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Platforms and incentives for consensus building on complex ICT systems: The development of WiFi

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ABSTRACT

This paper studies the organizational hiccups that can occur during the development of technological platforms for complex ICT systems and focuses on an important part of the ICT ecosystem; committees that develop common ICT platforms. Given the diverging interests of the parties involved, it is surprising that consensus is usually reached in these committees. A case study of the development of IEEE 802.11 is conducted which is presented as an emergent phenomenon. IEEE 802.11 is a typical example of a highly successful technological platform that encountered several organizational glitches during its development, but eventually achieved widespread market dominance. This study examines these glitches and proposes strategies to overcome them by using concepts from the governance literature.

1. Introduction

With the ongoing convergence of industries, complex ICT systems have emerged that consist of established technological components (Van de Kaa, Den Hartog, & De Vries, 2009). These components originate from various product markets. The wireless local area network in homes is an example of a complex ICT system as it includes components from computer manufacturing (e.g., personal computers) and computer peripheral equipment manufacturing (e.g., printers). The stakeholders involved in these product markets all strive for a common platform that can integrate and interconnect the once distinct components. Platforms are defined as "evolving organizations[1] or meta-organizations that: (1) federate and coordinate constitutive agents who can innovate and compete; (2) create value by generating and harnessing economies of scope in supply or/and in demand; and (3) entail a technological architecture that is modular and composed of a core and a periphery" (Gawer, 2014). This paper focuses on a system's interfaces,[2] which as a whole constitute the technological platform (Baldwin & Woodard, 2009). These interfaces can be used to interconnect the constituent components of technological architectures such as complex ICT systems. They enable two and multi-sided markets (Rochet & Tirole, 2003; Rysman, 2009), allowing various actors including platform users, complementors, platform providers, and platform sponsors to connect (Eisenmann, Parker, & van Alstyne, 2009; Suarez & Kirtley, 2012).[3]

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[1] Whereby an organization is defined as a "system of coordinating activities of two or more persons" (Barnard, 1938 as cited by Gawer, 2014).

[2] Which may become compatibility standards or dominant designs if used commonly.

[3] Thus, a platform can refer both to a set of (standardized) interfaces (such as IEEE802.11) and complex ICT systems that are enabled by those interfaces (such as the wireless local area network). The focus is on the former.

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The paper studies the organizational hiccups that occur during the development of technological platforms. The aim is to identify these glitches and to describe and discuss various high level strategies to overcome these inefficiencies, and to explain why actors remain committed or even become more committed to successfully develop the platform despite these difficulties during the platform development process. To achieve this objective, a case study (Yin, 2009) around the development of IEEE 802.11 has been conducted. This platform is a set of (standardized) interfaces that can be used to enable a wireless local area network (WLAN). IEEE 802.11 is a typical example of a highly successful technological platform that experienced several glitches during its development, but eventually achieved widespread market dominance. Secondary data was gathered in the form of previous scientific papers and online news archives such as minutes of committee meetings. Primary data was gathered by conducting several semi-structured interviews with key persons involved in the development of WiFi (including the committee chair).

The network around IEEE 802.11 consisted of committees, subcommittees, and task groups each comprising experts with various interests and sometimes conflicting agendas, thus making the network quite complex. Complexity arises when the dependencies among the elements become important (Miller & Page, 2007). It has been argued that in such complex environments, emergent behaviour may become apparent. Here the term *emergence* is used to denote something arising from the local interaction of agents (Epstein & Axtell, 1996). Bedau and Humphreys (2008) provide a comprehensive discussion of this concept. Under this definition, it may be argued that the development and promotion of IEEE 802.11 can be seen as an emergent phenomenon whereby individuals spontaneously came together in various institutions such as committees and consortia to develop and promote a common platform. This paper explores the extent to which high level strategies may surface in such networks to counteract the chaos that results from organizational hiccups.

The paper contributes to the literature on ICT platforms (Gawer, 2009, 2014; Gawer & Cusumano, 2002; Rochet & Tirole, 2003) by studying platforms from a governance perspective. ICT platforms have been studied from multiple perspectives, for example, from the area of strategy, economics, and engineering design (Gawer, 2014; Gawer & Cusumano, 2013). Scholars that apply perspectives from engineering define platforms as technological architectures that consist of interfaces which may enable innovation, whereas economists argue that the interfaces themselves can be considered as platforms which enable two and multi-sided markets (Gawer, 2014). Scholars in the area of strategy study factors that affect the outcome of platform wars (Blind, 2011; Gallagher, 2012; McIntyre & Subramaniam, 2009; Shapiro & Varian, 1999b; Sheremata, 2004). However, few scholars have examined platforms from a governance perspective. This paper suggests that the understanding of platform development is enriched by applying the lens of governance and change management (Axelrod, 1984; De Bruijn & Ten Heuvelhof, 2008; Lewis, 2011; Pestoff, Brandsen, & Verschuere, 2012). Governance is defined as "coordination and regulation of interdependent actors in the absence of an overarching political authority" (Rosenau & Czempiel, 1992, as cited by Mueller, 2010). Several incentives for consensus building were found; the perspective of future gain, the perspective of enduring gain, strong voting rules, a sense of urgency, and an incentive to compromise. These incentives explain why stakeholders remain committed to a decision making process, despite several organizational hiccups and bruises.

