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Mobile Platforms as Convergent Systems – Analysing Control Points and Tussles with Emergent Socio-Technical Discourses

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1. Introduction

In the field of information systems, mobile platforms as convergent systems represent a new direction for research. To date, platforms have been defined in terms of their composition as physical infrastructure (Gawer, 2009). However, the emergence of new digital and convergent services (e.g. VoIP, IPTV, etc.) as well as overlapping physical mobile telecommunications infrastructures provides the foundations for complex mobile platforms (Herzhoff, 2009e and 2011). Consequently, mobile platforms appear to be more complex than earlier work might indicate.

For the purposes of this chapter, and as an initial step to understand what a mobile platform is, the authors draw on the idea of mobile platforms as defined by Tiwana et al. (2010). They provide a richer definition that includes the complexity of all the contributors to a mobile platform. Together, they form a digital ecosystem (Tiwana et al. 2010) where multiple actors act and interact. A digital ecosystem includes a *platform* that serves as a core on which others can build *modules* that are designed to extend the service possibilities of the platform. It also includes various social actors who build the platform and various modules and a regulatory regime including standards that bind these heterogeneous actors together. In this context, control is a major factor in trying to understand the interactions between the many actors concerned within the ecosystem (Tiwana et al. 2010).

However mobile platforms need to be understood as more than just convergent technical systems, which mix multiple layers of physical and digital infrastructures for the creation and distribution of products and services. Mobile platforms also need to be understood in terms of the socio-technical discourses that play out through control points and tussles between the actors in the platform ecosystem.

Case studies of service convergence (e.g. VoIP, network sharing, mobile application markers, etc.) on platforms provide examples of tussles and control points, around which tussles unfold. Solving these tussles requires a reframing of controls points as socio-technical objects which are driven by the need to share resources and content over networks. In other words, control points as socio-material objects (Orlikowski and Scott, 2008) integrated into a socio-technical system (Herzhoff et al, 2009c). We believe that the technical evolution of mobile platforms will benefit from both a socio-technical and a technical

consideration of convergence. This view will enhance the comprehension and ways of providing guidance to network operators when making choices and decisions for the development of future networks associated with mobile service platforms.

Although the notion of convergence has attracted much interest over the past few years in both academic and enterprise spheres, analysis of its effect on platform ecosystems has still to be researched in depth. On one hand, convergence can be interpreted as a meaningless technology fad, but for other observers, convergence is an important factor for the design of new mobile information systems infrastructures and services (Herzhoff, 2010a). In the Information Systems discipline the idea of convergence has been mostly ignored, or applied occasionally in non-technical contexts such as strategic alignment (Herzhoff, 2009b). In recent years a new convergence discourse emerged around next-generation wireless infrastructures and services (Lind 2004). One such manifestation can be seen in the discussion of the mobile Internet and in new converging services connecting mobile telephony networks to the Internet. This new discourse has also evoked interest in the conceptual qualities of the notion of convergence in IS literature. An emergent group of IS researchers suggest that convergence is an important factor to consider in the design of new information infrastructures and services (Lyytinen & Yoo 2002; Yoo et al. 2009; Wareham et al., 2009).

According to Herzhoff (2009b), many different forms of convergence have been developed over the past 30 years, from digital convergence (Yoffie 1996) to cultural and organic convergence (Jenkins 2001). The loose usage of the convergence metaphor in both practice and academia has led to many observers no longer ascribing any meaning to it. In fact, scholars argue, "there seem to be as many definitions of convergence as there are authors discussing the topic" (Appelgren 2004: 246). Therefore, it does not seem to be too farfetched that observers from both practice and academia have begun to label convergence as a buzzword. Another school of thought sees convergence instead as a description of one of the driving forces for technological change (Lyytinen & Yoo 2002). In the meantime, the communications industry is experiencing increasing pressures from users' demands for new applications and services. In order to cope with unforeseen future socio-economic (user/network operator/service provider) demands, network technologies or mobile platforms that promote flexible, agile, dynamic and self-evolving networking are vital.

