AHMAD GHAZAWNEH

Towards a Boundary Resources Theory of Software Platforms

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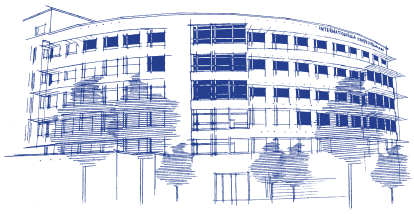

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The main objective of this thesis is to investigate and understand the role of boundary resources in platform owners' efforts to stimulate third-party development. To this end, this thesis proposes a theoretical model of boundary resources. This model centres on various drivers behind boundary resources design and use, and how these drivers interact in third-party development. The thesis also presents a comprehensive view of governance and strategizing practices used by platform owners through boundary resources. This thesis comprises a cover and a collection of five published research papers. The thesis applies a qualitative research method and employs multiple case studies. Boundary resources, innovation networks and platform governance perspectives have been synthesized to build a theoretical basis to analyze the empirical findings.

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To My Great Parents:
Mustafa and Wessal

To My Beloved Wife:
Mona

To My Sweethearts:
Mustafa-Gabriel, Bailasan and Amir

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In the name of Allah, the Beneficent, the Merciful

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Jönköping, October 2012.
Ahmad Ghazawneh

Abstract

The last few years have witnessed a significant increase in the frequency and magnitude of involving third-party application developers in software platforms. While this involvement offers great opportunities in building and sustaining platform innovation, it also exposes platform owners to significant challenges. Typically, platform owners facilitate the involvement of third-party developers by providing resources, referred to in this thesis as boundary resources, that give access to the platform, shift design capability, and facilitate the use of the platform's core technologies. At the same time, these resources have the potential to be used to maintain platform control. This involves seemingly conflicting goals that creates a challenge for platform owners in finding the right balance.

The main objective of this thesis is to investigate and understand the role of boundary resources in platform owners' efforts to stimulate third-party development. To this end, this thesis proposes a theoretical model of boundary resources. This model centres on various drivers behind boundary resources design and use, and how these drivers interact in third-party development. The thesis also presents a comprehensive view of governance and strategizing practices used by platform owners through boundary resources. This thesis comprises a cover and a collection of five published research papers. The thesis applies a qualitative research method and employs multiple case studies. Boundary resources, innovation networks and platform governance perspectives have been synthesized to build a theoretical basis to analyze the empirical findings.

This thesis complements and extends the literature on software platforms, and the insights derived from the thesis enhance previous research on third-party development. In addition, it provides a focused theoretical account of the interfaces between platform owners and third-party developers that contributes to the body of knowledge developed around using tools for innovation.

Keywords: software platforms, third-party development, boundary resources, innovation networks, resourcing, securing, governance.

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PART II Articles

1 Introduction

If you have an iPhone, a Samsung Galaxy, a Blackberry or any other smartphone, you certainly are using a software platform. If you have listened to music on Spotify, played a game on Facebook, or updated your status on Twitter you have used one too. All these products and services have a software platform at their cores. Software platforms provide a set of technologies and resources that make it easier to create a variety of services and make them available to heterogeneous end-users (Evans et al., 2006). For example, it would not be possible for the Finnish company Rovio to create their popular game *Angry Birds* and make it available for the iPhone, iPad and iPod touch devices without the software platform that was provided by Apple.

Traditionally, software platforms have been used for internal user base and within the boundaries of firms. They have also served as engines of innovation across various industries and power everything from personal computers (Bresnahan and Greenstein, 1999), video game consoles (Iansiti and Zhu, 2007; Romberg, 2007), smart mobile phones (Tiwana et al., 2010; Yoo et al., 2010), to web systems (Evans et al., 2006) and automotive technologies (Henfridsson and Lindgren, 2010). Software platforms have proved their powerful ability to extend the functionalities of products and services, and meet the needs of heterogeneous end-users. There is an emerging form of use where firms are starting to expand the scope of their platforms to include outside participation and rely on outsiders for developing the platform's complementary assets (Evans et al., 2006). For example, the decision of Apple in 2007 to release their iPhone platform to the community of third-party developers enabled them to turn their mobile phone into more than a smartphone. This device was later crowded with hundreds of thousands of applications that ranged from a simple calculator to a complex diabetes management application.

Software platform owners increasingly recognize the importance and value of third-party development (Bosch, 2009; Boudreau and Lakhani, 2009). The involvement of third-party developers plays a central role in building and sustaining platform innovation (Evans et al., 2006; Messerschmitt and Szyperski, 2003). To successfully extract a large share of economic value, platform owners shift their focus from developing complementary assets to facilitating third-party development and the integration of their complementary assets (Evans et al., 2006). These assets, in the form of software applications and services, promise to enhance the platform's appeal, address the needs of heterogeneous end-users (Adomavicius et al., 2007; Evans et al., 2006) and

extend the functionality of the platform. In addition, the role of the platform owner will be shifted from that of software producer "master developer" to a distribution channel instead, all while reaping the benefits of distributing, brokering, and operating the developed applications (Gawer, 2009; Meyer and Seliger, 1998; West and Mace, 2010).

Several firms such as Apple and Google are successfully increasing the value of their business models mostly by building robust software platforms, engaging third-party developers and developing the generative potential of their technologies (Tapscott and Williams, 2006; Yoo et al., 2010). At the same time, these firms must facilitate third-party development and employ careful and coherent management of platform ecosystem relationships, intellectual property rights and decisions on platform strategies (Cusumano and Gawer, 2002; Iansiti and Levien, 2004). To facilitate third-party development, platform owners provide resources that shift design capability to third-party developers (von Hippel and Katz, 2002) and facilitate the use of the platform's core functionalities and the deployment of applications (Baldwin and Woodard, 2009; Gawer and Cusumano, 2008; Tiwana et al., 2010; Yoo et al., 2010). These resources, referred to in this thesis as *platform boundary resources,* are located at the interface between the platform owner and third-party developers. Examples of platform boundary resources are technical boundary resources such as application programming interfaces (APIs) and software development kits (SDKs) (Yoo et al., 2010) as well as social boundary resources such as incentives, intellectual property rights, agreements between the platform owner and third-party developers, and the platform guidelines and documentation (Gawer, 2009). These resources provide access to the platform and support several platform actors in their development practices. At the same time, these resources enable platform owners to handle and maintain control.

The boundaries of firms adopting software platforms are increasingly shifting as third-party developers are harnessed to join the platform (e.g., more than 125,000 third-party developers for Apple's iOS). This shift is making governance of software platforms a major issue that requires a balance between control that is exercised by platform owners and third-party developers' autonomy. All in all, this offers an excellent unusual opportunity for Information Systems (IS) research (Tiwana et al., 2010). Previous studies of platforms have, for instance, focused on platform architecture and design (Baldwin and Woodard. 2009; Muffatto and Roveda, 2002), the economics of platforms (Evans, 2009; Meyer and Lehnerd, 1997), platform leadership (Evans et al. 2006; Gawer and Cusumano, 2002), and platform dynamics and strategies (Gawer, 2009; West, 2003). The main focus of this thesis is on the role of boundary resources in platforms. This thesis posits that platform boundary resources have the potential to be used to control third-party development, while at the same time stimulating third-party developers to join the platform

and transferring the design capability that facilitates their development practices. This involves seemingly conflicting goals that creates a challenge for platform owners in finding the right balance.