2. Theory

Platforms have been studied from multiple perspectives. Scholars in the area of engineering design envision platforms as technological systems or architectures (e.g., complex ICT systems) and study how such platforms result in innovation (Gawer, 2014). For example, they emphasize that the modular character of platforms enables innovation (Langlois & Robertson, 1992). In this respect, (standardized) interfaces are crucial as they facilitate the modularity of the technological system (Schilling, 2000). Economists study how such interfaces or platforms may be set. Platforms may be set in markets, in hierarchies, in a hybrid combination of markets and hierarchies, and in a network form of organizations.

When platforms are set in markets, they are developed and promoted by single firms or multiple firms that are active in e.g., consortia or alliances. Platform wars may occur in which competing platforms fight for market dominance (Shapiro & Varian, 1999a). Markets in which platform wars are fought are often affected by network effects (Farrell & Saloner, 1985; Katz & Shapiro, 1985), meaning that a platform increases in value once more users adopt the platform. Scholars in the field of technology management have attempted to explain the outcome of platform wars by identifying factors for platform selection given the occurrence of economic market mechanisms such as network effects (Schilling, 1998; Suarez, 2004; Van de Kaa, Van den Ende, De Vries, & Van Heck, 2011). Scholars seem to agree that increasing installed base is crucial for attaining dominance (Hill, 1997; Shapiro & Varian, 1999a). For example, this can be accomplished by pre-empting competitors by entering earlier (Lieberman & Montgomery, 1998) or by marketing communications to influence anticipated or expected installed base (Schilling, 2013).

When platforms are set in hierarchies they are developed in committees where actors discuss the contents of these technological platforms and try to reach consensus about specific aspects. Scholars have focused on the platform development process that takes place within committees. For example, Nickerson and Zur Muhlen (2006) incorporated an ecological perspective and Backhouse, Hsu, and Leiser (2006) examined the phenomenon through an actor network perspective and applied the circuits of power framework to understand the development of platforms. Leiponen (2008) applied the theoretical lens of social network theory to understand platform development for wireless communication.

Platforms can be set through a hybrid combination of markets and hierarchies (Farrell & Saloner, 1988; Funk & Methe, 2001). Platforms may also be set in "network forms of organization" (Powell, 1990) which is comparable to what Mueller (2010) refers to as "networked governance" in that it consists of "looser affiliations of organizations and individuals that rely

on regularized interaction to pursue cooperative goals." The Wireless Authentication and Privacy Infrastructure (WAPI) is an example of a platform that was developed jointly by several universities, a corporation, a committee, a research center, and a governmental organization (Van de Kaa, Greeven, & van Puijenbroek, 2013). In this paper, the focus is on such networked combinations and more specifically on situations in which platforms are developed in committees are then introduced in the market and compete with other platforms for dominance in platform wars.

The governance literature devotes considerable attention to issues of networked governance. As stated above, this refers to situations in which there is no overarching authority, but a multitude of autonomous but mutually dependent organizations, each with their own interests. Collective decision making requires cooperation between these organizations. However, due to conflicting interests and lack of a central authority, such cooperation cannot be taken for granted. One inherent characteristic of networked governance is that there is no unambiguous one right answer to the issues that are addressed in the committees with respect to the platforms (for reviews on networked governance, see: Blanco, Lowndes, & Pratchett, 2011; Klijn, 2008; Rhodes, 1996, 2007). In fact, in a standardization process, there is no single right or best decision, but participants pursue their own solutions which they perceive as the right solutions.

