contrasting analysis between the forms of command and control regulation produced by early radio enclosures positioned against the new modular forms of network control proposed to govern unlicensed radio transmissions it appears as through we have undergone a shift from static enclosures that exert control onto a system towards modulating and flexible forms of contract that are immanent to the system and operate within the constraints and affordances of its natural dynamics, rhythms and co-causalities. As discussed in chapter six, this is suggestive of a shift from a control that is exercised over space to a control that is rhythmic, fluctuating and operating over time, or reductively put, a transformation from enclosure through property, to enclosure through debt.

There is a definite correspondence between a theorisation of 'debt' as a system of command and the protocological forms of control or automated systems of management put forward by theorists such as Galloway (2004) and Kitchin & Dodge (2011). How conditions of indebtedness proceed in the new economy and how they progress and advance alongside network media is a proposed avenue for future research. While the recent work of Lazzarato (2012) and others in the wake of the financial crisis provides a theoretical starting point, future enquiry might concern how a theory of debt evolves and coalesces with the mechanisms of technical control and value capture that have been elaborated in this thesis. Similarly, it provokes a consideration of how flexible and co-casual forms of 'macroeconomic prescription and management' (op. cit, p.13) are made open to forms of individuation that were not specifically planned for or intended.

Control and Software

As a consequence of the new enclosures, the question of control and access to communications has never been more important. This is not simply a question of one particular resource and how it is consolidated; it points to an entire formal apparatus – the totality of techniques that facilitate accumulation at a social and economic level. This in turn gestures to the necessity for further research in the operations, not only of property relations in physical layer resources, but a thorough examination of how control operates through logical and software-defined operations.

The attention given to the operations of software in the thesis was necessarily brief, given that the enquiry focused more specifically on antagonisms to the resources underpinning rent accumulation than the precise mechanisms of extraction through digitally networked media. However, significant trends discussed and identified throughout this thesis suggest a need to pay closer attention to the role of logical processes operating in the network. This does not mean eschewing the materiality of the network, or discounting the significant role still played by a material substrate in the form of labour power, electrical power, mineral resources, real estate and hardware. However, the transformations indicated by spectrum regulation suggest that network virtualisation and systems of automated management are an increasingly significant component in the operation of positions of power and control in the political economy of networks. The example from this thesis concerned the development of cognitive radios and automated database systems for spectrum regulation, but cloud computing architectures and network virtualisation are another point of focus that merits significant analysis and consideration if we are to fully understand accumulation through networks.

Forms of Resistance

Finally, the theoretical outcomes of the thesis are diagnostic rather than prescriptive. The research details the dynamics of a sociotechnical system of accumulation, but it does not go so far as to analyse or elaborate strategies for resistance. Here practices ranging from hactivism, tactical media and critical design have a lot to offer in the quest for how to "struggle from assemblage against assemblage" (Terranova, 2010,

p.165)[152]. These practices often involve identifying points of weakness or exploit in complex sociotechnical systems. This is a critical practice that often makes visible a projection of possible modes of resistance or action in a way that critical theory alone does not. It is very possible that the nature of the modulating forms of control this thesis identified leave themselves open to new forms of exploit or individuation.

[152] See for example to work of Julian Oliver, Danja Vasiliev & Gordon Savicicic, Alessandro Ludovico, & Paolo Cirio, and Ubermorgen.

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