Mobile platforms, as part of a mobile system of infrastructures, need to be understood in the context of digital infrastructures. The Internet and global mobile telecommunications infrastructures are increasingly converging at different layers. Digital infrastructures are established and operated by a heterogeneous collection of public and private organisations, each governed by its own interests in the collaborative arrangement. The creation and distribution of value is collaborative, yet governed by conflicting interests. Two separate strands of research explore collaboration, conflict and control in digital infrastructure innovation. Research on tussles between participating interests focus on the need to understand the complex relationships between collaboration and conflict. Research on architectural control points emphasises individual organisations' ability to exercise control and generate value. So far these two research strands have not been subjected to a synthesis. Research is necessary in order to understand how the composition of these complex relationships, that both collaborate and conflict, affect the overall value chain of mobile digital infrastructures. An increasing problem faced by telecommunication network operators today is the need to monetise their network assets in the face of diminishing

margins on voice and data traffic. There are already many examples where virtual operators provide services using the infrastructure of a physical network provider. The question is then how can networks be shared fairly, between many providers, if providers are unwilling to exchange full information about their subscriber bases? Even if they were to do so, would regulators object on the basis of competition and privacy? Any practical solution must take into account all the stakeholders – users, network, service and application providers, manufacturers and regulators – and their various goals and aspirations. The first step in supplying a viable, long-term solution is to identify the tussles that result from the individual goals and aspirations of the stakeholders or entities (Clark et al., 2005).

In this chapter, we will use these components to present a framework model that integrates these concepts to the analysis of value networks, and in doing so we provide a complementary analysis of mobile platforms as convergent systems: the ecosystem composition, the interactions and the relationships and conflicts that are generated by those interactions.

This chapter aims to present a potential framework for the analysis of the composition of both ecosystems and value networks using tussles and control points. The remainder of this chapter is structured as follows: section 2 presents the definition of tussles and control points using a socio-technical analysis; section 3 introduces control points in the context of mobile digital infrastructures, its relevance and characteristics; section 4 provides a discussion on value networks using the control point analysis, in order to present our framework; finally section 5 concludes this chapter with the final remarks and future research areas to be explored.

2. Tussles

Clark et al. introduced the original idea of tussles in ACM SIGCOMM'02 Conference (2002). The idea was one outcome of a major research project funded by the US Defence Advanced Research Projects Agency (Department of Defence) to explore a Greenfield approach for designing the Internet. The paper points out that one initial assumption of the designers of the Internet was that everyone had aligned interests, which cannot be the case, as explained in the introduction of this paper. Although Clark et al. (2003) mention that the characteristic of tussle might be intrinsic to society, they point out that it also has another side where it slows down innovation and can decrease security on the Internet.

Clark et al. (2005) develop the concept of tussle in the context of network architecture design. They define a tussle as “the on-going contention among parties with conflicting interests” (p. 462). They further specify that in these tussles “different parties adapt a mix of mechanisms to try to achieve their conflicting goals, and others respond by adapting the mechanisms to push back” (p. 462). Although Clark et al. (2003) mention that the characteristic of tussle might be intrinsic to society, they point out that it also has another side where it slows down innovation and can decrease security on the Internet.

Clark et al. (2003) suggest that there are three forms of socio-technical tussles:

- Two or more users with common interests operate in presence of adverse third parties (e.g. government's desire to wiretap).
- Two or more users want to communicate but have conflicting interests. Here a third party might help (e.g. credit card company, to ensure trust).
- One party uses an application but is disturbed by some other intruding party (e.g. e-mail spam).

Clark et al. (2005) develop the ideas further and discuss in their revised journal paper the nature of tussle and in particular the specific role of technology in tussles. The term tussle is defined as an intense disagreement, or dispute, between parties who nonetheless have significant interests in collaborating. This concept can help explain a number of important changes at the core of mobile network innovation. However, the theoretical underpinning of the notion of tussle is still ambiguous. For example, the three types suggested by Clark et al. (2003) seem to be examples rather than a clear taxonomy of tussles. Schmidt and Kochan (1972) argue that a useful and precise conceptualisation of conflict needs to: (1) be devoid of value laden perspectives (2) should be conceptually distinct from both its conditions and consequences, and (3) the concept should be distinct from competition (Herzhoff et al., 2010b). Furthermore, Clark et al. (2005) themselves acknowledge that their multidisciplinary discussion of conflict only scratches the surface. Therefore, this section takes a closer look at some of the state of the art conflict theories within the social sciences, to identify ways to improve the conceptualisation of tussle.