A context with characteristics like these often results in a free fight between the actors involved, and blocks or seriously hampers the consensus building process. The literature on governance and change management has showed that in such a context the focus might change from a content perspective (what is the right solution?) to a process perspective (how can the right solution be reached?) (De Bruijn & Ten Heuvelhof, 2008). Governance thus concerns the manner in which the process of interaction between the most important stakeholders could be organized in such a way that they are able to reach consensus. In conflict situations, stakeholders have two options: exit (leave) or voice (participate) (Hirschman, 1970). If a decision requires the support of a critical mass of parties, voice is the preferred option and the process should offer each of the stakeholders involved sufficient incentives (1) to enter the process, (2) not to leave the process and, ultimately, and (3) to commit to the final decision. The most important incentive for the parties involved is obviously the perspective of gain (De Bruijn & Ten Heuvelhof, 2008; Huxham & Vangen, 2013). Once actors have entered the process, it might be hard to leave because participation deepens the investment in a community. Leaving the process can have repercussions. It can harm the interests of the other actors, it can be perceived as unreliable behaviour and therefore discredit an actor's trustworthiness, and there is always the risk that the other actors will get back at the party leaving the process and thus challenge the leaving party's perspective of gain.

Interaction-based governance leads to incremental decision-making, and it is often contrasted with command-and-control types of governance, which are better suited to hierarchical settings and which lead to more radical decision-making (De Bruijn & Ten Heuvelhof, 2008). Furthermore, consensus is less important within a hierarchical context, given the presence of a central authority. Nevertheless, simply opposing interaction-based governance and incremental decision-making to hierarchical governance and radical decision-making creates an overly simplistic, black-and-white image. Studies have shown that, in some cases, hierarchical forms of governance and radical decision-making can be effective within networks of mutual dependence (De Bruijn, 2005; Koffijberg, de Bruijn, & Priemus, 2012; Sawhney, 2001). One of the parties or a coalition of parties can assume a temporary position of power within a network. For example, this could occur when a critical mass of parties has an interesting perspective of gain and decides to cooperate, jointly carrying out a hierarchical intervention. Such a temporary position of power can also be assumed by a single party. For example, if the process is very slow, a stalemate occurs, or no results are visible, the parties involved could become frustrated. If this frustration reaches a sufficient level, it could strengthen the power position of a chairperson, thus rendering the parties in the process more vulnerable to hierarchical interventions that the chairperson might take in order to break a stalemate (De Bruijn & Ten Heuvelhof, 2008).

The literature contains examples of these smart hierarchical interventions, which are effective within networks of dependencies. For example, a hierarchical intervention could be used to impose procedures on parties unilaterally. Although this does not, as such, impose any constraints on the content of the discussion, the procedures can nonetheless steer the decision-making in a particular direction. Hybrid interventions are possible as well, involving unilateral and binding decisions (hierarchy) that nevertheless allow space for interaction (e.g., in implementation). Under certain conditions, many parties will then tend to accept the unilateral decision, taking advantage of the space that it allows.

These type of smart hierarchical interventions could be necessary, given the disadvantages that are associated with interaction-based governance such as slow decision-making (everyone must agree), and sub-optimal outcomes (reaching a compromise becomes more important than taking the (perceived) best decision).

One important aspect of networked governance is that changes are often emergent due to the multiplicity of players, who interact with each other, each bringing several issues to the table. This generates a wide range of possible connections or couplings between issues, which are difficult to anticipate in advance. Moreover, during this process of establishing such couplings, learning can occur among the partners that can, in turn, generate new, unanticipated opportunities (De Bruijn & Ten Heuvelhof, 2008, pp. 51, 52). The ultimate change thus emerges during the process and is often difficult to predict in advance.

3. Case study

3.1. History

In line with deregulation policy, in 1985 the US Federal Communications Commission (FCC) opened up the industrial, scientific, and medical radio bands for communications applications, making commercial wireless data communication

possible (Lemstra, Hayes, & Groenewegen, 2011). The FCC ruling triggered the funding of an internal feasibility study at NCR Corporation, a company that developed several products including cash registers, bar code scanners, and computers. The feasibility study evaluated the viability of a wireless radio for cash registers. In 1988, after the successful feasibility study, the team started to develop a wireless network interface card to create a wireless local area network (WLAN). To realize a WLAN, a wireless protocol was needed, and NCR became involved with the IEEE to find an appropriate existing protocol. It first participated in the IEEE 802.4 committee which had developed the token bus specification. Initially, NCR thought that it might be possible to use this protocol to also enable wireless communication. However, as a participant in the IEEE802.4 committee, NCR gradually concluded that the IEEE 802.4 specification could not easily be applied to wireless communication mainly because IEEE 802.4 was not efficient enough in correcting transmission errors. Later, NCR participated in the IEEE 802.3 committee which had developed the Ethernet specification. NCR proposed an extension to IEEE 802.3 to enable wireless communication. This proposal was rejected, but later the IEEE Standards Board approved the proposal for a new committee: IEEE802.11 (Jakobs, Lemstra, & Hayes, 2011). By participating in 802.3 and 802.4, NCR became familiar with the political and social processes within committees. This also created legitimacy in later stages. As the chairman of IEEE 802.11 comments "*because NCR had already worked in 802.4, other firms thought that they were experts.*"