1.1 Research Questions and Objective

Prior research documents the significance of using platform boundary resources (e.g. application programming interfaces) for stimulating platforms through third-party development. However, there are few, if any, theoretical accounts of this relationship. To this end, the overriding aim of this thesis is to create an understanding about platform boundary resources and their roles in software platforms. In order to address the purpose of this thesis, the following overall research question is raised to understand such roles and their use to stimulate third-party development:

How can we understand the role of boundary resources in platform owners' efforts to stimulate third-party development?

Further, in order to achieve a thorough account of the use of boundary resources in software platforms, the next sub research questions address the governance process and strategizing practices used by platform owners through boundary resources:

- ***What is the governance process by which proprietary platform owners can simultaneously maintain platform control and stimulate third-party development through platform boundary resources?***

- ***What characterize the micro-strategies used by platform owners in attempts to create and sustain platforms through boundary resources?***

1.2 Outline

This thesis comprises a cover paper and a collection of five papers published in international IS journals and conference proceedings. Following this introduction, chapter two presents the conceptual background and framing employed in this thesis. Thereafter, chapter three outlines the research methodology. This is followed by chapter four, which introduces and summarizes the five research papers. Chapter five discusses the findings. Finally, chapter six concludes the cover paper. After the cover paper, the

collection of the five papers follows. These papers are listed below in the order that they will be presented in the cover paper.

Paper 1 Ghazawneh, A. (2011), The Power of Platforms for Software Development in Open Innovation Networks, *International Journal of Networking and Virtual Organisations*, Vol. 9, No. 2, pp.140–154.

Paper 2 Ghazawneh, A. and Henfridsson, O. (2010). Governing Third-Party Development through Platform Boundary Resources. In: *Proceedings of the 31st International Conference on Information Systems, ICIS 2010*. St. Louis, USA. Dec 2010.

Paper 3 Ghazawneh, A. and Henfridsson, O. (2011). Micro-Strategizing in Platform Ecosystems: A Multiple Case Study. In: *Proceedings of the 32nd International Conference on Information Systems, ICIS 2011*. Shanghai, China. Dec 2011.

Paper 4 Ghazawneh, A. and Henfridsson, O. (forthcoming) Balancing Platform Control and External Contribution in Third-Party Development: The Boundary Resources Model. *Information Systems Journal*, forthcoming (DOI: 10.1111/j.1365-2575.2012.00406.x).

Paper 5 Rudmark, D. and Ghazawneh, A. (2011). Third-Party Development for Multi-Contextual Services: On the Mechanisms of Control. In: *Proceedings of the 19th European Conference on Information Systems*, *ECIS 2011*. Helsinki, Finland. June 2011.

2 Conceptual Background and Framing

2.1 Platforms

As early as 1574 the *Oxford English Dictionary* cites examples in which "platform" refers to "a design, a concept, an idea or a pattern." This concept has been thoroughly developed by researchers in three overlapping research settings: product development, technological strategy and industrial economics (Baldwin and Woodard, 2009). Product development researchers apply the term "platform" in projects where families of products are created. This intends to describe the products that are developed to meet the needs of core customers, but are designed to be easily modified into derivatives through adding, substituting or removing features (Wheelwright and Clark, 1992). This is followed by research on "platform thinking" (Sawhney, 1998), "platform planning" (Meyer and Lehnerd, 1997; Robertson and Ulrich, 1998), "platform technologies" (Kim and Kogut, 1996) and "platform investments" (Kogut and Kulatilaka, 1994).

Technology strategists view platforms as controlling points across industries. Platforms have the ability to determine the success and failure of firms at the industry level (Baldwin and Woodard, 2009). Firms approach platforms differently to gain market leadership and success. For example, Microsoft approached platforms through consolidating efforts around its Windows operating system (Cusumano and Selby, 1995). In contrast, Netscape adopted a different platform strategy and permitted its browser to work across different operating systems (Cusumano and Yoffie, 1998). Gawer and Cusumano (2002) articulate a general framework for "platform leadership" in product systems by extensively studying the cases of Intel, Microsoft and Cisco. Their study reports that implementing a successful platform strategy enabled firms to support their products and establish dominant market positions.

Industrial economists view platforms as mediators of transactions in two sided-markets (Rochet and Tirole, 2003). These markets are seen as an economic platform that provide services to two distinct groups of agents, in which where the platform owner attempts to set the price for both groups as "the benefits of one type of end-user increases as the participation of the other type of end-user

increases" (Chakravorti and Roson, 2004, p.1). The credit card payment system is an example of a platform-based two-sided market (Eisenmann, 2008).

2.1.1 Typology of Platforms

My literature review indicates that there exist different conceptualizations of the notion of platform. Even though these conceptualizations have common roots in engineering design (Baldwin and Woodard, 2009), it may be useful to categorize platforms and identify their characteristics and business contexts. For this purpose, I draw on the three-fold platform typology created by Gawer (2009). The first type is referred to as "internal platform." This type of platform is observed within firms and is widely used in the context of product development. Meyer and Lehnerd (1997) provide one of the most adopted definitions of such a platform type: "a set of common components, modules, or parts from which a stream of derivative products can be efficiently created and launched" (p. 7). Empirical evidence of internal platforms is heavily founded on manufactured products such as consumer electronics (e.g. Sony, Hewlett-Packard). The adoption of internal platforms allowed Sony to introduce more than 250 models of its Walkman in the 1980s (Sanderson and Uzumeri, 1997), and enabled Hewlett-Packard to successfully develop several models of its inkjet and laserjet printers (Feitzinger and Lee, 1997). The second type is referred to as a "supply chain platform". This type extends the concept of the internal platform into supply chains and enables partners along those supply chains to create and launch derivative products. Popular examples of supply chain platforms can be found in the automotive industry, such as the sharing of platforms between Mazda and Ford Motors. The third type of typology is referred to as an "industry platform," or sometimes "external platform." Gawer (2009, p.54) defines industry platforms as "products, services or technologies that are developed by one or several firms, and that serve as foundations upon which other firms can build complementary products, services or technologies". A key characteristic of this platform type is that the outsider firms and individuals developing complementary assets are not necessarily part of the supply chain, nor have they any cross-ownership and shared patterns. The Linux operating system and Apple's iPhone are examples of popular industry platforms.

