AN EXPLORATION OF NECESSARY CONDITIONS FOR STANDARD SUCCESS FOR COMPLEX SYSTEMS

GEERTEN VAN DE KAA
Delft University of Technology, Faculty of Technology, Policy, and Management, The Netherlands
g.vandekaa@tudelft.nl

ABSTRACT

Many markets are characterized by increasing returns to adoption and, often, in such markets standards battles are fought (Suarez, 2004; Schilling 1998; Van de Kaa 2011). Literature on standards selection predominantly focuses on standards that are part of a new single product or system, such as the internet or a telecommunications network (Bekkers 2002; Funk 2002). In this paper we explore factors for standard dominance for systems that connect multiple already existing subsystems and new subsystems to form a new system. We conduct an analysis of six standards battles for complex systems that have been reported in the literature and find three necessary conditions for standard success for complex systems; technological superiority, network diversity and stakeholder commitment. We contribute to the ongoing research on standards battles by studying success factors for standards for complex systems. Practitioners that are involved in developing standards for such systems can utilize the results from this research in their strategies.

Key words: standards battles; case studies; dominant designs; complex systems

INTRODUCTION

The situation where all different types of technology can communicate to each other and form one internet of things is becoming a viable one. Such a network will result in advantages in everyday life. Because each entity can communicate with each other entity, their functionality increases. Irrespective of the fact that the internet of things has been technically possible for many years and that there seems to be a demand for it, it has not yet become a practical reality. One reason is the lack of accepted standards for the interconnection between the entities. Although a lot of standards have been developed to connect (parts of) the internet of things, this also is one of the major bottlenecks since the more standards are developed, the higher the uncertainty attached to the decision to adopt a standard will become. When the uncertainty gets too high, firms, consumers and other stakeholders are not willing to take the risks which are attached to choosing a particular standard and will postpone their decision (Leiponen, 2006; Schmidt and Werle, 1998). Indeed, various standards are developed and these are fighting for market dominance in so called 'standards battles'.

Scholars in the area of technology and innovation management have proposed models which can be used to explain and even predict the outcome of these battles (Schilling, 1998; Suarez, 2004). However, the focus lies primarily at systems that have been developed in single industries. In this paper we focus on standards battles for complex systems that consist of established subsystems that originate from multiple industries that are converging with each other. The internet of things is a perfect example of such a complex system. The central question in this paper is what are necessary conditions for standard success for complex systems. We will attempt to answer this question by combining and analysing data reported in earlier research that have reported on standards battles for complex systems.

We address standardization from a market perspective (Farrell and Saloner, 1988; Keil, 2002), focussing on the process in which a standard becomes dominant in the market. Our model builds on existing literature on the selection process of standards and dominant designs from the fields of industrial economics, institutional economics and standardization (Schilling, 2002).

We define a compatibility standard as: a codified specification defining the interrelations between entities (Garud and Kumaraswamy, 1993) in order to enable them to function together (De Vries, 1998). In the remainder of this paper where we use the term standard we mean a compatibility standard. Standards often form important elements of a dominant design. A dominant design refers in general to a complete product (Suarez and Utterback, 1995). A standard refers to certain characteristics of a product, in our case an interface between different subsystems. A standard can concern a determining element of a product, such as in the case of early VCRs. The most important difference between VHS, Betamax and V2000 concerned two standards: the size of the tapes and the way information was recorded on them. But the dominant design of a product usually encompasses other elements, such as its architecture (Henderson and Clark, 1990).

We consider a standard to be dominant when it has achieved more than 50 percent market share (Anderson and Tushman, 1990) for a significant amount of time (Lee et al., 1995) in a certain product or service category.

THEORETICAL PERSPECTIVES ON STANDARD DOMINANCE

The dynamics in industries that lead to standards has been studied from multiple perspectives and disciplines. Scholars in the field of industrial economics have mainly concentrated on the role of standards in the dynamics in industries. Traditional industrial organization research focuses on such things as firm size and age of the firm as main contributors to firm's success in creating a standard (Willard and Cooper, 1985). It was supposed that the larger and older the firm, the greater the chances that the standard produced by the firm becomes dominant. Neo evolutionary economists have demonstrated that in network markets network externalities are important (Arthur, 1996) meaning that the benefits of the system for individual users increase when the number of users grows. One standard can gain mass support through a bandwagon effect (Straffin, 1977) because more and more people adopt the standard. The costs to switch to another standard increases and as a consequence people are getting locked into a particular standard (Cusumano et al., 1992; Katz and Shapiro, 1985; Lee et al., 1995; Shapiro and Varian, 1999; Shy, 2001). Shapiro and Varian (1999) use the example of a computer to explain these phenomena. When one owns a PC, one will also own software which can only be used with this PC. When one switches to a MAC, the software cannot be used anymore. When customers use products which apply a specific standard which have many complementary products, it becomes difficult for them to switch to another product because if they do so they cannot use the complementary products anymore (Brynjolfsson, 1996). The installed base of users of this product, and thus of its standard, is high, and these users will not easily switch to another standard (Shapiro and Varian, 1999).