The 802.11 working group was founded in 1990. Each working group consisted of several task groups for specific topics. At its November 1991 meeting, two task groups were established; the medium access control task group and the physical task group which were to develop the technological foundations of the first version of the platform. Normally, various meetings are needed to agree upon the contents of the specification. The chairman of the committee explained: *"We are an open group so anyone can join, but nobody has the right to vote immediately. You can earn the right to vote by participating in meetings. This means that you have to spend at least 75 percent of the time in the meeting. If you've participated in two plenary sessions, you get voting rights in the third plenary session."* At each meeting, discussions were held which resulted in several motions that were put to a vote. Various (groups of) stakeholders prepared motions for the technology and tried to gain support for their motions so that they could influence the contents and direction of the specification. A certain number of voting members were present at each meeting. They could approve, oppose, or abstain. A motion was accepted if it received more than 50 percent of the votes. Thus, in the case of IEEE 802.11 consensus refers to majority consensus and not to full consensus.

Between 1990 and 1997, over 100 sessions were held in the 802.11 working group to discuss the technical contents of the specification. Sessions consisted of one or more meetings over a period of one or more days (although most sessions lasted four to five days). In September 1997, the first version of the IEEE 802.11 standard was approved and in December 1997 it was published. After 1997, the network around IEEE 802.11 expanded. Between 1990 and 1997, it only consisted of the 802.11 committee and its subcommittees, but after 1997 stakeholders were added, including industry consortia and community initiatives that built private wireless LANs implementing IEEE 802.11 (Lemstra et al., 2011, p. 182). The Wireless Ethernet Compatibility Alliance was formed in 1999 which later became the WiFi alliance. This entity certified products that complied with IEEE 802.11 resulting in Wi-Fi certified products, and it promoted the IEEE 802.11 platform. This relieved the uncertainty among many actors towards the platform. Meanwhile, various task groups were established to discuss extensions to the platform. One example was the establishment of the IEEE 802.11i task group in 2004 which was responsible for developing a security protocol. Eventually, IEEE 802.11 became the dominant platform for wireless data communication.

3.2. Setbacks

Although IEEE802.11 eventually achieved widespread acceptance and is thus a typical example of a successful platform, many setbacks occurred during platform development. One of these setbacks relate to the voting rules. Although the chairman of the IEEE 802.11 committee applied strict voting rules, these were sometimes misused to gain support for a proposal. For example, in a specific subcommittee, a professor who wanted to gain support for a certain proposal (which included a patented technology) sent many students to obtain the required 50 percent level of support. These students all voted for the specific proposal which eventually led to the proposal being incorporated in the subcommittee (Lemstra et al., 2011, p. 81). Also, according to IEEE rules, engineers should always vote for the best technical solution. However, in reality, engineers represent their company and vote strategically. In this respect, individual membership is misleading as individual members will follow their company's position. The chairman of IEEE 802.11 committee commented: "*so if a person gets a job with another company, he can suddenly have a different opinion, but that's how it goes.*" Actors can have different goals, some actors may be active contributors, whereas others may be observers with less technological expertise who will not necessarily vote for the best technological solution or who may abstain from voting. Actors may be opponents and may purposely postpone or distract the process as they might want to protect their market position or they may "purposely vote opposite their affiliation to appear fair minded" (Lemstra et al., 2011).

Another glitch in the development process which caused delays was that, at different levels within the committee, members sometimes had conflicting goals. The primary goal of the IEEE and the committee's chairman was to reach a common technological platform, whereas the goal of individual participants was to implement their technology in the platform so that they could later benefit from profits accruing from intellectual property rights. There were also several battles between competing proposals in the committee which sometimes led to chaotic discussions which negatively affected the decision making process. One of these battles was about the proposal to implement Frequency Hopping or