A main focus of platform owners across all types is to provide a set of common components and resources that facilitate the process of generating complementary assets (Robertson and Ulrich, 1998), which therefore increase the value of the platform. According to Baldwin and Woodard (2009), the reuse of such components and resources is a powerful economic logic. First, economies of scale can be realized through increased production volume and the efficient use of complementary assets. Second, reducing the cost of developing products and services can create economies of scale that allow firms

to address the needs of heterogeneous end-users. Third, it allows firms to select the most appropriate complementary assets without any need to compromise the whole system, which creates value in the form of real options that positively affects development decisions.

Platform architecture encompasses a special modularity type of two sets. The first set is the "platform" with "low variety and high reusability." The second set is the "components" with "high variety and low reusability" (Baldwin and Woodard, 2009). The architecture of the platforms, whether their complementary assets are supplied within a single firm, such as Sony Walkman (Sanderson and Uzumeri, 1997) or supplied by many outsider firms like Microsoft Windows (Gawer and Cusumano, 2002), have fundamental similarities, and there is no inherent differences between them. All types of platforms "modularize the system in ways that facilitate component reuse and variety in product offerings," and they "implicitly or explicitly specify interfaces that mediate interactions among components" and "allocate decision rights (again, at least implicitly) that determine who can interact with or modify which components in what ways" (Baldwin and Woodard, 2009, p.25).

2.1.2 Software Platforms

The empirical settings of the "industrial platform" are often set in software development (Baldwin and Woodard, 2009; Franke and von Hippel, 2003; Gawer and Cusumano, 2008; Morris and Ferguson, 1993; West, 2003). Examples of software platforms can be found in settings such as personal computers (Bresnahan and Greenstein, 1999), video game consoles (Iansiti and Zhu, 2007; Romberg, 2007), smartphones (Tiwana et al., 2010; Yoo et al., 2010), web systems (Evans et al., 2006), and automotive technologies (Henfridsson and Lindgren, 2010).

A software platform is defined as "the extensible codebase of a software-based system that provides core functionality shared by the modules that interoperate with it and the interfaces through which they interoperate" (Tiwana et al., 2010, p. 676). It incorporates modules that are connected and deployed into the platform in order to extend its functionality (Baldwin and Clark, 2000, Sanchez and Mahoney, 1996). A module such as this is an "add-on software subsystem" (Tiwana et al., 2010, p. 676) in the form of an application or multiple applications that are designed and built by third-party developers. The collection of the technology elements (e.g., software platform, modules) and the actors across the platform (e.g., platform owner, third-party developers, platform's partners and users) form a functional unit referred to as the software ecosystem (Cusumano and Gawer, 2002; Gawer, 2009).

Table 1 below illustrates the main respective characteristics, business objectives, and key questions and challenges found in the literature that are faced by software platform owners. This table is extended and modified after Gawer (2009).

Table 1. Respective characteristics of software platforms

	Description
Context	Industry ecosystems
Number of participants	Several firms and individuals who don't necessarily have direct relationships, within the supply chain or have cross-ownership, but whose software applications and services must function together as a part of a technological ecosystem.
Platform objectives	For *Platform Owner*: to stimulate and capture values from external, complementary third-party development innovations. For *Complementors* (third-party developers): to benefit from the installed base of the platform and from direct and indirect network effects on complementary innovation.
Design rules	Interfaces around the platform allow deployment plugging in, and innovation on complements.
End-Users	Variety of end-users and end-uses may not be known in advance.
Key questions asked in the literature	How can a platform owner stimulate complementary innovation while taking advantage of it? How can incentives to create complementary innovation be embedded in the design of the platform?
Challenges faced by platform owners found in the literature	Attract Complementors (third-party developers) to tap into their platform and develop innovative applications and services, in particular within a context of competing platforms. Platform owners may end up in situations where actors are collaborators as much as they are competitors.

The degree of openness of a software platform is a key concern and crucial issue for platform owners (Gawer and Cusumano, 2002; West, 2003; Gawer and Henderson, 2007; Boudreau, 2008; Eisenmann, 2008). The level of openness or closeness is determined by four distinct roles: (1) the demand-side

platform users, who use the platform and its complements, (2) the supply-side platform users, who provide complements, (3) platform providers, who act as a primary point of contact between the platform and its users, and (4) platform sponsors, who determine who may participate in the platform, develop its technology, and exercise intellectual property rights (Eisenmann et al., 2009). Software platforms are found to mix open and closed roles across different patterns (Table 2 below).

Table 2. Comparison of platform openness (Eisenmann et al., 2009, p.133)

Roles	Linux	Windows	Macintosh	iPhone
Demand-side user (End user)	Open	Open	Open	Open
Supply-side user (Application developer)	Open	Open	Open	Closed
Platform provider (Hardware /OS bundle)	Open	Open	Closed	Closed
Platform Sponsor (Design and IP rights owner)	Open	Closed	Closed	Closed

If the software platform owner is the sole sponsor of the platform and the main provider of the platform technology, the platform is referred to as a proprietary software platform (Gawer and Cusumano, 2002; Iansiti and Levien, 2004; Yoffie and Kwak, 2006; Gawer and Henderson, 2007). A proprietary software platform plays a central role within its ecosystem and across all different patterns. Platform owners will have the ability to exploit a platform power and dominate and extract a large share of the platform market (Eisenmann et al., 2009). Apple's iPhone is an example of a successful proprietary software platform. The platform is closed on three of the four main roles. Only Apple manufactures and distributes technology for the iPhone. Apple applies tough regulations on third-party developers and reserves the right to reject any application due to quality or strategic concerns, and applications are available for end-users only through Apple's official digital marketplace "the AppStore."

2.2 Third-Party Development

Recent research on platforms has increasingly recognized the significant value of third-party developers and their contributions in platform innovation (Bergvall-Kåreborn et al., 2010; Bosch, 2009; Boudreau, forthcoming; Evans et al., 2006; Messerschmitt and Szyperski, 2003; Remneland et al., 2011). Third-party developers can be of great value to platform owners. Their importance

continues to be recognized with greater frequency as they build and sustain the platform innovations with huge numbers of complementary assets in the form of software applications and services (Evans et al., 2006; Hanseth and Lyytinen, 2010; Messerschmitt and Szyperski, 2003). The main aim of software platforms is to facilitate and increase this development process and maintain the integration of complementary assets. The more applications are developed, the more value is created for the platform and its users (Huang et al., 2009) via direct or indirect network effects (Gawer, 2009). These applications will probably address the needs of heterogeneous end-users (Adomavicius et al., 2007; Evans et al., 2006), and extend the functionality of the platform. In addition, the growing number of applications will act as an entry barrier for rivals or new competitors and enable the platform owner to reap the benefits of distributing, brokering, and operating the developed applications, thus transforming the owner from a software producer into a distribution channel (Meyer and Seliger, 1998; West and Mace, 2010).