It is necessary to lay down some basic assumptions about the very important distinction between competition and conflict (Economides, 1992 and 2006). Many studies, including the work by Clark et al. (2005), lack the conceptual clarity to differentiate between these two concepts. Others argue that this mainly results from the fact that the precondition of both competition and conflict is goal incompatibility. However, these incompatible goals can also be the result of contested resources, incompatibility of roles or incompatibility of values. Thus, competition is distinct from conflict. There are four different schools of thought on how the distinction between competition and conflict plays out:

- The first makes the distinction based on awareness: in this line of thought conflict is seen as a situation of competition in which parties are aware of their incompatible goals.
- The second school of thought examines how competition is regulated. Hence, competition becomes conflict if it goes beyond the limits of regulatory norms.
- The third school of thought bases the distinction on behaviour: two parties might compete and yet not be in a state of conflict, and will continue to cooperate on a daily basis. The behaviour of each party might be determined by different and incompatible goals, but this is not necessarily the precondition for a conflict to emerge, since this also requires some sort of motivation to interfere. This difference can be described as one of parallel striving (competition) and mutual interference (conflict) (Herzhoff et al, 2009c).
- The fourth school is based on Luhmann's (1995) systems theory. Competition is here seen as a descriptor for the environment of the organisation projected by one party, but direct interaction is not a necessary precondition. However, if direct interactions take place the possibility emerges for one party to communicate a "no" (Luhmann, 1995). It is this negation that may lead to the emergence of a conflict system.

According to Luhmann (1997), conflicts result from a communicated disagreement. Conflicts dissolve the predictability of the acceptance of a communication by taking back the initial complexity reduction and show that more is possible compared to what has been actualised. Therefore, Luhmann sees conflict as an immunisation for society. Conflicts test resistance potential (Luhmann, 1995) and are important for the immunisation of society and for its evolution. However, conflicts tend to become more and more decoupled from the initial disagreement, use more and more resources and attention by the so-called host systems.

Thus, conflicts can become highly integrated social systems in themselves. Luhmann calls this the parasitic character of conflict systems. The conflict system develops a life of its own and feeds itself from the host system, a term that will be discussed further later in this chapter.

Summarised, a systems-theoretical perspective fulfils the criteria of the conceptualisation of conflict put forward by Schmidt and Kochan (1972). It avoids value-laden perspectives and clearly distinguishes between condition and consequences of conflicts as well as between conflict and competition. These theoretical considerations are applied in this body of research, within the context of mobile information infrastructures and services.

Herzhoff et al. (2009a,b, c, and d) study mobile VoIP and mobile network sharing. In this context, network sharing is a cost-effective way of deploying 3G networks, and it has both benefits and drawbacks. Infrastructure sharing for example can be used both in the start-up phase to build coverage quickly and, in the longer term, to build cost effective coverage for areas of low reception. From the point of view of competition, many operators are satisfied with the arrangements established for sharing when it has a vertical distribution in the different telecommunication layers. However, changes in the sources of economic revenue are making it more common for operators to be willing or pushed to share on a horizontal basis – layer to layer – with other mobile operators.

In networking terms, tussles test the strength of control in a value network. If the tussle is too intense or cannot be resolved, then the control is completely overtaken by one player – hence it stops being shared but instead converts itself into a laissez-faire leader – or negotiations might occur, presenting a wide range of possible solutions. The concept of tussle therefore seems to stress more the dynamics of the conflict situation and the different mechanisms the contesting parties put in place. This brings us to the discussion of control and control points in digital infrastructure innovation.

3. Control points and mobile digital infrastructure

This section discusses the possible role of control points as an aid to understanding the complexity of digital infrastructure innovation. There are diverse discussions on the complexities of network architecture and modularity (Voss, 2009; Woodard 2008). With the increasing importance of alliances of participant stakeholders with different, and possibly diverging, interests, the issues of control and the associated process of organising collaboration under conflicting interests are brought to the fore. Hanseth and Lyytinen (2010) propose a high order discussion model on control and form part of a set of organising principles in which the Internet – and the networks linked to it – is composed of multiple layers of distinct information technology capabilities that carry out similar functions at different layers. Tilson et al. (2010) argue that digital infrastructure development is a continual process governed by the paradox of change with reliance on stability and the paradox of control coexisting with generativity. These conflicting interests regarding infrastructure developments can arise from a variety of socio-economic areas. In the case of the Internet, for example, the design is distributed between a large set of architects and developers, user communities and forms of governance (Hanseth & Lyytinen, 2010). The control of different network capabilities is separated and distributed, and the control forms are loosely coupled through architectural network principles. Hence mobile networks

usually present one or more actors actively seeking the control of a whole section of a mobile network.

The notion of “control points” has been used in several contexts, for example, to characterise essential architectural design decisions (Woodard, 2008), or to characterise the generation of value (Trossen & Fine, 2005). The concept was developed by the Value Chain Dynamics Working Group at MIT (Trossen & Fine, 2005) in order to understand how commercial benefit is gained from business models emerging in and around the telecommunications industry. Woodard (2008) defines architectural control points as “system components whose decision rights confer architectural control over other components” (p. 361). This effect can be small but also powerful, influencing the whole architectural landscape. Control points can broadly be defined as points at which management can be applied, and any encapsulated functional element of a system can be a control point (Trossen & Fine, 2005).