Direct Sequence Spread Spectrum (these were two incompatible technologies that the FCC allowed to be applied). Neither of the groups could secure the required level of support so eventually both proposals were supported. Another battle about the specification of the physical layer of IEEE802.11b was fought between Harris, Lucent, and Micrilor. Fifty-eight voting members attended the final meeting. Twenty-nine voted for the Micrilor proposal, and 28 for the Harris proposal, with one abstention. According to one interpretation of the rules, Micrilor had won but according to another interpretation it had not won since its proposal had received 29 out of 58 votes which is not more than 50 percent. This resulted in a fierce discussion about the interpretation of the rules and eventually the whole voting procedure was contested. One of the supporters of the Harris proposal even moved a motion stating that IEEE members had voted strategically for Micrilor to ensure that the Harris proposal would not be accepted. Another fierce discussion erupted: "The chaos created by this motion was incredible and the whole meeting went down in flames" (Lemstra et al., 2011, p. 75). Later that week, at an unofficial meeting, representatives of Harris and Lucent decided that a compromise solution was needed, and consequently, they developed and agreed upon a completely new technological proposal which incorporated the best elements of the original Harris and Lucent proposals. (Lemstra et al., 2011). According to Lemstra et al. (2011) "the two parties could agree on this alternative proposal, as it would provide improved performance compared to the original Harris proposal and reduced complexity compared to the original Lucent technologies proposal. Because this suggestion conferred no advantage (or disadvantage) to any other party, the joint proposal was accepted at the next meeting of the working group".

Apparently, the development of IEEE 802.11 was challenging. The IEEE802.11 committee was an open group and new actors could easily enter the arena which could negatively affect the speed and quality of the decision making process (De Bruijn, Ten Heuvelhof, & In't Veld, 2002). Actors can have different interests, goals, and behaviors. For example, they may be observers (fence sitters) with comparably less technical expertise or opponents (postponers) (De Bruijn & Ten Heuvelhof, 2008). This can lead to fierce battles over technological proposals to be incorporated in the platform. Although, IEEE participants have to explain why they vote against a proposal, which somewhat accelerates the decision making process and helps participants in reaching an acceptable solution, the voting procedure basically results in a victory of one side over the other. Thus, for the actors, it is perceived as a win–lose situation which can evoke aggressive behaviour. This happened in the IEEE802.11 case and it also led to strategic behaviour when engineers voted according to their company's position and not according to their technological expertise.

In summary, this appears as a recipe for failure. However, counterintuitively, actors remained committed to the platform and did not leave the process. Eventually, they reached consensus and the platform achieved widespread dominance in the market. The essence of the analysis is that several incentives for cooperative behaviour emerged during the decision making process. In the next section, these incentives are described.

3.3. Incentives for consensus building

3.3.1. Perspective of future gain

It appears that during all stages of the development of IEEE 802.11, the group of actors as a whole knew that they would benefit in the long-term from the outcome of the decision making process. Firstly, a company was always likely to get one or more of its proposals accepted. These proposals could include patented technologies that could turn out to be important for the platform, resulting in future revenues from these patented technologies (Bekkers, Bongard, & Nuvolari, 2011). Secondly, once a common platform was reached, complex ICT systems (in this case wireless local area networks) could be realized and actors could implement these systems for their customers. Even if a company's technological proposals were not considered during the decision making process, it could still benefit from the advantages of a common platform such as increased compatibility and lower prices of products in which the platform was implemented. Furthermore, merely participating in the standardization process also provides benefits in the time to market. Most actors tend to leave the decision making process if their input is not taken into account in the decision making process (Chisholm, 1989; Kooiman, 2003). However, in the IEEE 802.11 case, most actors accepted the fact that their technology was not incorporated because they realized they could reap some of the benefits once a common platform was reached. The development of IEEE 802.11 is a clear example of the generally acknowledged occurrence of both cooperation and competition among parties during platform development (Garud & Kumaraswamy, 1995). Once the platform has been developed, it is introduced in the market and a platform war might commence. Winners of platform wars may benefit from a "winner take all" situation (Shapiro & Varian, 1999b) and may become industry leaders. This reinforces the (possible) perspective of future gain. The perspective of future gain is obviously an important incentive for actors to take the voice option instead of the risky exit option. By taking the exit option, actors may not only forgo possible future gains, but may also lose their trustworthiness and be perceived as unreliable partners. This is a major risk. Given the repetitiveness of interdependencies, actors taking the exit option are likely to meet their former committee members again in the future. Having an image of unreliability is, of course, not conducive to future cooperation.

In some cases, the possibility of future gain for actors can increase even if their proposals fail to gain sufficient support. For example, both Frequency Hopping and Direct Sequence Spread Spectrum failed to achieve a majority vote and were both included in the platform as (incompatible) options. WiFi which resulted from the application of the Direct Sequence variant of the platform achieved success and reaped the benefits. However, actors who preferred the Frequency Hopping option chose to develop and promote the competing HomeRF platform, which eventually failed to achieve success (Van den Ende, Van de Kaa, Den Uyl, & De Vries, 2012).