At the interface between the platform and third-party developers, platform owners offer resources that shift design capability to third-party developers (von Hippel and Katz, 2002) and facilitate the use of core platform functionality. This enables third-party developers to tap into the platform and serve end-users through software application developments that will be deployed and become part of the platform ecosystem (Baldwin and Woodard, 2009; Gawer and Cusumano, 2008; Tiwana et al., 2010; Yoo et al., 2010). I refer to these resources as platform *boundary resources*. There are two types of platform boundary resources: *technical boundary resources*, such resources typically consisting of a software development kit (SDK) and a multitude of related application programming interfaces (APIs) (Yoo et al., 2010) and *social boundary resources,* such as incentives, intellectual property rights, platform's guidelines and documentation (Gawer, 2009). The power of these resources lies in their ability to give access to core modules of the platform and map the layers of the platform's digital technology (Yoo et al., 2010), which can enable firms to create the necessary complementary innovations (Gawer and Cusumano, 2008).

A popular boundary resource type is application-programming interface (API). It is a set of source code-based specifications and rules that are used as an interface by software platform components. It is offered, implemented and published by software platform owners, referred to as *API producers,* to enable third-party developers, referred to as *API consumers*, to access and make use of the services and resources offered by the software platform (de Souza et al., 2004).

According to de Souza et al. (2004) an API has two main roles. Firstly, it plays the role of a *contract* between the platform owner and the third-party developers. Once such a contract is published, a level of trust is established between the

provider and consumer of the API. The platform owner describes the functionality of the API accessible by third-party developers and pledges that the functionality works as advertised. In this sense, third-party developers have to depend on the platform owner to keep their commitment so that they can develop applications based on that functionality (Hung, 2007). It also allows the platform owner and third-party developers to conduct their work while minimizing the needed coordination between them. Secondly, the API plays the role of an *organizational boundary* where each API has the ability to access a particular service or set of services of the platform. This means that an API is created to be the external boundary of a specific component of the platform. The platform owner, through such a boundary, can define what can be known and what third-party developers can do. An API producer holds the responsibility of supporting, updating and backing-up the APIs in proportion to the evolution of the platform, while an API consumer has to find the appropriate ways to interact with the platform and its components.

2.3 Innovation Networks

Innovation can be viewed as a non-linear cyclic process that involves the initiation, development and implementation of new ideas by different and multiple actors engaged in particular relationships (Van de Ven et al., 2008). These relationships often go beyond organizational boundaries and incorporate external actors that enrich the innovation process with resources, competencies and legitimacy (Chesborough, 2003; Van de Ven et al., 2008). This form of innovation is increasingly recognized in IT innovation (Boland et al., 2007; Hanseth and Lyytinen, 2010; Robertson et al., 1996; Tuomi, 2002) since a single firm seldom "holds the necessary knowledge to innovate information services through combination of heterogeneous IT systems" (Andersson et al., 2008, p.19). This created a necessity for networked relationships and collaboration between innovating organizations (Chesborough, 2003; 2006).

An innovation network is conceptualized as a social-technical network spanning organizational boundaries (Boland et al., 2007; Chesbrough et al., 2006; Van de Ven et al., 2008; Yoo et al., 2008; 2009). The innovation network is formed once innovation processes are initiated and consists of multiple actors and technology functions that form, facilitate and enable innovation (Van de Ven et al., 2008). Innovation processes within such networks are becoming increasingly distributed and therefore are changing the role and relationships of innovators (Yoo et al., 2009), as explored in offshore software development (Ågerfalk and Fitzgerald, 2008).

Yoo et al. (2008; 2009) distinguish four types of innovation networks and examine their evolution during the innovation process. These new proposed

innovation networks are singular, distributed, systemic, and doubly distributed networks, classed by two dimensions: the first dimension is the homogenous verses heterogeneous nature of knowledge resources, and the second dimension is the distribution of coordination and control over actors and resources in the network (see Figure 1).

Heterogeneity of Knowledge resources		Distribution of coordination & control	
		Centralized	Distributed
	Homogeneous	**Singular** innovation form	**Distributed** innovation form
	Heterogeneous	**Systemic** innovation form	**Doubly Distributed** innovation form

Figure 1. Four Types of innovation Networks (Yoo et al., 2009, p.19)

The first two types of innovation networks (first raw) require homogeneous knowledge resources. The *singular* innovation network implies centralized organizational coordination and control. The structure of a singular innovation network is similar to internal R&D departments and their exclusively internal management and control of innovation processes. The *distributed* innovation network implies distributed coordination and control; actors are not bound by the centralized control as is the case of the singular innovation network. Open source software communities are classic examples of distributed innovation networks. The second two types of innovation networks (second raw) require heterogeneous knowledge resources. The *systemic* innovation network implies centralized organizational coordination and control to individual actors. This type of innovation network is commonly found within a single organizational boundary and is referred to as an "internal market of innovations." The *doubly distributed* innovation network implies distributed organizational coordination and control. It is considered to be the most complex form of the four types. Examples of this type of innovation network are networks formed by scientific communities.

In this thesis, third-party software development is viewed as an innovation network distributed across multiple actors and technologies (Boland et al., 2007; Chesbrough et al., 2006; Van de Ven, 2005; Van de Ven et al., 2008; Yoo et al., 2008; 2009). Actors in this type of innovation network primarily include third-party developers, platform owners and partners. These types of actors supply the required knowledge, ideas, resources and capabilities within the formed innovation network across the platform (Van de Ven et al., 2008). In addition, knowledge resources in this type of innovation network are distributed across many and varied actors, where the extent of knowledge

heterogeneity is determined by the degree of innovation complexity (Yoo et al., 2008). With regard to control and coordination, innovation networks within software platforms can operate along a continuum ranging from the quite centralized networks where you would find in automotive technologies (Clark, 1985; Henfridsson and Lindgren, 2010; Henfridsson et al., 2009), to the relatively decentralized networks that are found in open source software development (Ljungberg, 2000; Yoo et al., 2008). Proprietary platform owners apply centralized coordination and control to innovation networks formed around third-party development. Heterogeneous knowledge resources drive this type of innovation network: such resources come from the diversity of market segments and niches that software platforms tend to offer. Innovation in third-party development is translated into a set of software applications and services and become integrated into the platform (Yoo et al., 2008; 2009).

2.4 Boundary Objects Theory

A boundary object is defined as an object, artifact or a concept that is "plastic enough to adapt to local needs and the constraints of several parties employing them, yet robust enough to maintain a common identity across sites" (Star and Griesemer, 1989, p.393). In general, any object that is used to stabilize a particular relationship between multiple actors at different social worlds can be regarded as a boundary object (Bergman et al., 2007; Fujimura, 1992; Harvey and Chrisman, 1998; Star and Griesemer, 1989). Boundary objects provide constructed arrangement across multiple social worlds while participants attempt to find particular agreement forms of collaboration. This type of arrangement provides coherence for all participants and maintains power relations (Harvey and Chrisman, 1998).

