Draft book chapter: Sørensen, C. (Forthcoming): Digital Platform and -Infrastructure Innovation. In Mobile Strategy Challenges (In Japanese), ed. H. Higashikuni. Tokyo: Nikkan Kogyo Shimbun Ltd.
Please do not cite or circulate without the author's explicit permission!

Digital Platform and -Infrastructure Innovation

Carsten Sørensen
The London School of Economics and Political Science
Department of Management
The Information Systems and Innovation Group
London, UK
c.sorensen@lse.ac.uk
www.carstensorensen.com
www.digitalinfrastructures.org

1 INTRODUCTION

The past 20 years the role of digital infrastructures has expanded from a common good in society to an essential strategic and operational aspect of large organisations. Even for the smallest commercial enterprises advanced digital infrastructures can function as a platform for innovation and development. The second decade of the 21st Century has indeed turned into the decade of the global digital infrastructure in general, and that of the digital platform in particular.

There is currently not a sufficient understanding of the dynamics of digital infrastructures and -platform. This chapter reviews state-of-the-art in digital infrastructure and -platform innovation and explores the main challenges for further our current conceptualisations. The chapter argues for considering digital platform innovation as a particular instance of digital infrastructure innovation.

Many of the ideas in this chapter are also presented in a series of 10 easy-to-follow 3-minute videos on YouTube. Go to www.digitalinfrastructures.org for more information and direct access to the videos.

1.1 The iPhone Revolution

Despite many relevant developments prior to the launch of the first iPhone in 2007, then this event marked a watershed in the development of information technology. Not only is the the iPhone an example of the power of beautifully designed technology, but more importantly, the sequence of events its inception triggered has transformed the mobile industry from handset providers focusing on building clever mobile terminals to building digital empires.

At the iPhone launch in 2007, Apple intended the device to contain a few native applications built by Apple, and with the possibility of endless web-apps launched from within the Safari browser. However, a global community of enthusiasts managed to persist in circumventing these restrictions and open the device enabling the installations of third-party developed native applications. This dragged in 2008 a hesitant Apple into opening the iPhone for official third-party applications (called apps) through a process of strict quality control (Isaacson, 2011). As a result of this controlled opening of the iPhone, a global crowd of individuals and firms rushed to build iPhone applications.

The iPhone contained from its inception the core capabilities of the iPod music- and video players linking to the iTunes store for digital content. This content is procured through high-level distribution agreements with media organisations. However, opening the iTunes App Store suddenly enabled a large number of small and large software companies to join in the development of native iPhone applications. A wealth of computational creativity resulted from this mass-decentralisation of development and Apple managed to establish its mobile platform (iOS) as dominant with significant associated financial gains.

1.2 Platformisation and Convergence

The iOS platform proved highly successful but is far from the only one. Innovation through digital platformisation has become a common strategy for organisations, and some of the most successful digital platform companies are, apart from Apple, Google, Amazon, and Facebook (Manjoo, 2011). However, the platformisation of digital services can be seen broader than only the four poster companies and the process of cultivating ecosystems areound a core platform. The power of digitalisation transforms elements in discrete, heterogenous industry verticals into homogeneous streams of bits, which in principle renders the output from any process into the input of any other process (Tilson et al., 2010b; Tilson et al., 2010a). This digital disruption has resulted in strategic opportunities for a variety of actors and can in shorthand largely be characterised as an ongoing collision between the three galaxies of; The Internet, global telecommunications firms, and global mass-media conglomerates. This collision results in the reconfigration of existing control arrangement and platforms are here serving the purpose of re-distributing and institutionalising of control. The increased platformisation therefore also signals the emerging battles for control in the platform wars fought at the technical, legal, market, and social battlefields (Lessig, 2000; Elaluf-Calderwood et al., 2011).

1.3 Individualised Services at Low Cost

Seen in the broader context of consumption, the digital platformisation within the mobile industry exemplifies a new reconfiguration of the relationship between providers and consumers enabled by digital infrastructures. Broadly characterised, 20th Century industrialisation relied on a range of physical infrastructures providing transport, energy, water, etc. This enabled distributed factories to produce standardised consumer products. Through increased technological- and managerial advances manufacturing has in the 21st Century become globally distributed and highly effective. Even though the manufacture of standardised goods still forms an essential part of everyday consumption, then: Services rather than goods form a larger and larger part of consumption; consumers increasingly demand attention to their individual needs and wants (Zuboff and Maxmin, 2002); and it is generally an advantage to consider the producer-consumer relationship in terms of services (Vargo and Lusch, 2004).

The shift from standardised mass-produced goods to individualised services poses a significant innovation challenge (Zuboff and Maxmin, 2002), and one, which can only be met through extensive service automation and customer self-service (Sørensen et al., 2010). The digital platform is an example of an infrastructural element in the 21st Century provision of personalised services through a largely self-serviced customer relationship. Services that previously have relied on person-to-person interaction are increasingly subjected to automation. Automated telephone exchanges replaced people with automated support for customer self-dialling. The Automatic Teller Machine (ATM) reduced the need for bank customers to engage with a bank clerk in order to withdraw money from their account. The Dutch airline KLM has introduced complete customer self-service for the check-in process combining the self-service kiosks with self-serviced baggage drop-off stations. In a similar manner, the current generation of smartphones with associated app stores automate the process of customers extending and maintaining the software installed on their phones. This arrangement allows each individual to extend the basic features with an unique combination of the available applications. The number of available applications is greatly expanded through the open global recruitment of developers.

1.4 Infrastructural Paradoxes

Recent research argues that there is a distinct lack of research into digital infrastructures (Tilson et al., 2010b). However, an emerging research field seeks to understand digital infrastructures in terms of change and control, and argue that socio-technical processes of digitalisation loosen the previous tight couplings between the digital object and associated: Storage formats; Processing technologies; and Transmission technologies (Tilson et al., 2010a; Tilson et al., 2010b). This leads to a destabilisation of previously settled control arrangements and creates an opening for these to be reconfigured. The dynamics of digital infrastructures can be understood in terms of the paradoxes of change and control.

The paradox of change implies that in order to facilitate change, the infrastructure must remain a stable foundation, yet this will impede change. The paradox of control implies that in order to facilitate a highly generative infrastructure where new and innovative aspects emerge, some control must be implemented; yet extensive control may impede generativity. The Apple iTunes App Store is a good example of the difficulties in balancing these two paradoxes, but also of the possibility for success when done right. This ecosystem is tightly controlled by Apple, yet highly generative in terms of 3rd party developers contributing with their applications. The underlying platform for engaging in this global collaboration and innovation is continuously changing, yet remains a stable foundation.

This chapter is organised as follows. Section 2 explores the origin and importance of digital infrastructures. Section 3 looks closer at digital platforms. Section 4 highlights digitalisation as a powerful force in digital infrastructures. Section 5 furthers this by linking it to the notion of generativity. Section 6 focuses on the digital infrastructure paradox of control and generativity. Section 7 in turn emphasises the paradox of stability and change. Section 8 discusses the platform wars and draws up some consequences of the current status of digital infrastructures.

2 INFRASTRUCTURES

Policy documents from the Clinton-Gore administration in USA and from the Bangemann committee under the European Commission launched in the early

1990s the concept of the Global Information Infrastructure. This was to a large extent inspired by the very fast adoption of Internet technology as a result of freely available World Wide Web technologies.

The global diffusion of digital mobile telephony had lead to the concept of wireless infrastructures, which can be viewed firstly in terms of the relationship between convergence, the mobility of client technologies and the reliance of services based on global or national infrastructures (Lyytinen and Yoo, 2002). The evolution of wireless infrastructures and -services critically rely on the establishment of standards. The diffusion of the services is shaped by relationships among three analytically distinct domains (Lyytinen and King, 2002; Yoo et al., 2005):

1) The Innovation system is the interlinked network of sites, competencies, ideas and resources, capable over time of developing novel technologies and solutions based on research and development activity. Exploitation of these innovations and technologies in wider systems often requires the creation of standards.