3.3.2. Perspective of enduring gain

The development of IEEE 802.11 can be characterized as a step by step decision making process, with regular meetings at which proposals were discussed and put to a vote. Although this may result in slow decision making, the step by step approach allows for more interaction and more opportunities for rigorous proposal reviews compared to a big bang approach (which has a limited number of big steps). Thus, the step by step approach is conducive to learning (Clarke, 2004): when more meetings are scheduled, more interaction can take place among participants through which learning can occur. During IEEE802.11's development, the decision making process was incremental instead of radical, with multiple meetings at which an actor's (patented[4]) technology could be implemented in the platform, and several technologies from different parties could be incorporated. This step by step approach offers participants the perspective of enduring gain (Teisman, 2000) which may even increase as more of an actor's technologies can be implemented in the platform gradually and throughout the process. This approach to decision making also ensures that there could be future meetings in which the actor's technology *can* be taken into account. In short, actors accept the fact that their technology is not implemented in the platform and stay committed to the process because of the perspective of enduring gain.

In other words, enduring gain constitutes an incentive for voice and a disincentive for exit.

3.3.3. Strong voting rules

Strict voting rules may also have contributed to the successful development of IEEE 802.11. Decisions were based on majority consensus and there was an incentive to more or less commit to these rules. These rules reward active participation. However, the rules were sometimes not clear and there was discussion about their interpretation. Sometimes, this evoked strategic behaviour. Still, the rules keep the decision making process on (a meandering) track. It is important to emphasize that the function of the rules is not to unambiguously guide the participants in a certain direction but to keep them committed to the process. Although they were sometimes misused, none of the actors challenged the idea that the rules of the game should apply. Also, it can be observed that there is a strong chairman. The chairman applied Robert's Rules of Order (which is part of the IEEE process), had a strong focus on the process, maintained order, and disciplined actors who breached the rules of the game. However, since there is the perspective of future gain, not many actors breached the rules as they had to re-earn their voting right as a result.[5] Also, the more meetings actors attended, the more time and money they invested in the process. The cost of leaving the process thus gradually increased.

3.3.4. A sense of urgency

The case provides a first indication that throughout the process, there was a growing sense of urgency among the group of involved actors that consensus had to be reached. This feeling of urgency started when NCR decided to realize a wireless local area network. It developed in the course of time, as more actors joined the committee, and the network expanded. Expectations of the participants involved but also of the outside world increased this sense of urgency. Competing platforms were being developed in parallel. At the time, HomeRF was a competing platform. It is generally acknowledged that as the sense of urgency grows, actors will become more committed to the process of reaching consensus, which improves the speed and quality of decision making (De Bruijn et al., 2002; Kotter, 1996). These are important factors for platform dominance (Van de Kaa et al., 2011). This may also provide incentives to (more strongly) cooperate. As a result, relationships among actors grow stronger. Indeed, in the case of IEEE 802.11, some actors that were involved in the IEEE 802.11 committee and were proponents of the Direct Sequence technology also established and participated in the Wireless Ethernet Compatibility Alliance (which was later called the Wi-Fi Alliance). This alliance was created to guarantee compatibility among Direct Sequence variants, reducing uncertainty among platform adopters. For example, in the midst of the platform war between IEEE 802.11 and HomeRF (2001), 3COM, Cisco Systems, Intersil, Lucent Technologies, and Nokia participated in both the IEEE802.11 committee and the Wi-Fi Alliance.

3.3.5. Incentive to compromise

Throughout the development of the platform, actors knew that they might be involved in a platform war. Consequently, they felt the need to compromise and achieve a common platform in the community as soon as possible as competing platforms might be developed in parallel. Thus, all participants gradually developed an interest in coming to closure – the community had to reach a decision. Indeed, eventually, there was a platform war between IEEE 802.11 and HomeRF (Van den Ende et al., 2012), and IEEE 802.11 achieved dominance. At this stage, actors whose technology was not implemented in the platform still benefited as they had supported the platform that achieved dominance. So, the losers in the development stage were compensated in the selection stage. Thus, initially, it could be seen as a win–lose situation (either your technology gets implemented or my technology gets implemented) for the actors involved, but this was not entirely true. In subsequent stages, an actor's technological proposals may be implemented in the platform (in which case the actor may derive income from patents) and platform dominance might be reached in the end (in which case the actor can benefit from

[4] It has to be noted that, in the IEEE, insertion of technology that is patented is avoided but, if it is included, firms will have to agree to license a patent under fair, reasonable and non-discriminatory terms (FRAND) before it is accepted to become part of a platform. When firms fail to abide by these terms, participants will attempt to avoid a situation in which actors can take on a blocking patent position.