Boundary objects are catheterized as: (1) weakly structured in common use; (2) strongly structured in individual site use; (3) having different meanings in different social worlds, with a structure that is common enough to all; (4) simultaneously concrete and abstract, specific and general, conventionalized and customized; and (5) often internally heterogeneous (Star and Griesemer, 1989). These properties have been studied across different settings including museums (Star and Griesemer, 1989), GIS technology (Harvey and Chrisman, 1998), systems design (Bergman et al., 2007; Richards et al., 2006), patient medical records (Berg and Bowker, 1997), air cargo bills (King and Forster, 1995), product development (Carlile, 2002), and design engineering (Henderson, 1991).

There are four types of boundary objects that have the ability to mediate multiple actors across different social worlds (Carlile, 2002; Star and Griesemer, 1989). First, *repositories* supply a common reference point of data that are built

to deal with problems of heterogeneity. This type of boundary object provides shared definitions and values for solving problems caused by differences in unit of analysis. An example of a repository is a database, library or museum. Second, *ideal type*s, are simple or complex objects that can be observed and used across different functional settings without embodying descriptions of their details. Examples of ideal types are diagrams, prototypes, mockups or computer simulations. Third, *coincident boundaries,* represents common objects that have the mutual dependencies that exist between actors but with different internal contents. These types of boundary resources enable actors to use their different perspectives relatively autonomously and to share a common referent. Examples of coincident boundaries are Gantt charts, roadmaps and workflows. Fourth, *standardized forms,* are boundary objects that are devised as methods of common communication across dispersed actors. Methods of collecting, aggregating and transferring data within multiple social worlds are very common communication methods. Examples of this type of boundary resource are user-manuals, software development documentations or registration forms.

In general, the employment of boundary objects in all work and across different settings follows a central principle that "the mediation of diverse social interests occurs in and during the construction of technology" (Harvey and Chrisman, 1998, p. 1686). Boundary objects mediate between actors and serve a dual function similar to that found in geographic boundaries. A key difference is the dynamics of technological boundary objects as they are subject to change and modifications, whereas geographic boundaries become solid anchors for relationships between different actors (Neumann and Star, 1996; Star, 1995; Star and Griesemer, 1989). An object or artifact can serve as a technological boundary object if it has the ability to establish a shared syntax for individuals to represent their knowledge. It provides a concrete means for them to specify and learn about their differences and dependencies across given boundaries. In addition, technological boundary objects should have the ability to facilitate a process in which individuals can jointly transform their knowledge (Carlile, 2002).

This thesis synthesizes boundary objects theory (Bergman et al., 2007; Star and Griesemer, 1989) that provides a basis for understanding the role of boundary resources such as SDKs and APIs in enabling coordination of activities across the platform (Bergman et al., 2007; Briers and Chua, 2001; Star and Griesemer, 1989). The boundary objects theory is used to understand the ability of platform owners to combine centralized control with decentralized heterogeneous knowledge resources. Conceptualizing boundary resources as boundary objects is a key issue in understanding the attempts by platform owners to maintain tight integration at the platform, while allowing loose couplings horizontally to cater to the needs across innovation networks (Baldwin and Clark, 2000; Yoo et al., 2009).

2.5 Platform Governance

The concept of governance has been used in many different disciplines of the social sciences, and there are various differences in how it is defined and applied (Kooiman, 1993). Over the last decade, IS scholars have drawn huge attention toward governance (Brown, 1997), mainly as a new emergent form to meet changing IS role demands (cf. Allen and Boynton, 1991; Dixon and John, 1989; Zmud et al., 1986) and as a strategy to ensure the fusion of business and IT by controlling formulation, implementation and adoption of IT (cf. Van Grembergen et al., 2003; Weill and Ross, 2005). Accordingly, this demands the involvement of a higher level of management in which all stakeholders have added their necessary input to a particular decision-making process.

Most software platform governance research is found in open source literature (cf. Markus, 2007). The literature addressed the various purposes of open source platform governance, such as solving collective action dilemmas (Franck and Jungwirth, 2003; Hann et al., 2004; Roberts et al., 2006; O'Mahony, 2003), solving development coordination problems (Jensen and Scacchi, 2004; Jørgensen, 2001) and creating a better climate for third-party developers (Franke and von Hippel, 2003; Manville and Ober, 2003). Surprisingly little is known about the actual process of governing proprietary software platforms, and the existing literature seems to ignore the means by which governance is exercised beyond processes and through boundary resources. While the open source literature may serve as a backdrop (cf. Markus, 2007), it has little to offer when it comes to analyzing the tension between maintaining platform control and, at the same time, stimulating third-party developers to join forces with the platform owner by developing applications.

The governance of proprietary software platforms involves two seemingly conflicting goals: the maintenance of platform control and the transfer of design capability to third-party developers. First, platform owners need to implement a certain level of control over their platforms and related services. This control seeks to address concerns such as business value, security and integrity, as well as the rights management of the platform. Second, platform owners simultaneously need to "transfer design capability to users" (von Hippel and Katz, 2002, p. 824) for generating complementary assets in the form of applications or services (cf. Teece, 1986). To achieve simultaneous accommodation of platform control and external contribution, platform owners seek to establish boundary resources that enable application development. In this thesis, it is argued that over time such resources become an important element in governing and supporting application developers that contribute end-user functionality. In this sense two main dimensions for software platform governance are identified. First, *the community* of third-party

developers and users that are simultaneously independent of (e.g. no employment contracts) and dependent on (e.g., access to application distribution channels) the governance exercised by the platform owner. Second are *the boundary resources,* which are the actual and practical boundaries between the platform owner and the community of third-party developers. Drawing on Lynn et al. (2001), the governance of proprietary software platforms is defined as: *the means of achieving the direction, control, and coordination through boundary resources of wholly or partially autonomous individuals and organizations on behalf of a software platform to which they jointly commit and contribute to build strong and competitive innovation networks.*

In this thesis, platform governance is investigated with a specific emphasis on the boundary resources offered to third-party developers. Given the challenge of third-party development in the proprietary context, it is vital to develop new knowledge about its nature and the role of platform boundary resources. Little is known about the means by which platform governance is accomplished through direction, control, and coordination of third-party development through the boundary resources of a platform. Indeed, there is a dearth of theoretical accounts that examine how boundary resources can help address the problem of simultaneous control and external contribution in third-party development.

3 Research Methodology

3.1 Philosophical Considerations

The work of this thesis is based on the interpretive approach to qualitative research. It is significant for researchers to understand the thoughts and actions of humans within social and organizational settings. The interpretive research perspective emerged to facilitate this process of understanding and to produce deep insights into the studied phenomena (Klein and Myers, 1999). This research perspective posits that our knowledge of reality is a social construction constituted by human actors (Walsham, 1993; Walsham, 2006).

Interpretive research is a well-established part of the field of information systems (Walsham, 2006). IS researchers can be classified as interpretive if "it is assumed that our knowledge of reality is gained only through social constructions such as language, consciousness, shared meanings, documents, tools and other artifacts" (Klein and Myers, 1999, p.69). The focus of interpretive research is on the complexity of human sense making rather than predefining dependent and independent variables (Kaplan and Maxwell, 1994); it attempts to understand the studied phenomena through the meanings assigned by humans (Orlikowski and Baroudi, 1991). In the field of IS, interpretive research aims at "producing an understanding of the context of the information systems, and the process whereby the information systems influences and is influenced by the context" (Walsham, 1993, p. 4-5).