2) The Marketplace is a set of actors that produce some telecommunications services or technologies (within a value network) exploiting the technological potential defined within telecom standards, and

3) The Regulatory regime is any type of authority (industrial, national, international), which can influence, direct, limit or prohibit any activity in the innovation system, the marketplace or the regulatory regime itself

In order to understand the innovation of wireless infrastructure standards it is essential to consider the networks of influence established by institutions from these three domains (Tilson, 2008).

2.1 Traditional Infrastructures

Significant insights into digital infrastructures can be gained from a traditional infrastructure perspective (Hanseth, 2000). There is an abundance of infrastructures in the modern world. They provide, for example; running water, electricity, gas, sanitation, roads, railways, bus services, airline services, ferries, bridges, payment systems, telephones, etc. Several of these infrastructures link into each other. The electricity infrastructure, for example, only works because the transport infrastructure ensures the timely transport of oil, coal or other energy sources to the power plants. One way of looking at digital infrastructures is then to consider these as the railway system of the 21st Century. This will enable us to discuss the development of systems using available infrastructures, and to appreciate the impossibility of developing and changing infrastructures rapidly.

Generally, we can define an infrastructure as: "a substructure or underlying foundation; esp., the basic installations and facilities on which the continuance and growth of a community, state, etc. depend such as roads, schools, power plants, transportation and communication systems, etc." (Hanseth, 2000, citing Websters Dictionary). Digital infrastructures should be understood in terms of the equipment; the information itself; the applications and software; the network standards and transmission codes facilitating interconnection and interoperation; and the people who create the information, develop applications and services, construct the facilities etc.

The availability of digital infrastructures have all made it simple and cheap to provide a number of products and services that use these readily available infrastructures. This is of course similar to the products and services readily using the physical infrastructures. It is easier to sell toasters when there is electricity in most households, and companies such as DHL and Federal Express have a much easier job with the availability of transportation infrastructures such as roads and airports. What we already have seen with the advent of digital infrastructures are a host of new applications and services. In that sense the digital infrastructures provide shared, enabling functions. There is a standardised interface between elements. The infrastructures are characterised by openness as opposed to proprietary closed systems. There is an unlimited numbers of users, developers, stakeholders, and components. The infrastructures are characterised by heterogeneity and complexity (Hanseth, 2000).

The issue of openness is one that has attracted much attention in terms of the role of intellectual property rights and innovation. The argument is that in order to get a return of investment the innovator must retain the intellectual property right, but conversely, if there is open access to use an innovation others can use the innovation for further development. The issues of openness will be discussed in a later section relating to the paradox of control and generativity.

Standards and standardisation organisations are essential elements in the establishment of digital infrastructures (Hanseth and Monteiro, 1997; Nickerson and Muehien, 2006). As an example, the establishment of a global mobile telecommunications industry is a global standardisation process where specific choices lead to significant differences across markets (Funk, 2002). Bowker and Star (1999) investigate the issue of standardisation and classification on a global scale.

2.2 Digital Infrastructures

Although much can be learnt from considering the similarity between digital infrastructures and their physical or analogue counterparts, then it is also essential to highlight and place at the centre of any analysis the unique characteristics of digital infrastructures. This section simply provides a few pointers as much of the remaining text in this chapter deals with characteristics unique to digital infrastructures (Tilson et al., 2010b; Tilson et al., 2010a).

Digital infrastructures are relational across layers and not recursively organised as their analogue counterparts. Electricity and water utilities cannot generatively create new infrastructure businesses to challenge incumbents.

Digital infrastructures are extremely saleable through the replacement of key-components. The impending doom of the Internet grinding to a standstill due to lack of bandwidth has been predicted several times over the years. As compression- and fibre-technology has been introduced, along with general upgrades (some financed through the dot-com boom and bust in the early 00s), the capacity has grown and grown. One exception is the issue of the IPv4 numbering system running out of numbers until servers are upgraded to IPv6.

Digital infrastructures are extremely flexible and offer amble technical opportunities for reconnecting elements to create new services.

3 PLATFORMS

The term platform has a variety of meanings related to both the physical foundation for other activities, to more abstract notions. The concept has been introduced within industrial innovation management. A platform denotes a way of characterising the essential trade-off between the need for standardisation of activities subjected to economies of scale with the need for product variation. The platform concept here follows naturally from the discussions of how to manage industrial innovation processes (Chandler, 1962; Abernathy and Utterback, 1978;

Utterback, 1994). The arrangement of innovation decisions in design hierarchies (Clark, 1985) allows for tightly controlled, yet distributed, activities. The car manufacturer can centrally control the distributed manufacture of parts of the car through this design hierarchy. As various standard ways of designing products and distributing the activities emerge and are tested, a dominant design (Utterback and Abernathy, 1975; Suárez and Utterback, 1995) may emerge, which will shape the innovation within a specific area.

The distinction between product architecture and its constitutive modules has been promoted as a way of understanding the balancing of standardisation and variety (Henderson and Clark, 1990; Baldwin and Clark, 2000). Here, modules represent core concepts and components, and the architecture denotes the linkages between these core concepts and components. Incremental innovation is then the minor changes to both the core components and their linkages. Modular innovation maintains the existing linkages but overturns some of the core concepts, for example, replacing the photographic film with a digital sensor in a camera. Architectural innovation basically reinforces the core concepts and components but change their linkages. Finally, radical innovation both overturns the core concepts and re-configures their linkages.

The globalisation of product manufacture can both be attributed to and explained by research on dominant design, dominant design, and modularity. Intelligently considering, conceptualising, and designing mutual interdependencies between product elements and the associated manufacture processes enables a high degree of physical distribution of the process as well as the modularisation of the process across firms. The emergence of the platform as a conceptual unit of analysis of innovation and production activities denotes the increased importance of understanding this distribution of activities across a variety of firms (Gawer and Cusumano, 2002; Gawer, 2009b). Platforms can be internal arrangements for the purpose of balancing the conflicting concerns of the manufacture process; they can support the management of the supply-chain; or function as a means of organising a whole industry (Gawer, 2009a). Industry platforms where a number of firms participate in jointly contributing to and innovating the platform are in effect two- or many-sided markets (Boudreau and Hagiu, 2009). A platform will form the anchor-point for a surrounding ecosystem of contributing firms and customers who both extend the reach, content, and possibly the makeup of the platform. A vibrant and active ecosystem is essential for a platform, but vibrancy is not necessarily securing financial success as long as will be discussed later.

3.1 Digital Platforms

The discussions of product platforms offer a solid foundation for the understanding of digital platforms, such as those established by Apple, Google, and Facebook. The platform denotes the core innovations, which are under the direct control of the platform owner, which may be one organisation or a conglometrate of organisations. Around this platform, an ecosystem of indivifual developers, firms, enablers, and customers contribute to the platform by developing new features, provide new architectural elements, and spending money.

As a way of example, Apple's iOS platform for the distribution and innovation of apps, as well as a variety of digital content, is made up of elements that are within Apple's direct control: The iOS operating system; the hardware devices; the iOS Software Development Kit (SDK) providing developers with a framework for contributing to the platform; the Application programming Interfaces (APIs) allowing for homogeneity in design and easy access to core operating systems facilities; the iTunes application functioning as portal for purchases and updates; and the iAds functionality allowing developers to embed advertisement into the apps. For Apple's iOS platform, the associated ecosystem is primarily made up by: Platform enablers, such as the advertisement platform AdMob; the approval- and support processes both helping third-party developers in contributing to the ecosystem while ensuring that contributions are desirable; and a wealth of resulting digital content carefully curated by Apple, such as apps, movies, television programmes, podcasts, and music.