[5] For example, when people had earned the right to vote, they had to be present during at least two of the four consecutive meetings. If they did not follow this rule, they had to re-earn their right to vote.

the advantages that a common platform brings). Thus, the win–lose situation as initially perceived by the group of actors gradually appeared to change to a win–win situation at the end of the development process. Basically, losers became winners.

4. Discussion

This paper contributes to the literature on ICT platforms (Gawer, 2009, 2014; Gawer & Cusumano, 2002; Rochet & Tirole, 2003) by incorporating a governance perspective. Most theory on platforms is based on theory stemming from the economics and engineering design disciplines (Gawer, 2014) and few scholars have incorporated the governance perspective. Scholars with a background in economics have focused on how interfaces are set in the market, but they rarely focus on how these interfaces are actually developed within committees and the governance mechanisms that come into play. Engineering design scholars have focused on how platforms facilitate innovation, but they assume that the underlying interfaces are stable, and do not describe how interfaces and platforms change over time (Gawer, 2014). This study provides an illustration of the underlying governance mechanisms that come into play when developing interfaces and how these interfaces change over time.

This paper suggests that the understanding of platform development can be enriched if focus is directed not only on the content but also on the process and on the incentives emerging during the process. In the case of IEEE 802.11, several incentives for consensus building were found: the perspective of future gain, the perspective of enduring gain, strong voting rules, a sense of urgency, and an incentive to compromise. Interestingly, these incentives are not so much related to the content of the issues at stake, but more related to the characteristics of the process of decision making. Most incentives emerged in the course of time. The voting rules, however, were explicitly designed, and imposed by the chairperson during the process, which means this is a case of a hierarchical intervention within a network of interdependencies. The chairperson adopted the procedures, thereby imposing discipline on the behaviour of actors within the process. While the parties retained considerable freedom in terms of the content of the process, the procedures nonetheless affected both the process and the outcomes. It is a smart form of hierarchical intervention.

In fact, upon closer examination, the development of IEEE 802.11 had many emergent properties and resulted in (partly) emergent outcomes. The process was, at times, chaotic (fierce discussions, random communications among parties involved etc.), but did result in order (in the form of (majority) consensus[6] and a successful platform). Furthermore, no fixed or predictable outcome exists ex ante. Some authors argue that groups of people may create emergent organizations that are not envisioned ex ante by the individuals that make up that group; "self-organized collectives of people create emergent group-level patterns that are rarely understood or intended by any individual" (Goldstone, Roberts, & Gureckis, 2008). In this regard, the network around IEEE 802.11 may be seen as an example of an organization where technical experts spontaneously come together in committees and consortia and together develop and promote a common platform. The large number of parties, interactions and issues created emergent patterns, and thus an emergent outcome that could not be predicted in advance.

Still, given the emergent character of the process, chaos was limited and incentives generated order. However, most of the incentives for consensus building only (in part) become visible when analyzing the system as a whole (perspective of future gain, perspective of enduring gain, sense of urgency, and losers develop into winners). In this respect, in terms of emergence theory, these incentives can be seen as the "high-level functions" of the system whereas the individuals and their interactions can be seen as the "bottom-up mechanisms" (Epstein, 1999, 2007).

Also, the network around IEEE 802.11 can be seen as a "complex adaptive system" whereby "agents residing on one scale start producing behaviour that lies one scale above them: ants create colonies, urbanities create neighbourhoods,…" (Johnson, 2001). According to Mitchell (2009, p. 13), a complex system is "A system in which large networks of components with no central control and simple rules of operation give rise to complex collective behaviour, sophisticated information processing and adaptation via learning or evolution." A complex adaptive system then is a dynamic system which is able to adapt and evolve within a changing environment. Complex adaptive social systems exposed to strong stimuli can produce macro-level emergence (Miller & Page, 2007).

In this case, technical experts (at an individual level) started exhibiting behaviour (incentives for consensus building) at a higher level (network of IEEE 802.11) and this was partly affected by external stimuli including the technological change that affected the decision making process. The behaviour (incentives for consensus building) cannot be explained at the individual level as individuals have conflicting interests, but it can be explained at the organizational level by means of incentives. In other words, the organizational processes that occurred within the network of IEEE 802.11 cannot all be explained by analyzing the constituent parts of the network (e.g., the individuals in the IEEE committee). In this regard, it is evident that the network around IEEE 802.11 was greater than the sum of its constituent parts, i.e., it was emergent and non-aggregative (Wimsatt, 2000).