Institutional theorists focus on how individual firms can increase the possibility that their technology will become dominant (Christensen et al., 1998; Suarez and Utterback, 1995). A firm's capabilities lie in strategically positioning technologies so that they will become dominant. By incorporating specific innovative elements into their design a firm can reach a technologically superior product and thus increase the chances of reaching a dominant design (Christensen et al., 1998). Suarez (2004) stresses the importance of strategic maneuvering in the first stage of the battle for dominance. Especially in the early stages of the competition the strategy with respect to the position of products or technologies in the market is of great influence to its survival (Khazam and Mowery, 1994). Another aspect emphasized by institutional theorists is the time of introduction of the technology in the market (Lieberman and Montgomery, 1998; Suarez and Utterback, 1995). For instance, in the disk drive industry there existed a time period from 1980 to 1983 prior to the emergence of the dominant design in this industry in which it was ideal to enter the market. All parties which entered before or after this 'window of opportunity' were less successful than the parties which entered from 1980 to 1983 (Christensen et al., 1998).

Standardization literature has paid attention to the adoption of standards by individual organizations (Gerst and Raluca, 2005; Roy and Craparo, 2001; Weitzel et al., 2003), and to the role of standardization organizations on these adoption decisions (De Vries, 1998). Some authors in this field study the topic from a game theory perspective (Belleflamme, 1999; Farrell and Saloner, 1988; Park, 2005).

Suarez (2004), Schilling (2002), and Van de Kaa et al. (2011) have developed models in which the above mentioned factors are integrated. In the remainder of this study we will use the model that was developed by Van de Kaa et al. (2011). This model has been successfully applied to standards battles for various complex systems including wireless home networks (Van de Kaa and De Vries, 2015) and building automation systems (Van de Kaa et al., 2014a). We can thus assume that the framework's completeness and relevance is guaranteed.

RESULTS

In order to explore what are necessary conditions for standard success for complex systems we analyse 6 cases of standards battles for complex systems that have been reported in the literature (Van de Kaa and De Vries, 2015; Van de Kaa et al., 2014b; Van de Kaa et al., 2015; Van de Kaa et al., 2014c; Van den Ende et al., 2012); the battle for a standard for computer peripheral equipment, wireless local area networks, multi-channel audio sound, photovoltaic technology system, building automation systems, and Dutch E-purse systems.

The battle for a standard to connect peripheral equipment to the personal computer was between USB and Firewire. It is a typical example of a standards battle for a complex system (personal computer) and it was fought between firms representing both consumer electronics and information technology firms. Firewire's main advantage over USB was its superiority in terms of data rate that it could offer. However, at the time that it was introduced, people were not interested in the large amount of data rate. Furthermore, the promotors behind Firewire were not fully committed to success of the standard. USB's promotors were fully committed and the network of actors that supported the standard was diverse; it consisted of firms from three industries (IT, consumer electronics, and telecommunications) (Van de Kaa and De Vries, 2015).

The battle for a wireless local area network standard was waged between WiFi, HomeRF, and DECTprs. While the DECTprs was introduced early (1992) and HomeRF was priced lower as compared to WiFi, the latter standard still achieved success mainly because of its diverse and committed supporters (Van de Kaa and De Vries, 2015).

The battle for a multi-channel audio standard was between AC-3 and MPEG-2 Audio. Although MPEG-2 Audio was backwards compatible and could thus make use of a large previous installed base, the battle was eventually won by AC-3 because the promotor behind that standard (Dolby) could build up a large network of movie studios that implemented the standard in their films increasing the availability of complementary goods enormously (Van de Kaa and De Vries, 2015).

The battle for a standard for a photovoltaic technology system is between Mono-crystalline silicon (sc-Si)), Multi-crystalline silicon (mc-Si), Cadmium telluride (CdTe), Amorphous silicon/ hydrogen alloy (a-Si), and Cu(In, Ga)Se2, copper indium (Gallium) selenide (CI(G)S) and is still ongoing. Although the market for photovoltaic technology systems is still small, it is rapidly increasing. Main factors affecting standard success in this market are technological superiority of the standard and the costs of the PV panels in which the standard is implemented (Van de Kaa et al., 2014b).