Klein and Myers (1999) propose a set of principles for conducting and evaluating interpretive research in IS. The first principle is *the hermeneutic circle,* which is the fundamental to all other principles and suggests that our understanding is achieved through an iterative process of the interdependent meaning of the whole and the parts that come from it. The second principle, *the contextualization*, is an important element in deciphering data in interpretive research and emphasizes the role of the critical reflection of both the social and historical background of the research settings. The third principle emphasizes the role of the interaction between the researchers and the studied subject and material and to what extent they are socially constructed. The fourth principle, *abstraction and generalization,* emphasizes the role of relating the interpreted data to the theoretical and general concepts. The fifth principle, *dialogical reasoning*, suggests that the theoretical concepts guiding the research and the actual findings require sensitivity to possible contradictions. The sixth principle, *multiple interpretations*, requires sensitivity to the possibility of differences in

interpretations. The last principle, *suspicion*, requires researchers to be aware of and sensitive to possible biases in the narratives of the collected data.

The vehicle for such interpretive investigation is often in-depth case study research (Walsham, 1995), as well as action research and ethnographies (Walsham, 2006). Examples of interpretive research that are among the first to be published in IS journals are: Orlikowski's (1991) ethnographic study of a software consulting firm; Walsham and Waema's (1994) case study of a building-society institution; and Myers' (1994) case study of an education department. However, the debate on interpretivist versus positivist approaches to IS, or even possibilities of combination (Gable, 1994), is an endless matter (Orlikowski & Baroudi, 1991; Walsham, 1995). Case study researchers working in these two perspectives have to have a mutual understanding and share many points of agreement. For example, Yin (2009) implicitly approaches the case study research from a positivist stance, but interpretive researchers would accept his views on the preferred research strategies.

As with any tradition, the use of theory in interpretive studies remains a key question for researchers. Walsham (1995) discusses this issue in case study research and illustrates three distinct theory uses. A list of these three uses of theory and examples and motivation for their use in interpretive IS case studies are given in Table 3.

Table 3. The use of theory in interpretive IS case studies (modified after Walsham (1995, p. 76))

Use of theory	Interpretive IS case study	Motivation
As an initial guide to design and data collection	Walsham (1993)	Creates an initial theoretical framework which takes account of previous knowledge, and informs the topics and approach of the early empirical work.
As part of an iterative process of data collection and analysis	Orlikowski (1993)	Willingness to modify initial assumptions and theories.
As a final product of the research	Orlikowski and Robey (1991)	Output from case study research may be concepts, a conceptual framework, propositions or mid-range theory.

Another critical issue for researchers is the generalization of their results. This issue is often raised with respect to case studies (Yin, 2009). There are four types of generalizations from interpretive case studies (Walsham, 1995). The first type of generalization is the development of concepts. A popular example

here is the development of the "informate" concept, that is developed by Zuboff (1988) and has been widely adopted in the IS literature. The second type of generalization is the generation of theory. A good example to illustrate theory generation on interpretive IS case studies is the theoretical framework that is developed by Orlikowski and Robey (1991) concerning the organizational consequences of using IT. The third type of generalization involves the drawing of specific implications. Such implications are drawn by Walsham and Waema (1994) in their in-depth case study of IS development. One major implication concerns business strategies and their relationships with design and development processes. The final type of generalization concerns the contribution of rich insight. This type mainly deals with "the reading of reports and results from case studies that are not easily categorised as concepts, theories, or specific implications" (Walsham, 1995, p. 80) in order to capture insights. The work of Suchman (1987) on the problem of human-machine communication and the various developed concepts and theories is an example of this generalization type.

3.2 Research Design

The selection of an appropriate research strategy is influenced by the goals of the researcher and the nature of the studied topic (Benbasat, 1984). One of the most challenging research strategies in social science is case study research (Yin, 2009). Case study research is well suited to my thesis work as it is the preferred strategy to understand contemporary and complex social phenomena (Yin, 2009). My research and theory are "at their early, formative stages," and the research problems are practice-based, in which "the experiences of the actors are important and the context of action is critical" (Benbasat et al., 1987, p.369).

The nature of case study research and the range of its research alternatives make it highly adaptable for researchers in general and Information Systems researchers in particular. It is used in the positivist (Cavaye, 1996) and interpretivist philosophical traditions (Carroll and Swatman, 2000; Klein and Myers, 1999; Walsham, 1995), for theory testing (Benbasat et al., 1987) or theory building (Atkins and Sampson, 2002; Carroll and Swatman, 2000) by the use of qualitative or mixed methods (Cavaye, 1996; Darke et al., 1998; Walsham, 1995; Yin, 2009). Table 4 presents a list of the key characteristics of case studies as presented by Benbasat et al. (1987).

Table 4. Key Characteristics of Case Studies (Benbasat et al., 1987, p.371)

1. Phenomenon is examined in a natural setting.
2. Data are collected by multiple means.
3. One or few entities (person, group, or organization) are examined.
4. The complexity of the unit is studied intensively.
5. Case studies are more suitable for the exploration, classification and hypothesis development stages of the knowledge-building process; the investigator should have a receptive attitude toward exploration.
6. No experimental controls or manipulation are involved.
7. The investigator may not specify the set of independent and dependent variables in advance.
8. The results derived depend heavily on the integrative powers of the investigator.
9. Changes in site selection and data collection methods could take place as the investigator develops new hypotheses.
10. Case research is useful in the study of "why" and "how" questions because these deal with operational links to be traced over time rather than with frequency or incidence.
11. The focus is on contemporary events.

Central to the design of case study research is to consider whether the study will be based on a single case or multiples (Benbasat et al., 1987; Darke et al., 1998; Yin, 2009). In this thesis, both single and multiple cases were conducted.

3.2.1 Single-Case Design

Yin (2009) illustrates the five main rationales for the use of a single case study method. One rationale is the critical case, used for testing a well-formulated theory. A second rationale is the extreme or unique case. A third is the representative case, suitable for capturing the circumstances of typical situations. Fourth is the revelatory case where the researcher has an opportunity to access, observe and analyze an inaccessible environment. A fifth rationale is the longitudinal case, which is appropriate for studying one particular case at various different points over time.

For this thesis, three single case studies are conducted (papers 2, 4 and 5). All represent extreme cases (Gerring, 2007; Yin, 2009). The main motivation to select an extreme case is the "extreme" value it has on dependent or independent variables of interest and its usefulness for theory generation (Gerring, 2007). This extreme value is defined as an "observation that lies far away from the means of a given distribution" (Gerring, 2007, p. 101-102). The selection of Apple's iPhone platform is used as single cases for two of my studies, and a Swedish software platform for a third study reflects the use of

extreme cases. These are typically considered to be "prototypical or paradigmatic of some phenomenon of interest" (Gerring, 2007, p. 101).