A stable understanding of platforms is still to emerge, for example, in terms of a typology and a classification of essential platform characteristics separating the diverse set of phenomena all grouped into this one category (Tilson et al., 2012b). It is particularly problematic as digital platforms offer characteristics beyond those observed in the traditional discussion of industry platforms. The following will discuss the core themes of relevance for digital platform innovation.

In terms of the distinction between digital platforms and -infrastructures, then the core issue of one of digital infrastructures being subjected to much more nebulous control arrangements than digital platforms. Whereas an application is subjected to centralised control and with bounded and context-free evolution, then a digital infrastructure is generally subjected to highly distributed and dynamically negotiated control and highly path-dependent evolution (Hanseth and Lyytinen, 2010). Digital platforms mixes these characteristcs as they are subjected to path dependent evolution, yet at least partly subjected to centralised control. Although as will be discussed later, there are distinct limits to the extent the platform owner can exercise this centralised control.

It is, however, essential to acknowledge that the evolutionary complexity links digital infrastructure and -platforms in many ways. Even if digital platform dynamics is an order of magnitude less complex to analyse than digital infrastructure dynamics, then the former is still not well understood (Tilson et al., 2012a).

4 DIGITALISATION

Within industries and sectors, vertical integration organises the division of responsibilities between a variety of participant organisations (Chandler, 1977). These arrangements are the results of market forces and deliberate managerial decisions. They provide stability, and to some extent also protection from open competition (Wu, 2010). The vertical integration across the telecommunication- and media industries can be characterised through the partition into organisations that provide: 1) Content, such as news organisations publishing web-based reports on current events; 2) applications, such as the software companies providing a suitable web browser to access the content; and 3) infrastructucture, for example the range of organisations involved in providing access to the Internet (Lessig, 2002). Within these vertical arrangements, the different layers are self-contained and can either be open or closed, in the sense that a closed layer is one where one organisation or actor entirely controls that layer, and an open layer is one where no single entity is in control (Lessig, 2002).

The distinction between content, application and infrastructure is black-boxing a number of layers and thereby simplifying a more complext arrangement. The provision of Internet is in itself a complex vertical arrangement of a number of different organisations. The discussion of net-neutrality is largely one of to what extent the Internet provides an infrastructure where open and equal access is provided to all. The web-browsers provided free of charge by Microsoft, Google and Apple, are closed in that each of these three firms as a single entity controls the behaviour of their browser. The increased standardisation of web-standards has, however, reduced the concerns that in the 1990s led to the Microsoft anti-trust court case. The regulatory concern over Google's alleged favouring of some search results over others is a reflection of the de facto closed character of parts of the Internet infrastructure (http://en.wikipedia.org/wiki/Criticism_of_Google).

In the traditional analogue world, products tend to stay within verticals. The music business produced music imprinted on sheets, or recorded to vinyl. Once recorded to a vinyl disc, the music could be distributed within a complex global arrangement of wholesale and retail stores. Once purchased, the customer could then play the music on his or her turntable. The characteristics of such analogue arrangements are that there are stable and fixed arrangement of how digital objects, such as music, film etc are: 1) Stored, for example on vinyl; 2) transmitted, e.g., through a wholesale and retail network; and processed, in this example on a turntable (Tilson et al., 2010b; Tilson et al., 2010a). A VHS video recording can only be played on a VHS video recorder, and not on a turntable. In analogue arrangements provided tight coupling between the underlying business models and the respective storage, distribution and processing (Tilson et al., 2010b; Tilson et al., 2010a). These tight couplings, along with the traditionally regulated character of both the telecommunications- and mass-media industry (Wu, 2010), maintained a relative stable arrangement of business models where verticals remained separate.

The primary difference between the traditional discussion of platforms anchored within a manufacturing paradigm, and the analysis of digital platforms is that digital platforms are either entirely software-based or they are mixtures of physical and digital elements, and therefore can display some of the characteristics of layered-modular architectures (Yoo et al., 2010). It also implies that the dynamics only to some extent is a matter of innovating for economies of scale rather than economies of digital abundance. Layered-modular architectures and purely digital architectures are also subjected to the forces of digitalisation, which can disrupt existing vertical integration and business models.

Digitalisation is a two-stage process where the first part is simply the technical process of digitsing analogue objects, such as music or film. This results in the pure technical transformation of analogue objects to digital ones. The analogue grooves on the vinyl disc are digitised into a digital stream of zero and ones. The analogue strip of film is equally transformed into a digital stream, as is the printed book, and the tape containing a recording of a radio broadcast. However, a broader socio-technical process of digitalisation will be associated with the technical process of digitising. This marks the application and consequences of digitising to the wider social context (Tilson et al., 2010b; Tilson et al., 2010a).

At the technical level, digitising transforms separate materials into the unifying bit, and therefore in principle opens the possibility of any output from any process to act as the input to any other process. It also allows the crossing of storage so a diversity of objects can be stored on a diversity of storage formats. The transformation from one digital format to another may impose a penalty in terms of processing time and storage, but the extent to which fidelity is lost in the transformation is merely an issue of design choice. Digitising also opens for the possibility of the same object easily being distributed along a range of distribution channels, and similarly being processed on any number of technologies. Once the vinyl record is digitized into a music file, it can be copied to CDs, stored on a memory sticks, or uploaded to a file server. It can be distributed along traditional distribution networks once materialised onto a bearer (Faulkner and Runde, 2009; Faulkner and Runde, 2011), or be transmitted along any appropriate digital network. The music file can be played on a CD-player, a computer, a smartphone, or any other device that reads digital files and decodes it into sound.

The technical digitising removes the tight couplings between the object and its storage, distribution and processing. The subsequent loose coupling can lead to fundamental challenges to existing social and institutional arrangements through the process of digitalisation, even if existing arrangements may be sufficiently strong to resist for a period. The digitising of music from vinyl to CDs merely optimised the existing arrangement with the same institutions managing the vertical integration (Tilson et al., 2010a) as the bearer was exchanged. However, the MP3 algorithm reducing file size, the Internet, and peer-to-peer protocols transformed the existing arrangement, which has led to an increase in music sold in digital format as downloads or streams, as well as a dramatic increase in illegal music sharing.

The long-established institutional arrangements within both the telecommunications- and the mass media industry is rarely disrupted, especially at the fundamental level experienced when AT&T in 1982 was broken up (Wu, 2010). As an example, until a few decades ago, fixed-line telecommunication firms in most countries remained in control over their infrastructure and what devices were connected to it.

The forces of digitalisation with the associated disruption of existing couplings and business arrangements can be characterised as the underlying force of three galaxies colliding with associated disruption and the establishment of new institutional and business model arrangements. The regulated and centralised telecommunications industry and the mass media industries also with an established vertical stack, both rely on stable regulation and the protection of intellectual property and licensing. This enables tight control. However, these two galaxies are colliding with the third galaxy represented by the computing industry and the Internet infrastructure, at least initially without clear lines of centralised control and based on entirely different business models. This collision both creates disruption and chaos, as for example in the rampant pirating of media content and software on the Internet. It does, however, also create strategic opportunities, for example, allowing Apple and other platform owners to harness newly conquered control inside own platforms.

5 GENERATIVITY

Digital infrastructures are generative at a different order of magnitude than analogue equivalents. Through digitization, any output from any process can in principle serve as input to any other process as illustrated in a cartoon from 1996 where Bob is listening to his dad's technology question on the phone (www.randyglasbergen.com): "Hello, Bob? It's your father again. I have another question about my new computer. Can I tape a movie from cable TV then fax it from my VCR to my CD-ROM then E-mail it to my brother's cellular phone so he can make a copy on his neighbour's camcorder?" Various social and usage-constraints of course limit this unboundedness, yet the uncoupling of digitalization creates new flexibility.