One starting point in the context of conflicts and the role of control points in the mediation of those points is the question of what are relevant host systems. In mobile telecommunications, Lyytinen and King (2002) studied conflicts in the standardisation arena and distinguish between a marketplace, innovation, and regulatory system. Another approach is to consider functional differentiation. One of the key distinctions for a functional differentiation is between service and infrastructure as suggested by Lyytinen and Yoo (2002). The infrastructure system comprises the network itself, the data pipe, and the transport technology. It can be based on different types of technology (e.g. Wi-Fi, 3G, LTE). The second system is the service system. The service system comprises any type of service, e.g. in the case of mobile VoIP a voice service. Another important function is regulation. This is not strictly limited to a formal governmental regulation authority since many entities can ‘regulate’. However, in the context of this paper, the regulatory system comprises all regulatory functions like e.g. spectrum regulation and setting of interconnection charges. Finally, the use system is comprised of all functions in the use domain of a specific service and a specific infrastructure, i.e. the device, the operating system or the user interface. This is a complementary approach to the one proposed by Lessig (2000).

Cyberlaw scholars concerned with the legal regulation of the Internet against abuse provide a complementary view of infrastructure development (Tilson et al, 2010; Herzhoff et al, 2010b; Eaton et al., 2010). Benkler (2005), for example, suggests that appropriate regulatory frameworks in a converged network should orient themselves towards democratic values and he proposes an approach to develop descriptive models based on how laws concentrate or distribute control over production and exchange of information. Lessig (2000) identifies four types of modalities of regulation: (1) laws, (2) social norms, (3) markets and (4) architecture or code. While Lessig applies these modalities within the limited context of regulation, Murray and Scott (2002) argue that the modalities of regulation are not limited to regulation but are part of any form of control system.

Additionally the concept of control points is complemented by the idea of triggers, which considers not only the dynamics but also the interactions between the different systems. Based on Luhmann’s Theory of Social Systems (Luhmann, 1995), systems are operationally closed but structurally open. This perspective suggests that outside stimuli or triggers have to be considered. However, the effects of these outside triggers on the system are

determined by the internal operations of the system, in this case the mobile digital infrastructure.

A mobile digital infrastructure is formed by an ecology of devices and services aiming to provide a seamless experience to the network users. Enabling technologies within this type of network promotes flexible, agile, dynamic and self-evolving networking capable of coping with unforeseen socioeconomic demands, e.g. user/network operator/service provider, so that the seamless goals can be achieved. There are three components contributing to the definition of a digital infrastructure (Mobile VCE, 2007, 2008):

- **Social factors:** This component is the voice of the user perception when using services provided by a digital infrastructure. It should be a seamless service, ideally with a featured configuration provided free (or at minimal cost), and requiring little user awareness of changes in formats, protocols or quality of service.
- **Economic and business factors:** This component is the voice of the network operators. In an operational digital infrastructure it implies the use of an intelligent decision making process. Computational algorithms should provide a working framework to optimise allocation of the resources available within networks. These should be informed by, and configured according to, advanced dynamic service level agreements, discovery service intelligence, digital market oriented application, and regulatory requirements.
- **Network factors:** A digital infrastructure shall be adaptable when network expansion is required. This adaptability is understood in terms of network capacity and protocol negotiation.

In general, the design of communication infrastructures cannot be considered as an entirely isolated design of each part of the infrastructure without overall insight into the end-to-end delivery of services, since low-level services may prove redundant or ineffective when applied at aggregate levels (Saltzer et al.1984). The increasing number of conflicts caused by the convergence of information and communication technology puts pressure on the existing infrastructure (Clark et al., 2005; Tilson et al., 2010). Parties with conflicting interests get increasingly incentivised to actively engage in interference. These interferences increase the complexity of the infrastructure and may lead to breakdowns in operation. A possible strategy to overcome these problems is the development of digital infrastructures in terms of structural flexibility, e.g. network virtualisation, and control flexibility. This constitutes a dynamic market approach (MVCE, 2008; Irvine, 2002; Bush, 2009). The idea of digital infrastructures faces three main challenges: (1) the role played by heterogeneous systems in terms of transmission power, frequencies, range, quality of service (QoS) requirements, spectral efficiency, and standards (Grøtnes, 2009); (2) the limited or no communication between these systems; and (3) the way systems change rapidly and the way digital infrastructures have to adapt quickly without degradation of service (Herzhoff et al, 2009c).