3.2.2 Multiple-Case Design

A multiple case study method is desirable for theory building, theory testing and descriptive research studies (Benbasat et al., 1987). It is a powerful method for conducting cross-case analysis and the extension of theoretical perspectives, and it is typically believed to yield more general research results (Benbasat et al. 1987; Eisenhardt, 1989). In addition, evidence from multiple case study methods are typically considered to be more compelling, and the overall study is therefore more robust (Yin, 2009).

In this thesis, a multiple, comparative case study is conducted (paper 3) (Gerring, 2007; Yin, 2009). The context of the study is Apple's iPhone platform. The study consists of four embedded extreme cases (Gerring, 2007; Yin, 2009) and represents four different and important APIs. There is a chief reason why this study embarked on a multiple case method. Multiple case studies support a comparative analysis approach, and their analytical generalization logic is reinforced through theoretical replication logic (Yin, 2009). Furthermore, and since this study engages in theory-generation, the use of multiple extreme cases is useful because extremes or ideal types typically define theoretical concepts (Gerring, 2007).

3.3 Research Process

The research process of this thesis is performed over three phases. The first phase is theoretical and meant to explore the field of software platforms. This phase aims at examining the nature of these types of platforms and how their adoptions stimulate contributions from third-party developers. The extensive literature review and the analysis of three examples of platforms give more insights into the studied subject. This phase is reported in Ghazawneh (2011) (see Paper 1).

The second phase is empirical and builds on extensive study of Apple's software platform. This phase is divided into three parts: the first part focuses on the governance process of platforms through boundary resources. The outcome of this part is the development of a grounded process perspective of platform governance, which is reported in Ghazawneh & Henfridsson (2010) (see Paper 2). The second part focuses on the strategizing practices used by platform owners in attempts to create and sustain platform through boundary resources. In order to address this aim, a multiple case study of Apple's

resourcing their platform is engaged and analyzed, and thoroughly discussed in Ghazawneh & Henfridsson (2011) (see Paper 3). The outcome of the first and the second parts led to the quest for a theoretical perspective with higher explanatory value. A theoretical model of boundary resource design in third-party development is developed, which is subsequently applied to a detailed case study of Apple's iPhone platform. The effort of the third part is reported in Ghazawneh & Henfridsson (2012) (see Paper 4).

The third phase is also empirical and aims to investigate the phenomenon of boundary resources in different empirical settings. A single case study of a software platform released by a Swedish public transportation company is conducted. The goal of this inquiry is to understand the adopted control mechanisms by platform owners for multi-contextual services in third-party development settings. This phase is reported in Rudmark & Ghazawneh (2011) (see Paper 5).

3.4 Data Collection

3.4.1 Secondary Data

This research is mainly rooted in Web-based data sources. All empirical material is my own, save for the fifth study of this thesis. Web-based qualitative data input can be gathered as primary data from direct sources such as e-mail surveys, or as secondary data from indirect sources such as Internet discussion forums or other online sources (Finch, 1999; Finch and Luebbe, 1997; Romano et al., 2003). Data from nine Web-based sources inform this research. The data sources inlcude: archival data, emails, interviews, public government documents, online articles, open letters, conferences, workshops and special events, and Apple's press releases, news, and announcements (see Table 5).

The use of secondary data, or data that is already collected and made available for uninvolved researchers in the original study, has a long, rich tradition in social sciences such as economics (Atkinson and Brandolini, 2001), political science (Fisher et al., 1998) and psychology (Trzesniewski et al., 2010). However, the use of secondary data in case study research is unusual in information systems, and a typical concern would be a perceived distance between the researcher and the context in which the data originates (cf. Walsham, 1995). The promise in the use of secondary Internet-based data sources is the valuable production of information for case study research (Yin, 2009). Secondary data sources produce a large volume of data that would be impossible using data collection techniques such as the qualitative interview (Romano et al., 2003), and goes beyond typical data collection techniques such

as observations (Creswell, 2003). In addition, it provides a perspective that covers key stakeholders, whose input is often necessary for sensitizing why particular initiatives were taken as a response to environmental changes (cf. Hargadon and Douglas, 2001).

Earlier in this chapter I discussed the principles for conducting and evaluating interpretive research in IS. My data collection and analysis should be seen as a hermeneutic process between the emerging understating of the interpretive researchers and the data material collected from various sources. In addition, secondary data collection is powerful for building the extensive and longitudinal database needed for contextualization of the historical background and plot of the research setting. Meeting the requirements and suggestions of the fundamental principle of the hermeneutic circle and the principle of contextualization is important in interpreting data in interpretive research (Klein and Myers, 1999).

Secondary data collection is necessary where insights from first-hand observation cannot be obtained (Hargadon and Douglas, 2001; Kieser, 1994). It should be also noted that secondary data avoids possible biases introduced in real-time case studies in which different forms of impression management on behalf of the stakeholders may distort collected data about ongoing events. Secondary data sources, such as documentation and archival documents, are among the main sources of evidence in case study research (Walsham, 1995; Yin, 2009). The strengths of such sources lie in their stability and being reviewed repeatedly. They are unobtrusive and are not created as a result of the case study. Such sources contain accurate and exact details of events, and they have a broad coverage (long span of time, many events, and many settings) (Yin, 2009).

3.4.2 Data Triangulation

The use of multiple sources of evidence is a major strength of case study research (Eisenhardt, 1989; Yin, 2009). The process in which a researcher attempts to combine multiple data sources about the studied phenomena is known as data triangulation. It is believed that data triangulation allows researchers to address a broader range of behavioral, historical and attitudinal events (Yin, 2009). In addition, data triangulation maintains the development of converging lines of inquiry and increases the validity of the collected data (Yin, 2009).

Data triangulation enables building and organizing case study databases (Yin, 2009). Such databases, as I discussed earlier in this chapter, are needed for contextualization of the historical background and plot of the research setting (Klein and Myers, 1999). In addition, the use of multiple data sources helps in

maintaining a chain of case evidence that increases the reliability of the information in a case study (Yin, 2009). A description of all secondary data sources and motivations behind using them is presented in Table 5 below.