Upwards flexibility allows the creation of any service utilising a set of underlying communication and storage capabilities (Tilson et al., 2010b). As an example, most contemporary platforms offer Application Programming Interfaces (APIs), which can be utilised by independent developers for a variety of services. Indeed, it can be argued that essential aspects of a platform owner's management of innovation on the platform is conducted through the provision of APIs as boundary resources (Ghazawneh and Henfridsson, 2012).

Downwards flexibility of digital infrastructures imbues a diversity of digital and physical networks the potential to provide interconnectivity. As a simple example, mobile voice calls can be made through both the standard line-switched GSM infrastructure or on a variety of different Voice over IP (VoIP) protocols.

Furthermore, digital infrastructures relying on the combination of physical and digital elements produces a new type of architecture. The layered-modular architecture combines the modular separation of concern in physical products with the layered architecture of software (Yoo et al., 2010). The four loosely coupled layers of the software part can be characterised as the: Content layer; Service layer; Network layer divided into logical transmission and physical transport; and Device layer also divided into logical capability, the operating system, and physical machinery, e.g., the computer hardware (Yoo et al., 2010).

Layered-modular architectures are characterised by the doubly distributed control over product components across a number of firms, and the reliance on knowledge distributed across heterogeneous communities, thus rendering the traditional design hierarchy assumption (Clark, 1985) of centralised control invalid (Yoo et al., 2010; Eaton et al., 2012).

Digitalization leads to loose couplings and flexibility. The highly distributed arrangements of digital and physical assemblages lead to lack of centralised control. All of this implies the reliance of innovation emerging from distributed, heterogeneous, actors with different interests (Clark et al., 2005; Tilson et al., 2010b) with the result that the initial vision of a certain arrangement subsequently can be questioned, reshaped and altered as the various actors make their independent decisions. This leads to drift (Ciborra and Associates, 2000) or generativity (Zittrain, 2006; Zittrain, 2008).

Digital infrastructures are generative as they are never fully complete and always open for further improvements (Zittrain, 2008, p.43). They are subjected to some degree of late- or procrastinate binding of capabilities allowing for important decisions on the relationship and dynamics of elements to be deferred (Eaton et al., 2012).

Generativity can be characterised as the ability of an infrastructure to generate or produce new behaviour, structure, or output without the direct involvement from the originator of the system (Tilson et al., 2010b). Zittrain (2006, p.1981) argues that: "Generativity is a function of a technology's capacity for leverage across a range of tasks, adaptability to a range of different tasks, ease of mastery, and accessibility." This implies the following five distinct characteristics (Zittrain, 2008, p.71):

1. Leverage – the extent to which the technology helps in performing a task otherwise not possible or difficult.

2. Adaptability – signifies the degree of flexibility and breath.

3. Ease of mastery – how easy it is to adopt and adapt by a broad audience.

4. Accessibility – how easy it is to use and control and what information it is needed to master it.

5. Transferability – how easy is it to establish an ecosystem through it.

Analysing the iPhone and Android platforms and associated ecosystems using these five categories in the context of open innovation processes, it can be argued that generativity rather than openness drives the financial success of a mobile platform (Remneland-Wikhamn et al., 2011).

6 CONTROL

The organisational use of information is traditionally associated with control (Beniger, 1986). To control that citizens pay their taxes requires information, and the complexity of doing so in large scale has always required complex information systems. The rise of modern scientific management in large distributed organisations around 1850-1920 was the co-development of management practices and complex information systems for reporting, copying, communicating, and filing (Yates, 1989). Contemporary global supply-chain management equally require highly complex information management to keep the channels of products lean and rapidly re-stocked in sync with product life-cycles.

The concept of modularity is one of the key-aspects of understanding and managing control in complex systems (Simon, 1996; Schilling, 2000). The notion of loosely connected modules interacting through pre-defined interfaces is a foundational idea in a number of areas, such as object-oriented methods (Parnas, 1972) and manufacturing (Ulrich, 1995). This breaks with the notion of integrated designs where individual elements can not easily be untangled, and opens for the recombination and reuse of modules without the risk of compromising the overall design (Ulrich, 1995). Assuming that modules keeps within one design hierarchy (Clark, 1985), then modular architectures directly supports the flexible co-ordination of distributed innovation in complex arrangements (Henderson and Clark, 1990; Baldwin and Clark, 1997).

Particular definitions and configurations of modules may over time emerge into dominant design (Utterback and Abernathy, 1975), which in turn bestows the owner of such a dominant design with economies of scope and scale. The owner will be able to exercise control through design rules specifying: modules, module interfaces, and integration- and validation protocols (Baldwin and Clark, 2000). Here, the diversity of innovations can be characterised in terms of the following four archetypes (Henderson and Clark, 1990): Incremental innovation where modules and their interlinking in an architecture are tweaked; modular innovation where (some) modules are changed, but not the interlinking; architectural innovation changes interlinking of modules but not the core modules themselves; and radical innovation where both modules and their interlinking are changed.

Following from this discussion of the relative weighting of openness versus generativity for the economic success of a platform, then generativity can be related paradoxically to the issue of control (Tilson et al., 2010b; Tilson et al., 2010a). Whereas more tightly controlled arrangements indeed may result in the loss of generativity as opportunities may be removed, then tight control can paradoxically also result in increased generativity. This seems to be one way of characterising Apple's dominance through their iOS platform, which is both financially successful as well as highly controlled, and -generative (Eaton et al., 2012; Tilson et al., 2012a).

The paradoxical relationship between generativity and control also relates directly to the conceptual relationship between convergence and control. Convergence can be defined as the inability to uphold existing distinctions, and the opposite to convergence is control understood as the ability to uphold and maintain distinctions (Herzhoff, 2011). The traditional telecommunications firms were able to maintain control and, for example, uphold the clear distinction between long distance and local telephone calls. The digital Blue-Box constructed by Steve Wozniak is an example of a simple device that nullifies the control of upholding such a distinction in that it allowed the user from a simple device to completely manoeuvre a global telephone infrastructure at the cost of a local call (Isaacson, 2011).

Digital infrastructures are subjected to the paradoxes of control and change (Tilson et al., 2010b). These two paradoxes characterise the non-linear and counter-intuitive interrelationships between; control and generativity; and between stability and change. This section explores the control and generativity paradox, and the following section discusses the stability and change paradox.

Digital infrastructure innovation is subjected to heterogeneous and distributed actors' independent choices beyond the control of any central actor. This results in generativity as discussed in the previous section. However, a truly successful digital infrastructure will require some degree of control balancing the distributed acts so these do not unduly destroy the infrastructure, or indeed force overly controlling mechanisms from seeking to exercise tighter control (Zittrain, 2006; Zittrain, 2008).

Control can be centralised under the assumption of simple, stable, and bounded organisational systems (Mintzberg, 1980), and applications (Hanseth and Lyytinen, 2010). However, with the increase in socio-technical complexity and under uncertainty, highly distributed activities can lead to complex and non-linear relationships between, for example, managerial action and related outcomes. This can better be understood in terms of drift in decisions rather than control (Ciborra and Associates, 2000).

In the case of highly distributed digital infrastructures, such as the Internet, centralised control is generally an impossibility (Hanseth and Lyytinen, 2010). Here, the conflicting interests of the complex arrangement of heterogeneous actors will never be resolved (Clark et al., 2005; Elaluf-Calderwood et al., 2011; Trossen and Kostopoulos, 2012). It is, therefore, essential to design spaces for engaging in tussles rather than seeking through design to obliterate the conflicting interests (Clark et al., 2005). These tussles between organisations with conflicting interests can be concerned with a range of issues, such as; The interconnection of networks; ownership of the experience; how much to reveal in order to obtain what is wanted; the difference between the content provided and the content wanted, etc (Trossen and Kostopoulos, 2012).