A digital infrastructure cannot be singled out as a network demand or capacity tussle mediator. The common use of expressions such as “a network capable of coping with unforeseen demands” or “a network able to resolve tussles on demand” represent partial or incomplete views of what a digital infrastructure can do. A digital infrastructure is not able to resolve, using its self-contained resources, all tussles generated internally. A requirement for digital infrastructures is not a justification for an expansion of the network that does not

take into account the variations in usage the network might have. A digital infrastructure shall not be the replicator or amplifier of current network hierarchy, or a computational tool to extend current IP networks and protocols (Herzhoff et al, 2009a; Herzhoff, 2009b).

When taken as a whole, these components of tussles, control points, triggers, and digital infrastructure provide a means to address the research question proposed in the introduction of this chapter. This research question concerns how to understand an ecosystem of mobile convergence platforms.

4. Control points and value in networks

Tussles can occur between and within these four different socio-technical systems. The infrastructure system comprises the network itself, the data pipe, and the technology enabling the transport. It can be based on different types of technology (Wifi, 3G, LTE etc.). The service system can be of any type, e.g. in the case of mobile VoIP, a voice service. The regulatory system consists of all regulatory functions such as spectrum and setting of interconnection charges. Finally, the use system consists of all functions in the use domain of a specific service and a specific infrastructure, e.g. the device, the operating system and the user interface. Combining the discussion of regulation with infrastructure, service, and use provides a comprehensive perspective on the aspects relevant to a discussion of control points and tussles in flexible mobile network innovation. The model presented in Figure 1 uses these four elements to explain the relationships between the tussles elements relevant to this analysis.

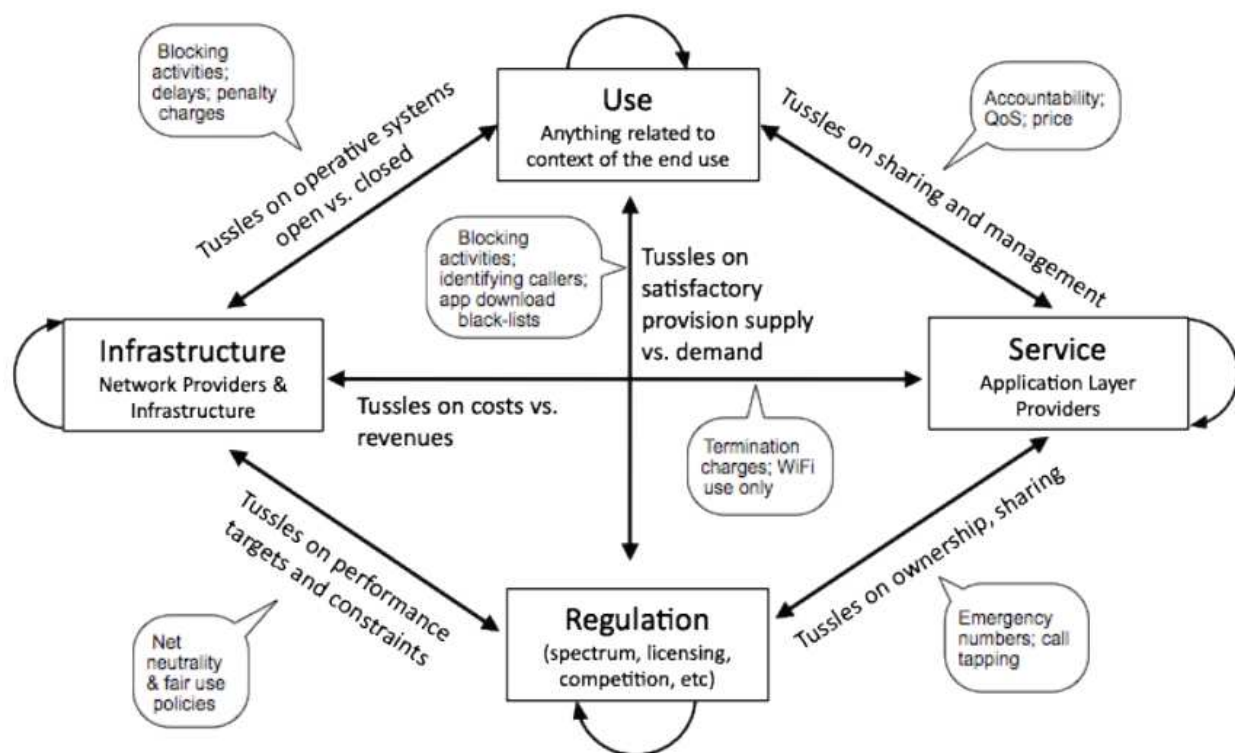


Fig. 1. Tussles and control model of relationships in a mobile platform convergence system (Elaluf-Calderwood et al, 2011)