Despite the emergent character of the process, control was still possible to some extent. It could thus be argued that the case of platform development could be seen as a case of weak emergence (Bedau & Humphreys, 2008) since the high level

[6] One exception is the fact that no consensus could be reached concerning whether Frequency Hopping or Direct Sequence Spread Spectrum had to be supported.

properties of the system (the incentives for consensus building) were not possessed by the individuals alone, but were the result of the (simple) combination of actors in the group. So, the incentives for consensus building are "theoretically reducible to the known laws governing the microstructure but the calculations required to predict the resulting phenomena are so complex as to be effectively impossible" (Wimsatt, 2000). Because most complex systems are not analytically tractable, their study requires the application of simulation techniques such as agent based modelling (Epstein, 1999, 2007).

The question arises whether these incentives for consensus building could be generalized beyond the case of WiFi and could be used to limit chaos and explain order in other cases of platform development. This might be a fruitful area for future research whereby simulation techniques might be used to model the complex behaviour to predict the outcome of platform development. The results from this study may be used as input in these simulation models.

Also, the question arises how could these incentives emerge? The main explanation is that the actors that work together on a platform are mutually dependent and are part of a larger network of actors. They are part of a pattern of interdependencies. In the first place, these actors compete with actors that are developing competing platforms in committees or consortia. Should these competing actors manage to get their solution developed earlier, the focal actors might be left empty handed. In the case of IEEE 802.11, the competing actors were the promoters of HomeRF (a competitor of IEEE 802.11). If these actors had introduced their solution earlier in the market than IEEE 802.11, they might have achieved acceptance with their platform through network effects (Schilling, 1998).[7] As a result, the actors involved in IEEE 802.11 would have lost. The sooner actors reach consensus in the committee, the greater the chances their solution will achieve acceptance. In the second place, actors working together on a platform depend on each other. During the process, they learn that pursuing their conflicting interests might result in slow decision making or in failure to reach consensus, and therefore in a lose–lose situation. The decision making process might start as a zero-sum game (it is either your solution or mine), but given the time pressure, will develop in a win–win game – if we work together, there will be gain for all of us. These incentives emerge in the course of time, due to these interdependencies. The paper contributes to the literature by making these incentives explicit. This study was limited to one case. Future research might examine more cases using the same approach so that incentives for consensus building can be further explored.

From the case it can be observed that mutually acceptable or compromise solutions had to be reached in the various battles that occurred within the committee. As a result, the relative advantage in technology development is often cancelled out. A large differential advantage is rarely allowed to progress through the standardization process, and if this does occur, the market place will select which technology to be used. For example, in the case of Wired LAN, IBM pushed its own version resulting in three LAN variants to be standardized. Eventually, Ethernet achieved market dominance.

Despite all the glitches that occurred during the development of IEEE 802.11 and the fact that it still achieved widespread acceptance, the platform can be considered a success story. Actors that are active in committees might use similar governance processes as applied in IEEE 802.11 (e.g., strong chairperson, Robert's Rules of Order, etc.) to achieve similar success.

5. Conclusion and recommendations

This paper illustrates the organizational hiccups that occurred during the development of IEEE 802.11. Various incentives for consensus building around IEEE 802.11 were discussed. The paper attempts to explain why actors remain committed or became even more committed towards the successful development of the platform in spite of numerous glitches in the platform development process. This paper suggests that the understanding of platform development is enriched by applying the lens of governance and change management.

The following recommendations have been formulated on the basis of the analysis:

1. Important conflicts of interest are always involved whenever committees develop common ICT platforms. This means focus should not only be directed at the content of developing platforms but also at the decision-making process.
2. The decision making process will partly emerge spontaneously, although it can also be designed.
3. When designing this decision making process, it is important to ensure there are sufficient incentives for the participants to take part in the process (voice), to continue to participate, and to reach a (majority) consensus. Examples of such incentives include a prospect of future gain, a prospect of enduring gain and a sense of urgency. It is also important for losers in one round to have a new prospect of gain in subsequent rounds.
4. Not all forms of governance need to be based on interaction and consensus. There is also space for smart hierarchical interventions, for example through procedure management: voting rules can be imposed upon participants, thus providing them with space while also giving direction to the process. These kinds of smart hierarchical interventions can be used to prevent the disadvantages associated with decision-making processes based exclusively on interaction and consensus.
5. Governance within a network implies considerable space for emergence. It is difficult to predict which parties will participate and with which level of commitment, which issues they will bring to the table, which connections will

[7] It should be noted that this is just one of the factors that influenced that HomeRF did not achieve market acceptance. Other factors included, for example, HomeRF's lower data rate compared to WiFi.

emerge between issues, and which outcomes these connections will generate. The knowledge that such emergence is inherent to networks reinforces the importance of paying attention to the process and to its design. A well-designed process can ensure that the variation generated by emergence will also lead to selection and closure in decision making.

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