Control and regulation in highly distributed infrastructures will be manifest in the following four distinct, yet interrelated areas (Lessig, 2000, Chapter 7; Murray and Scott, 2002): (1) Laws, (2) social norms, (3) markets and (4) architecture or code. Architectural control points (Woodard, 2006; Woodard, 2008) are then discrete arrangements of subsets of these four categories. For digital infrastructures within the telecommunications sector, the four spheres of regulation can be translated into the areas of (Elaluf-Calderwood et al., 2011): The end-user context; service provision; infrastructure provision; and regulation. Tussles can occur within and between areas (see Figure 1).

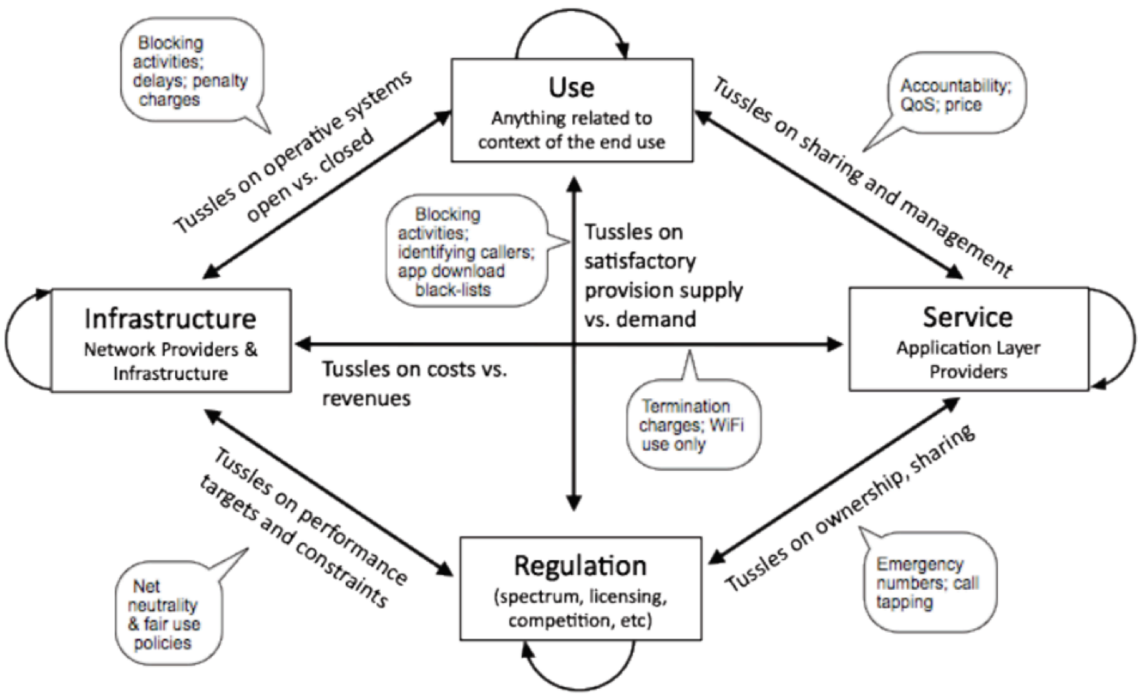

Figure 1: A tussle and control model for the telecommunications sector (Elaluf-Calderwood et al., 2011).

Internet generativity is conducted within an open digital infrastructure and leads to a range of highly positive innovations. Yet at the same time, the openness also produces the conditions for its possible downfall, namely the ability for heterogeneous actors with relative ease to generate innovations that largely must be characterised as negative, such as malware, phishing, Trojan horses, and worms (Zittrain, 2008). Protecting the individual non-expert consumer from the effects of this negative generativity involves some degree of control. The operating system manufacturers have had several attempts at taming the Internet - most famously Microsoft's failed attempt of hijacking it through the proprietary network only accessible through Windows 95. Apple's notion of "sandboxing" of applications is an attempt to create a simple control mechanism for end-users by default only installing applications that are trusted.

Digital platforms are examples of arrangements allowing for the simultaneous balancing of concerns for control and generativity. Here, the platform owner is a single entity acting as the custodian balancing generativity and control, yet without maintaining complete control as innovation boundaries are contested. The section on dynamics will explore the inner workings of the management of the paradoxes of change and control in greater detail. In essence, the continual balancing of generativity and control is conducted through adjusting the control points regulating the abilities of distributed actors to innovate.

7 DYNAMICS

Infrastructures are connected and interrelated, constituting ecologies of infrastructures where one infrastructure can be built as a layer on top of another. Related networks can be linked and independent components can be integrated, making them interdependent.

When growing infrastructures, the economics of standards is a crucial aspect to consider. The value of a communication standard is to a very high degree determined by the extent to which it is adopted. Assuming that the users provide positive feedback, a larger installed based will lead to more complements and a greater credibility of the standard. This reinforces the value to the users, leading to further adoption. The lock-in effect signifies situations with unacceptable cost and co-ordination problems associated with a switch from the existing standard to another. Because a number of factors, of which the technical qualities of the innovation is only one such factor, there is no guarantee that the technically best solutions will win and subsequently form the standard with the largest installed base of users.

7.1 Gateways

There are two ways of getting out of a lock-in in digital infrastructures: The revolution strategy and the evolution strategy. The former is inherently risky. It cannot work on a small scale and usually requires powerful allies. The battle between Microsoft and the US Anti Trust legislation can be viewed as an example of Sun Microsystems, Netscape and a few others together with the High Court Judges attempting a revolution. The evolution strategy is generally much more reliable and safe. It comes in two basic variants: slow evolution based on backward compatibility and fast evolution based on gateways linking the new and the old. Shapiro & Varian (1999) elaborate extensively on the dynamics of what they call the "Network Economy" in terms of issues such as lock-ins, positive feedbacks, and standards wars.

The gateway concept can be used as a means of understanding how to change and recombine infrastructures. When designing highly distributed information infrastructures, the gateway is viewed as a design tool enabling the co-existence of heterogeneous elements. Digital infrastructures are like physical infrastructures very difficult to change. Migrating from one network protocol to another takes a long time and is impossible to do in one go. Instead gateways are built allowing heterogeneous configurations to co-exist. Information infrastructures are, however, also very different from physical infrastructures in that they are subjected to the forces of digitalisation.

7.2 Platform- and Ecosystem Innovation Management

In terms of the paradox between stability and change, then the development of digital infrastructures require stable standards, which over time can provide a foundation for building the infrastructure and allow a highly distributed and heterogeneous group of actors to enroll and contribute (Tilson et al., 2010b; Tilson et al., 2010a). Simultaneously, however, growth will also require continuous change and flexibility to broaden and deepen the infrastructure reach. The paradox of change and control will be negotiated in order to balance the need for a stable and appropriated regulated infrastructure, which at the same time, due to its flexibility, may lead to an undermining of the stability. The distinction between stability and change can be characterised as a duality rather than a dualism, emphasising a far more complex and mutually enabling interrelationship than the mere distinction between two mutually exclusive states (Farjoun, 2010).

Balancing the paradoxes of control and change can both lead to radical change, as for example the widespread success of a variety of platforms ensuring tightly controlled phenomenal growth and generativity. The balancing can also result in much slower and more complex dynamics, such as the lengthy and challenging migration from IPv4 to IPv6 (Monteiro, 1998).

The management of ecosystems associated with digital platforms can be subjected to substantially more centralised control, for example through the platform owner deciding what boundary resources are available to third party developers contributing with innovations to the platform and associated ecosystem (Ghazawneh and Henfridsson, 2012). However, even if the platform owner is able to stipulate changes far more easily and directly than any of the distributed actors in non-platform digital infrastructures, then platform- and ecosystem dynamics is still shaped by a complex non-linear process between design decisions, governance, and dynamics of the environment (Tiwana et al., 2010). Indeed, rather than a straightforward control-feedback process, platform- and ecosystem innovation management can be viewed as an interactive process between the platform owner and the independent developers (Eaton et al., 2012).