The figure illustrates the conflicts or tussles that may occur within and between socio-technical entities in terms of the existing infrastructure, the services offered by the various providers, the regulatory system, and market demand (Herzhoff et al., 2009a). Each of the four socio-technical systems presented above has certain functions, which can also be described as control points. These control points can follow different modalities. They can be hierarchical, market-oriented, design-oriented, or community-oriented. In a market environment, control points are defined by the actor(s) interested in the maximum revenue, or stake of control. However they will also expect to limit the scope of usability when subject to regulation. Regulation can exclude certain types of control point (e.g. compulsory provision of emergency services) or determine the limits of power for certain control points (e.g. limitation in charges or service pricing).

Depending on their role in the revenue value-model, an actor could have a set of control points defined based on regulation, which leads one to think that control points are not an off-the-shelf definition but vary depending upon the circumstances in which regulation is applied. As explained, control points enable the controller to exercise power over other players or actors of a socio-technical ecosystem. They represent a socio-technical mechanism expressing the boundaries of areas of economic power in the value networks identified within a telecommunications network.

Trossen & Fine (2005) show how control points can be identified and implemented within communications architectures, and how they can facilitate the construction of potential business models that in turn can be evaluated in terms of viability and sustainability. This manner of use of control points also shows how external triggers, arising from different domains (e.g. changes in technology, the business cycle, industry structure, regulatory policy, customer preference, capital markets and corporate strategy), can lead to control points increasing or decreasing in importance, which in turn affect the strength of business models.

Business models and value chains can be defined in terms of “the way a network of companies intends to create and capture value from the employment of technological opportunities” (Faber et al, 2003). Fine (1998) was one of the first researchers to work on comparative studies using the approach of value chain dynamics, cross-industry comparisons, and the exploration of life-cycles in complex value chains. Fine (1998) proposes a double helix model, which for telecommunications captures this life cycle in four phases – integration, market differentiation, verticalisation and disintegration. It visualises a complex trigger dynamic analysis that leads to the observed integration/disintegration effects. Trossen and Fine (2005) extend this to develop analysis methodologies that allow for segmentation into value chains or value networks. Fine (1998) also discusses the bullwhip effect, whereby a complex value chain can amplify changes in demand, the impact being increased volatility of demand further up the supply chain. While this more traditionally relates to inventory-based value chains, a similar behaviour can be observed in telecommunications (equipment stock) and computer industry (investment in R&D). Mitigating this effect, within the context of future network design, is desirable.

Clark and Blumenthal (2007) apply a socio-economic perspective to network architectural design in a systematic manner and thereby shape the foundation for trust-to-trust principles. Sollins and Trossen (2007) extend the “Design for Tussle” concepts towards a

vision for a flexible execution environment that incorporates tussles – and the concerns that drive them – directly into the formation of the dynamic execution environments. As an example of such evaluation, Trossen & Fine (2005) outline the potential application of such an evaluation tool in the area of VoIP, informing decision makers at the regulatory level, in this case the FCC in the US market, on the required speed of regulatory action, a crucial part of an overall design process.

Finding a method to identify the creators of value is a major concern. Eaton et al. (2010) propose the use of control points in the mobile Internet for the determination of value networks in a two-stage model that includes the creation of a map of the various constituent actors within the industry. This map serves to illustrate the businesses that may exist across the industry, and control points are used to examine where and how members of the value network can extract value and the use of triggers in order to understand the sustainability of this economic power given the impact of external factors.

Faber et al. (2003) definition of the business model highlights the networked character of digital infrastructure innovation, the value creation and captures involved in the trade-off, as well as the issues connected with technology design (Ballon, 2009). Value networks are defined as: *“a dynamic network of actors working together to generate customer value and network value by means of a specific service offering, in which tangible and intangible value is exchanged between the actors involved”* (De Reuver, 2009). In doing so, there are three critical dimensions of analysis (Ballon, 2009) mirroring the model in Figure 1; Industry structure and value network; functional and technical architecture; and value creation and capture. Based on the empirical evidence collected by the authors, there are no strong indicators to challenge this description of the fundamentals of tussle creation and management between operators as proposed in figure 1.