The battle for a building automation system standard is between Konnex, COBA, BACnet, and others is also still ongoing and many factors appear to be relevant including technological superiority, the availability of complementary goods, installed base, reputation and credibility, and marketing strategies (Van de Kaa et al., 2014a).

Finally, the battle for a Dutch e-purse system was between Chipknip and Chipper. Eventually Chipknip achieved success. One of the advantages of Chipknip was that there were more terminals as compared to Chipper. Furthermore, Chipper had a lower reputation because it did not follow up on pre-anouncements. Chipknip was also introduced earlier then Chipper and could thus pre-empt the market (Van de Kaa et al., 2015).

In table 1 we provide an overview of the results. Table 1 provides the relevant factors for standard dominance (using the list of van de Kaa et al (Van de Kaa et al., 2011)) for each standards battle. We can observe that three factors appear to be relevant in each standards battle; technological superiority, commitment, and diversity of the network.

Table 1: factors for standard success for complex systems

	Factor	Computer peripheral equipment	Wireless local area networks	Surround sound	Photovoltaics	Building automation systems	Dutch E-purse systems
		USB, FireWire	WiFi, HomeRF	Dolby AC-3, MPEG-2 Audio	sc-Si, mc-Si, CdTe, a-Si, CI(G)S	Konnex, COBA, BACnet	Chipper vs Chipknip
Characteristics of the format supporter							
1	Financial strength				■	■	
2	Brand reputation and credibility			■	■	■	■
3	Operational supremacy				■		
4	Learning orientation				■	■	
Characteristics of the format							
5	Technological superiority	■	■	■	■	■	■
6	Compatibility			■		■	
7	Complementary goods	■	■	■		■	■
8	Flexibility	■	■		■	■	
Format support strategy							
9	Pricing strategy				■	■	
10	Appropriability strategy				■	■	
11	Timing of entry	■	■		■	■	■
12	Marketing communications		■	■	■	■	■
13	Pre-emption of scarce assets				■		
14	Distribution strategy						
15	Commitment	■	■	■	■	■	■
Other stakeholders							
16	Current installed base					■	■
17	Previous installed base			■		■	
18	Big Fish					■	
19	Regulator					■	
20	Judiciary					■	
21	Suppliers			■		■	
22	Effectiveness of the format development process		■			■	
23	Diversity of the network	■	■	■	■	■	■

DISCUSSION AND CONCLUSION

Our results point to a first indication that technological superiority, commitment, and diversity of the network are necessary conditions for standard success for complex systems as they determine success in each standards battle that we studied. Thus, to reach a successful standard that enables communication between subsystems that originate from multiple industries that are converging, it appears to be necessary to guarantee technological superiority and to have a diverse and committed network of actors supporting the standard.

When we compare our results to the extant literature on standards battles in general we can notice some similarities and differences. The relevance of technological superiority as a factor for standard success in regular standards battles has been stressed quite often (Lee et al., 1995; Schilling, 1998; Suarez, 2004; Wade, 1995). However, several authors also emphasize that the dominant standard or design is not necessarily the technologically superior one (Cusumano et al., 1992; David, 1985).

The relevance of commitment in relation to achieving standard success has, to our knowledge, been studied only scarcely before in the literature on standards battles in general (one exception includes Tegarden (1999) who stress that divided commitment is detrimental for a firm's market share).

The relevance of inter-organizational networks has often been stressed in previous research on standards battles. Cooperation between firms, and cooperation between firms and other institutions, often appears to be important in the standard development and selection process (De Vries, 1999; Den Hartigh et al., 2016; Egyedi, 1996; Fomin and Lyytinen, 2000; Van de Kaa and De Bruijn, 2015). Bekkers, Duysters et al (2002) have also applied a network approach to standard development. According to these authors, the market share of a standard can be increased by the position of the actor in a network of actors. The importance of networks of actors also appears from the VCR case. According to Cusumano, Mylonidas, et al. (1992), the primary reason behind the triumph of JVC (VHS) over Sony (Betamax) and other competitors was the strategy of JVC to form as large a group of firms supporting the standard as possible. Another example is the US microprocessor industry. Complex instruction set computers (CISC) which dominated the computer workstation industry were being replaced by reduced instruction set computers (RISC). RISC technology was licensed and CISC not (Khazam and Mowery, 1994).

We encourage future research to study more standards battles for complex systems to study whether the necessary conditions that we found hold. The internet of things, the example used at the start of this paper, could be an appropriate area for doing so. It is currently introduced and developing, which facilitates examining the dynamics of the standardization process. Moreover, in case of the internet of things this process seems to be not too fast, so that researchers have time to make repeated measurements of the factors in our model and market shares of alternative standards. Such research will not only increase our understanding of standard selection processes, but will also be relevant for research on technology selection in general.

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