The dynamics of platform and ecosystem innovation is comprised of a range of events and acts. The platform owner will continuously seek to improve the platform through new versions of the APIs and the SDKs, as well as seek to include desirable services and content onto the platform. An essential part of platform innovation is made up by activities aimed at innovating the surrounding ecosystem based on, and extending the platform. Here, independent third-party developers add their applications (apps) to the platform ecosystem in the expectation of gaining impact and in many instances also with the aim of gaining direct financial return for their efforts. Most of these applications will in all likelihood be derivatives of existing apps, and therefore only signify incremental innovation (Henderson and Clark, 1990). However, some apps seek to gain advantage from pushing the existing boundary of acceptable innovations through suggesting novel types of apps, in a micro-move of creating a new uncontested market-segment to avoid heavily overcrowded segments elsewhere (Kim and Mauborgne, 2005).

While some ecosystems are very loosely controlled, innovations on other ecosystems are more strictly curated. Google's Android ecosystem, for example, is highly forgiving concerning the applications allowed, and largely only includes a mechanism for removing malicious applications after they are published. Apple's iOS ecosystem, on the other hand, is tightly controlled and each application goes through a pre-approval process. This processes, amongst others, weeds out applications that: Do not do what they promise; are deemed inappropriate, e.g. pornographic; challenge the platform owner or partners' revenue stream; or challenge the platform owner control (Eaton et al., 2012).

The process of the platform owner and third-party developers negotiating the in- or exclusion of innovative- or contested applications can be described in terms of the following two sets of four possible actions regarding the boundary of acceptable innovation on a platform-centric ecosystem (Eaton et al., 2012). Third-party application developers can: Request, Bypass, Regroup, and Influence. The platform owner can: Allow, Block, Ignore, or Refine.

The third-party developer can request a new application included into the ecosystem. To this, the platform owner cans either: Allow the app to be included; block the app; ignore the request; or ask the developer to refine the app in order for it to be included. Assuming that the app is not accepted outright, then the third-party developer can seek to: Bypass this decision through finding a way around the platform owners scope of control; regroup and either change the app or innovate a new one; or seek to exercise influence over the platform owner to have the app accepted anyway. In some instances, app developers have sought to influence Apple through the blogosphere in advance of submitting the app. In the conflict between Apple and Google regarding Apple's rejection of the Google Voice app onto the iOS ecosystem, Google, for example, bypassed Apples rejection of the native iOS app by coding the Google Voice functionality into a web-service that could be accessible from the Safari web-browser (Eaton et al., 2012).

8 WARS

The platformisation of the open Internet infrastructure has resulted in a number of global platforms drawing their strengths from large and innovative ecosystems of third-party contributors. The current platform and ecosystem resembles, in terms of control, partly the walled gardens of the 1990s, However, a range of differences both in the context, regulatory arrangements, and technological maturity, meant that the customers responded much less favourably to a majority. The prospect of spending £5 to download a short video to be downloaded to a mobile phone when the same video was freely available on the Internet did not appeal to customers. Also, the inability to access websites beyond the walled garden represented too strict control mechanisms. The content and experience simply did not prove sufficiently compelling, the price-plans and lack of transparency of data costs, made these ecosystems problematic.

The mobile platforms and ecosystems in Japan in the 1990s proved successful in terms of user adoption, such as the NTT DoCoMo iMode. The Japanese success can be attributed to a number of factors, such as lower adoption of networked stationary computers at home, and longer commutes than in Europe. However, from the perspective of control, these platforms were explicitly set up so independent service providers could make some money on the arrangement, for example with NTT DoCoMo only taking a percentage charge off the data traffic. However, it can be argued that the degree of sophistication of the Japanese mobile service platforms and -ecosystems also presented a barrier for the transition to the fully converged mobile Internet with associated platforms and ecosystems.

The current development of the global platforms and -ecosystems is one resembling the general tussles in cyberspace (Clark et al., 2005) characterised by complex combinations of collaboration, yet also battles, between the participants. As an example, Apple is relying critically on Samsung to deliver components for its products, yet it is also engaged in patent battles with Samsung. It seems that the dominant platform owners Google, Apple, Facebook, and Amazon, all are trying to establish a similar suit of services to each define monolithic platforms serving a range of needs (Manjoo, 2011). In the global battle for users' attention, Apple is currently commanding a register of 140 million active credit cards and is the most valuable company in the world (as of January 2012). Facebook has, despite a disappointing post-IPO period still more than 800 million users who increasingly spend more and more time using the service. Amazon seems unstoppable in the web-retailisation of both all things purchable as well as cloud services. Google reigns supreme as the global search engine harvesting double-digit billions of dollars in advertisement revenue each year.

Current platform developments clearly confirm the old adage that during a gold rush most of the money are made by those providing pick-axes, alcohol and other supplies to the gold prospectors, and not those who do the digging. Whereas digital platforms have made it easier for the bedroom developer to have a shot at big time success, they also helped shift software development further down low-paid work scale (Claburn, 2009).

The management of a digital platform is one of continuously balancing the need for control and for generativity. Control will continuously be challenged by groups of heterogeneous actors in order to shift or question the platform boundary.

For some organisations it will be feasible to home-grow a platform, for example, based on a large customer-base. For others it can be beneficial to simply contribute to one or more platforms owned by others through services, applications or enabler technology. This will allow for the strategic opportunity to challenge the boundary of these platforms for own benefit, but also the constant uncertainty of the platform owner challenging the business model justifying the specific involvement in the platform.

For some organisations being platform agnostic, seeking to gain benefit from ubiquitous participation in any relevant platform can indeed be a good strategy.

Yet an opportunity can be to establish a ‘marsupial platform’ - a platform within a platform, which for example can provide apps for special groups or sub-stores.

The future of platforms will consist of continuing patent battles in court, innovation battles over novel services users want (Apple has shown this to be a prosperous route), and big-data customer battles over our credit cards and behavioural data. However, serious issues emerge on the near and medium-term horizon for any of the contenders for global platform domination. Any dominant technological arrangement can represent a foundational barrier for the next level of technological development. For both Microsoft and Nokia it has been a significant challenge of moving with the times from the PC- and mobile phone age respectively and into the age of platforms and ecosystems and they have decided to join forces on the mobile platform front (Ziegler, 2011; Vanity Fair, 2012). Equally, it may proved problematic for the current dominant platforms to move beyond their current paradigm of complex services simplified and atomised according to the "there's an app for that" paradigm. The generativity of the current platforms may hit limitations as the installed base of technology and users along with the notion of controlled walled gardens represent intertia and design path-dependency not easily overcome.

As an example, the simple differences in iOS and Andoid's implementations of how to prioritise touch interaction by the user where iOS prioritises all user-interaction with maximum priority, implies that it is more responsive than Andoid. This difference may in effect be impossible to change as this would constitute a fundamentally disruptive change to the installed based of legacy Android apps (Earley, 2012). More complex scenarios can be predicted in terms of complex services where simple atomised apps would be insufficient. These may be difficult to shoehorn into a framework of distinct simple apps.

Furthermore, although the dominant digital platforms all display impressive features, then they each have distinct strengths, and the customer will rightfully wish to be able to select best-of-breed aspects from each platform and associated ecosystem. For now, Amazon is happily offering the Kindle software across a number of other platforms as this is beneficial for the company. Apple iOS 5 provided deep integration of Twitter functionality and iOS 6 integrates Facebook features in the operating system.