The authors encountered a mirrored reflection of the high-end tussles models on the analysis of value networks completed by Ballon (2009): for each component of the proposed model by Herzhoff et al. (2009d), there is a value component in the model proposed by Ballon. If the tussle model proposed an ontology considering the potential relationships between the actors influencing the tussles, then the business model ontology incorporates four different levels of a business model: a strategic, functional, financial, and value configuration level. At the strategic level, a business model is concerned with the value network configuration, i.e. setting up roles and relations between actors, and the physical and virtual flows between them. At the functional level, a business model describes the architecture of a product or service, which is determined by a specific configuration of modules, interfaces and intelligence. At the financial level, a business model describes the cost and revenue sources, as well as the distribution of flows for the actors involved.

Together, these three levels contribute to the fourth and final level of a business model, i.e. the value configuration. We propose that within complex and converging business and digital infrastructures, characterised by value co-creation within a large “industrial architecture”, research should not just focus on any clear cut value proposition, but rather on the process of value construction leading to various value configurations. This deals with the way in which actual value is created in the market. While specific design choices also need to be made at this level, the value configuration can also be viewed as the logical

outcome of business model design choices made at the previous levels. Figure 2 illustrates the basic, bi-directional relations between the different levels.

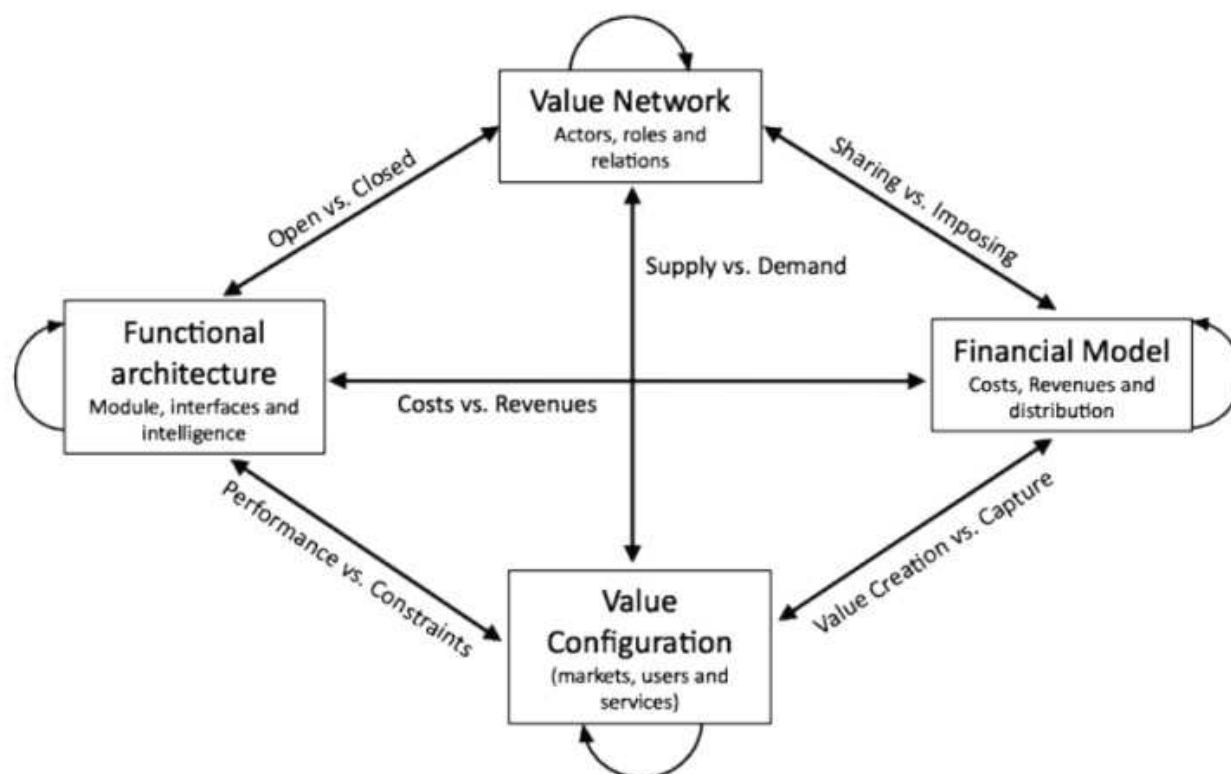


Fig. 2. High-End Tussle model transposed to value networks (Elaluf-Calderwood et al, 2011)

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In reality, a range of complex, both direct and indirect, bidirectional relations between the different levels exist. Also, which particular relationship is focused on and in which ‘direction’ the impact is studied depends upon particular cases and contexts. One of the tasks of a design approach that takes into account contextual contingencies will be to identify the realistic scope for choice available to technology producers and users at the various levels and subsequently work out the impact of the various ‘degrees of freedom’ among the different levels. However, in order to enhance the clarity of the initial ontology, it is proposed here as a point of departure that the value network is the primary agent, which designs and uses a functional architecture and shares cost and revenues, and that the value configuration is the primary outcome of the business modelling process.