However, the ongoing conflict between Apple and Google where close collaboration began faltering after Google began competing with Apple on smart phones has so far led to the focus on Apple pushing Siri voice-activated search circumventing Google search, and replacing Google Maps on iOS 6 with a proprietary mapping service. If the platforms engage in entrenching seeking to further delineate their separate platform boundaries and keep traffic as inside their ecosystem as much as possible, then this will not necessarily be the most beneficial solution for the users.

It may be far from feasible that these global walled gardens are entirely closed, thus restricting the movement of people's purchased media and applications, personal data on their social network (Johnson, 2012), and digital footprints (Höök et al., 2003) with associated barriers to further innovation (Lessig, 2002). The lock-in of having invested significant time, effort and money on domesticating a particular operating system and associated services and apps, will not easily be undone. Furthermore, if the vital data residing on the platform of choice cannot easily be migrated to another, then the customer lock-in will represent a disincentive for the platform owner to innovate, or indeed to provide better performance at comparable cost.

This problem is in may ways similar to the pre-regulated mobile telecommunications world before mobile number portability. Here the customer was lock-into using the operator where their mobile number was registered. Mobile number portability is now implemented in all but a few countries in the world. However, there are not yet signs of similar lock-ins being removed from the digital platforms. Google has a project seeking to make it as easy as possible for users to export their data for usage elsewhere (www.dataliberation.org), and Facebook has a similar initiative (Cheng, 2010).

The future will most likely see innovations in how to mash-up and converge a complex variety of services across any platform and ecosystem in order to produce complex aggregate service, and here the current architectures and simplistic attempts to create walled gardens may be sufficiently inhibiting for innovation for other agile entrants to create new markets. In any case, the regulatory and competition concerns will unsoundly raise questions concerning the arrangements and possibly also seek to gain more insights and regulatory oversight over these vital institutions.

9 ACKNOWLEDGEMENTS

This research was partially funded by the LSE Enterprise project on Internet Innovation and Value Networks Analysis, funded by Telenor, Norway; as well as by a grant from the President of the Tokyo University of Science and Technology enabling participation in the workshop on mobile platforms in Tokyo, February 2012. I wish to thank (in alphabetical order only) the colleagues who have participated in and contributed to our research on digital platforms- and infrastructures at LSE since 2008: Ben Eaton, Silvia Elaluf-Calderwood, Jan Herzhoff, Kalle Lyytinen, Daniele Pica, David Tilson, Youngjin Yoo. Any misrepresentations or errors in this chapter are of course entirely mine.

10 REFERENCES

Abernathy, W. J. & J. M. Utterback (1978): Patterns of Industrial Innovation. Technology Review, vol. 80, no. 7, pp. 40-47.

Baldwin, C. Y. & K. B. Clark (1997): Managing in the Age of Modularity. Harvard Business Review, vol. 75, no. 5, pp. 84-93.

Baldwin, C. Y. & K. B. Clark (2000): Design Rules, Vol. 1: The Power of Modularity. Cambridge, MA: MIT Press.

Beniger, J. R. (1986): The Control Revolution: Technological and Economic Origins of the Information Society. Harvard University Press.

Boudreau, K. J. & A. Hagiu (2009): Platform Rules: Multi-Sided Platforms as Regulators. In Platforms, Markets and Innovation, ed. A. Gawer. Cheltenham, UK: Edward Elgar Publishing Limited, pp. 163-191.

Bowker, G. C. & S. L. Star (1999): Sorting Things Out: Classification and its Consequences, Inside technology. Cambridge, MA: MIT Press. wlad, n/a, from [Edwards #602].

Chandler, A. D. (1962): Strategy and Structure: Chapters in the History of the American Industrial Enterprise. Cambridge, MA: MIT Press.

Chandler, A. D. (1977): The Visible Hand: The Managerial Revolution in American Business. Boston, MA: Harvard University Press.

Cheng, J. (2010): Data Portability Finally Comes to Facebook, Plus Friend Groups. Ars Technica, October 6th. http://arstechnica.com/business/2010/10/data-portability-finally-comes-to-facebook-plus-friend-groups/

Ciborra and Associates, C. U. (2000): From Control to Drift: The Dynamics of Corporate Information Infrastructures. Oxford: Oxford University Press.

Claburn, T. (2009): Apple iPhone Developers Mostly Don't Make Much Money. InformationWeek, June 12th. http://www.informationweek.com/news/personal-tech/smart-phones/217801029

Clark, D. D., J. Wroclawski, K. R. Sollins, & R. Braden (2005): Tussle in Cyberspace: Defining

Tomorrow's Internet. IEEE/ACM Transactions on Networking, vol. 13, no. 3, pp. 462-475.
Clark, K. B. (1985): The Interaction of Design Hierarchies and Market Concepts in Technological Evolution. Research Policy, vol. 14, no. 5, pp. 235-251.
Earley, D. (2012): Android may never be as smooth as iOS, says ex-Googler. Android and Me, December 7th. http://androidandme.com/2011/12/news/android-may-never-be-as-smooth-as-ios-says-ex-googler/
Eaton, B., S. Elaluf-Calderwood, C. Sørensen, & Y. Yoo (2012): The Dynamics of Digital Service System Innovation: Control and Generativity in Apple iOS. Second-Round Review of MIS Quarterly Special Issue on Service Innovation.
Elaluf-Calderwood, S., B. D. Eaton, J. D. Herzhoff, & C. Sørensen (2011): Mobile Platforms as Convergent Systems: Analysing Control points and Tussles with Emergent Socio-technical Discourses. In Recent Developments in Mobile Communications - A Multidisciplinary Approach, ed. J. P. MaícasIntech - Open Access Publisher pp. 97-112. http://www.intechopen.com/books/recent-developments-in-mobile-communications-a-multidisciplinary-approach/mobile-platforms-as-convergent-systems-analysing-control-points-and-tussles-with-emergent-socio-tech
Farjoun, M. (2010): Beyond Dualism: Stability and Change as a Duality. Academy of Management Journal, vol. 35, no. 2, pp. 202-225.
Faulkner, P. & J. Runde (2009): On the identity of technological objects and user innovation in function. Academy of Management Review, vol. 34 no. 3, pp. 442-462.
Faulkner, P. & J. Runde (2011): The Social, the Material, and the Ontology of Non-Material Technological Objects. Cambridge: University of Cambridge, http://www.lse.ac.uk/collections/informationSystems/newsAndEvents/2011events/rundeFaulkner.htm
Funk, J. (2002): Global Competition Between and Within Standards: The Case of Mobile Phones. New York: Palgrave.
Gawer, A. (2009a): Platform Dynamics and Strategies: From Products to Services. In Platforms, Markets and Innovation, ed. A. Gawer. Cheltenham, UK: Edward Elgar Publishing Inc, pp. 45-76.
Gawer, A. (2009b): Platforms, Markets and Innovation: An Introduction. In Platforms, Markets and Innovation, ed. A. Gawer. Cheltenham, UK: Edward Elgar Publishing, Inc., pp. 1 - 16.
Gawer, A. & M. A. Cusumano (2002): Platform Leadership: How Intel, Microsoft, and Cisco Drive Industry Innovation. Boston, Mass.: Harvard Business School Press.
Ghazawneh, A. & O. Henfridsson (2012): Balancing Platform Control and External Contribution in Third-Party Development: The Boundary Resources Model. Information Systems Journal, vol. 22, no. 2, pp. Forthcoming.
Hanseth, O. (2000): Infrastructures: From Systems to Infrastructures. In Planet Internet, ed. K. Braa, C. Sørensen, and B. Dahlbom. Lund, Sweden: Studentliteratur, pp. 217-238.
Hanseth, O. & K. Lyytinen (2010): Design Theory for Dynamic Complexity in Information Infrastructures: The Case of Building Internet. Journal of Information Technology, vol. 25, no. 1, pp. 1-19.
Hanseth, O. & E. Monteiro (1997): Inscribing Behavior in Information Infrastructure Standards. Accounting, management and information technologies, vol. 7, no. 4, pp. 183-211.
Henderson, R. M. & K. B. Clark (1990): Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms. Administrative Science Quaterly, vol. 35, no. 1, pp. 9-30.
Herzhoff, J. (2011): Unfolding the Convergence Paradox: The Case of Mobile Voice-Over-IP in the UK. PhD Thesis, London School of Economics and Political Science.
Höök, K., D. Benyon, & A. J. Monroe, ed. (2003): Designing Information Spaces: The Social Navigation Approach. Computer Supported Cooperative Work. London: Springer-Verlag. 1 85233 661 7.
Isaacson, W. (2011): Steve Jobs: The Exclusive Biography. New York: Simon & Schuster.
Johnson, S. (2012): Can Anything Take Down the Facebook Juggernaut? Wired Magazine.