Finally, a value network consists of actors possessing certain resources and capabilities, which interact and together perform value activities or roles, in order both to create value

for customers and to realise their own strategies and goals. It is the result of organisational and strategic design, in which control points as an analytical tool provide insightful understanding of the forces in place for the development of business models. The four levels of this framework and their interrelationship need to be detailed, and subsequently the levels or domains need to be extrapolated into a number of parameters, i.e. the crucial configuration parameters that would need to be addressed by any business model aiming for new or improved digital infrastructures products or services.

5. Conclusion

The convergence of mobile telephony networks with the Internet has resulted in an increasing number of conflicts or tussles. These tussles emerge around control points within an infrastructure. These conflicts challenge the key assumptions of information infrastructure design and lead to inefficiencies and system failures. The analysis of tussles based on Luhmann's Theory of Social Systems indicates that tussles can emerge around four different types of system: the infrastructure system, the service system, the regulatory system, and the use system.

These control points can be architectural, hierarchical, community, or market-based. These control points enable a system to produce a communicative disagreement. This communicative disagreement can often be quickly resolved through exercising power (e.g. by the regulator, the dominant actor on the ecosystem) or by putting in play economic factors (e.g. T-Mobile's offer to enable mobile VoIP for higher paying customers, optional IPTv services, etc).

Overall, these conflicts often result in a dynamic self-sustaining autopoietic system - a dynamic set of tussles. In particular, we argue that the notion of control points may be helpful in providing a better understanding of sociotechnical tussles. This may in turn facilitate dialogue between management and information infrastructure engineers. The concept of control points, as a methodological tool for the analysis of the development of network design, has been successfully transposed from its technical origins to become a socio-technical variable. By including the multiple relationships, tussles and ambiguity between stakeholders in an analysis, control points can become a tool that adequately addresses the complexities attached to the development of digital infrastructure design.

Although control points are contributing significantly to the analysis of and planning for tussles, there are some shortcomings to the approach. It is necessary to complement this analysis with a revision of the combination of methods used to exploit value chain dynamics in conjunction with other approaches as part of an analysis of metrics. Furthermore, a conceptual clarification of control points needs to be part of this process, e.g. the role of tussles, granularity of the analysis, value web, etc. Particular stress must be placed on understanding what is controlled, e.g. network behaviour, revenue, resources, functionality, generativity, innovation.

Control points have been used at the network, management and content, and business model layers as a powerful tool to understand challenges brought about by the evolution and fast innovation of the technologies described. This method of analysis can be used to understand the relationships between the different stakeholders in the ecosystem, the roles

and functions they bring to the value chain, and the short and long term effects of those relationships.

Further work is required to complement the understanding of the tussle concept. Perhaps the goal ought to be the development of a tussle taxonomy, which clarifies the important distinctions between tussle, conflict, collaboration, and competition. Some tussles will continue to be external to socio-technical approaches and need to be properly identified.

By including a socio-technical metrics definition in this analysis, we have opened a number of research opportunities, which have arisen from the development of socio-economic metrics for network selection algorithms. Metrics that require to be investigated in future might include: 1) profitability metrics, e.g. profitability per byte; 2) trust metrics, for example based on user rating or network strength (e.g. by the inclusion of other people using the network, and who are known to the user); 3) consumer surplus metrics, not only based on network strength but also on other cost profiles converted in utility; and 4) pay-off metrics, e.g. taking into consideration tussles between users and operators. These areas are of relevance to mobile operators in order to identify the optimal value chain and areas of value add that emerge from these new digital infrastructures.

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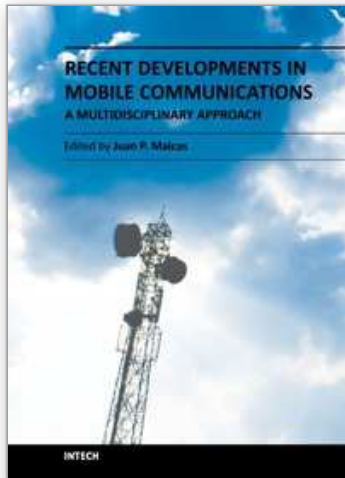
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