http://www.wired.com/business/2012/05/mf_facebook/
Kim, W. C. & R. Mauborgne (2005): Blue Ocean Strategy: How to Create Uncontested Market Space and Make Competition Irrelevant. Harvard Business Press. 1591396190.
Lessig, L. (2000): Code and Other Laws of Cyberspace. Basic Books,
Lessig, L. (2002): The Future of Ideas: The Fate of the Commons in a Connected World. New York: Vintage Books.
Lyytinen, K. & J. King (2002): Around The Cradle of the Wireless Revolution: The Emergence and Evolution of Cellular Telephony. Telecommunications Policy, vol. 26, no. 3-4, pp. 97-100.
Lyytinen, K. & Y. Yoo (2002): The Next Wave of Nomadic Computing. Information Systems Research, vol. 13, no. 4, pp. 377-388.
Manjoo, F. (2011): The Great Tech War of 2012. Fast Company, pp. 106-114. http://www.fastcompany.com/magazine/160/tech-wars-2012-amazon-apple-google-facebook
Mintzberg, H. (1980): Structure in 5's: A synthesis of the research on organization design. Management Science, vol. 26, no. 3, pp. 322-341.
Monteiro, E. (1998): Scaling Information Infrastructure: The Case of Next-Generation IP in the Internet. The Information Society, vol. 14, no. 3, pp. 229-245.
Murray, A. & C. Scott (2002): Controlling the New Media: Hybrid Responses to New Forms of Power. The Modern Law Review, vol. 65, no. 4, pp. 491-516.
Nickerson, J. V. & M. z. Muehien (2006): The Ecology of Standards Processes: Insights from Internet Standard Making. MIS Quarterly, vol. 30, no. Special Issue, pp. 467-488.
Parnas, D. L. (1972): On The Criteria To Be Used in Decomposing Systems into Modules Comm. ACM, vol. 15 no. 12 pp. 1053-1058
Remneland-Wikhamn, B., J. Ljungberg, M. Bergquist, & J. Kuschel (2011): Open Innovation, Generativity and the Supplier as Peer: The case of iPhone and Android. International Journal of Innovation Management, vol. 15, no. 1, pp. 205-230.
Schilling, M. A. (2000): Toward a General Modular System Theory and its Application to Interfirm Product Modularity. Academy of Management Review, vol. 25, no. 2, pp. 312-334.
Shapiro, C. & H. R. Varian (1999): Information Rules: A Strategic Guide to the Network Economy. Boston: Harvard Business School Press.
Simon, H. A. (1996): The Sciences of the Artificial. Cambrdige, MA: MIT Press.
Sørensen, C., R. Gear, & D. Elton (2010): Listen! Engage! Be! Open for Innovation with Information Technology. LSE - PA Consulting Group Report. http://mobility.lse.ac.uk/whitepapers.html
Suárez, F. F. & J. M. Utterback (1995): Dominant Designs and the Survival of Firms. Strategic Management Journal, vol. 16, no. 6, pp. 415-430.
Tilson, D. (2008): The interrelationships between technical standards and industry structures: Actor-network based case studies of the Mobile Wireless and Television industries in the US and the UK. Unpublished Doctoral Dissertation, Case Western Reserve University.
Tilson, D., K. Lyytinen, & C. Sørensen (2010a): Desperately Seeking the Infrastructure in IS Research: Conceptualization of "Digital Convergence" as co-evolution of Social and Technical Infrastructures. In 43rd Hawaii International Conference on System Sciences, Hawaii, USA.
Tilson, D., K. Lyytinen, & C. Sørensen (2010b): Digital Infrastructures: The Missing IS Research Agenda. Information Systems Research, vol. 21, no. 4, pp. 748-759.
Tilson, D., C. Sørensen, & K. Lyytinen (2012a): Change and Control Paradoxes in Mobile Infrastructure Innovation: The Android and iOS Mobile Operating Systems Cases. In 45th Hawaii International Conference on System Science (HICSS 45), Maui, Hawaii, USA: pp. 10.
Tilson, D., C. Sørensen, & K. Lyytinen (2012b): Platform Complexity: Lessons From Mobile Wireless. In The 11th International Conference on Mobile Business (ICMB), ed. H. Bouwman and V. Tuunainen. Delft, The Netherlands: AIS, pp. 289-300.
Tiwana, A., B. Konsynsky, & A. A. Bush (2010): Platform Evolution: Coevolution of Platform Architecture, Governance, and Environmental Dynamics. Information Systems Research, vol. 21, no. 4, pp. 675-687.
Trossen, D. & A. Kostopoulos (2012): Techno-Economic Aspects of Information-Centric Networking.

Journal of Information Policy, vol. 2, pp. 26-50.
Ulrich, K. (1995): The Role of Product Architecture in the Manufacturing Firm. Research Policy, vol. 24, pp. 419-440.
Utterback, J. (1994): Mastering the Dynamics of Innovation. Boston, MA: Harvard University Press.
Utterback, J. M. & W. J. Abernathy (1975): A Dynamic Model of Process and Product Innovation. Omega, vol. 3, no. 6, pp. 639-656.
Vanity Fair (2012): Microsoft's Downfall: Inside the Executive E-mails and Cannibalistic Culture That Felled a Tech Giant. Vanity Fair.
Vargo, S. L. & R. F. Lusch (2004): Evolving to a New Dominant Logic for Marketing. Journal of Marketing, vol. 68, no. 1, pp. 1-17.
Woodard, C. J. (2006): Architectural Strategy and Design Evolution in Complex Engineered Systems. PhD Thesis, Harvard University.
Woodard, C. J. (2008): Architectural Control Points. In Third International Conference on Design Science Research in Information Systems and Technology (DESRIST 2008), Atlanta, GA.
Wu, T. (2010): The Master Switch: The Rise and Fall of Information Empires. Knopf Publishing Group.
Yates, J. (1989): Control through Communication: The Rise of System in American Management. Baltimore: The Johns Hopkins University Press. 0-8018-3757-X.
Yoo, Y., O. Henfridsson, & K. Lyytinen (2010): The New Organizing Logic of Digital Innovation: An Agenda for Information Systems Research. Information Systems Research, vol. 21, no. 4, pp. 724-735.
Yoo, Y., K. Lyytinen, & H. Yang (2005): The Role of Standards in Innovation and Diffusion of Broadband Mobile Services: The case of South Korea. Journal of Strategic Information Systems, vol. 14, no. 3, pp. 323-353.
Ziegler, C. (2011): Nokia CEO Stephen Elop Rallies Troops in Brutally Honest 'Burning Platform' Memo?, http://www.engadget.com/2011/02/08/nokia-ceo-stephen-elop-rallies-troops-in-brutally-honest-burnin/.
Zittrain, J. (2006): The Generative Internet. Harvard Law Review, vol. 119, pp. 1974-2040.
Zittrain, J. (2008): The Future of the Internet: And How to Stop It. Allen Lane.
Zuboff, S. & J. Maxmin (2002): The Support Economy. New York: Viking.