Table 5. Data Collection

#	Data Sources	Description	Motivations
1.	Archival data	All publically available case documents such as the Registered iPhone developer agreements, iPhone human interface guidelines, and SDK agreements.	1. The agreements and guidelines were changed and updated several times, so it was important to understand the boundary resources and their change over time. 2. They provide more insights about Apple's official strategy.
2.	Apple press releases, news, and announcements	• All press releases collected from Apple's online press release library (January 2007 – February 2011). 58 out of 91 press releases were selected for further analysis. • Developer news and announcements published by Apple at the iPhone Developer Center	1. Establishes timelines of key events of the studied cases. 2. Supports the decomposing of the process into episodes for structuring the analysis (For more details, I refer to the papers). 3. This data was important for gathering Apple's official data on the number of downloads, applications, and third-party developers at different points in time
3.	Conferences, workshops and special events	Data collected from video archives and transcriptions of keynotes, speeches, and presentations took place at: • MacWorld Conference & Expo: MacWorld 2007 and MacWorld 2008. • Apple Worldwide Developers Conference (WWDC): WWDC 2007, WWDC 2008, WWDC 2009 and WWDC 2010. • Apple's SDK events: iPhone SDK 2008, iPhone SDK 2009 and iPhone SDK 2010. • Apple's special events: Rock and Roll event 2009 and Tablet event 2010.	1. Serves as a documentation of Apple initiatives and how the firm officially framed these initiatives. 2. Another official and reliable source for gathering Apple's official data on the number of downloads, applications, and third-party developers at different points in time. 3. Apple's strategic announcements and news usually revealed at such events and conferences. So this was important to follow their strategic moves from the day they are announced. 4. An official source to get the view, comments and opinions of Apple's CEO and all other VPs.

	Data Sources	Description	Motivations
4.	Corporate blog posts	Data from corporate blog posts of Adobe and Skype.	1. Official source for views and thoughts of Apple's partners and competitors.
5.	E-mails	22 messages between Apple and developers, Adobe and developers, Apple/Adobe and media, Google and media, Federal Communications Commission (FCC)/ Federal Trade Commission (FTC) and media.	1. These messages often made points that not necessarily were in Apple's interests. Typically, they provided a counterview to Apple's official line. 2. These messages showed how Apple's actions and strategic moves are perceived by competitors and other actors in the ecosystem.
6.	Interviews	*Two interviews with Apple's CEO, Steve Jobs:* 1. 6-minute video recorded interview by ABC News. 2. Transcribed interview by Time magazine. *Two interviews with Apple's Senior VP Worldwide Product Marketing, Phil Schiller:* 1. Transcribed interview by The Engadget (highly profiled Group-edited blog about technology). 2. Transcribed interview by Business Week. *One interview with a developer:* 1. 26-minute recorded and transcribed interview with a notable iPhone developer (Joe Hewitt). The interview was conducted by two well-known high-tech analysts (Michael Arrington and Nik Cubrilovic).	1. The two interviews with Apple's CEO, Steve Jobs helped in understanding the very early initiatives and strategies. In addition to his views on the platform. 2. The two interviews with Apple's Senior VP Worldwide Product Marketing, Phil Schiller helped in understanding Apple's market strategies and tactics used. 3. The interview with a notable iPhone developer (Joe Hewitt) was used to understand thoughts of third-party developers on the challenges and opportunities around iPhone application development.

	Data Sources	Description	Motivations
	Interviews (cont.)	*One interview with Adobe's CEO, Shantanu Narayen:* 1. 5:31 minutes video recorded interview by Bloomberg Television. (highly profiled Group-edited blog about technology). 2. Transcribed interview by Business Week. *One interview with a developer:* 1. 26-minute recorded and transcribed interview with a notable iPhone developer (Joe Hewitt). The interview was conducted by two well-known high-tech analysts (Michael Arrington and Nik Cubrilovic). *One interview with Adobe's CEO, Shantanu Narayen:* 1. 5:31 minutes video recorded interview by Bloomberg Television.	4. The interview with Adobe's CEO, Shantanu Narayen was used to understand Adobe's point of view about Apple's counteracting Flash on iPhones, iPods and iPads.
7.	Public government documents	• Three documents from the Federal Communications Commission (FCC) to Apple, Google and AT&T. • Three response letters from Apple, Google and AT&T to the FCC.	1. They provide detailed views and actions of governmental agencies regarding Apple's decisions, actions and strategic moves.

	Data Sources	Description	Motivations
8.	Online Articles	620 articles from multiple online sources: • General magazines, newspapers and journals such as BusinessWeek.com, NYTimes.com and WSJ.com. • Technology-focused magazines and journals such as Computer World.com, MacWorld.com, and TheRegister.co.uk. • Highly profiled Group-edited blogs such TechCrunch.com, GigaOM.com and Engadget.com • Highly profiled tech news and analysis websites focusing on Apple news, its products and marketing strategies such as: AppleInsider.com, iLounge.com and Roughlydrafted.com.	1. This data generated a comprehensive understanding of the cases 2. This data was particularly useful for providing multiple interpretations of single events. 3. This data covered the actions and strategic moves of Apple and all other actors in the ecosystem. This helped in connecting the points and draw rigor case stories that covered all engaged parties. 4. This data linked to official data sources.
9.	Open Letters	• One open letter by Apple's CEO, Steve Jobs.	1. Steve Jobs official views and thoughts on Adobe's Flash on why it is not allowed on iPhones, iPods and iPads.

3.5 Data Analysis

I have adopted Romano et al. (2003)'s data analysis methodology to analyze the collected data material. This generic methodology provides tools for analyzing qualitative data based on IS principles that ensures: (a) efficient and effective process and (b) meaningful results. It provides a structured approach to deal with the dynamic, rich and huge volumes of qualitative data and data that is collected from Internet-based sources. The methodology consists of three steps: elicitation, reduction and visualization.

Step 1: Data Elicitation

Elicitation is the process of gathering and dealing with data from various qualitative sources (Miles and Huberman, 1994). It is considered an important part of research in qualitative studies (Miles and Huberman, 1994). Web-based qualitative data input can be gathered as primary data from direct sources such as e-mail surveys or as secondary data from indirect sources such as Internet discussions (Finch, 1999; Finch and Luebbe, 1997; Romano et al., 2003).

Multiple and various data sources are used to elicit relevant data to be included in the database of my case studies. My initial search queries included keywords such as iPhone, Apple, AppStore, iPhone platform, iPhone APIs, iOS APIs, and combinations of these keywords. This search concentrated on the time period between January 2007 and February 2011. On the basis of this massive material, I started an initial screening for selecting relevant data for my studies. This screening process was based on an intensive and careful review of all collected data types, in which the initial coding (Charmaz, 2006) resulted in numerous concepts relating to categories such as third-party developers, SDK, API, platform governance, developers' community, and iPhone ecosystem. The selected data was stored in a Qualitative Data Analysis (QDA) software system based on the day/month that it appeared online, which helped in tracing the historical process and securing a correct timeline of events across all cases. Table 6 below presents data elicitation tasks and outputs in relation to my papers.

Table 6. Data Elicitation in relation to papers

Papers	Tasks	Outputs
Paper 2	• Elicited data from the six data sources • Stored the data in a Qualitative Data Analysis (QDA) software system based on the day/month data appeared online. • Initial coding. • Identifying several case story phases.	• Research database. • Numerous concepts. • Four main phases were chosen for further investigation.
Paper 3	• Elicited data from nine data sources. • Stored the data in a Qualitative Data Analysis (QDA) software system based on the day/month data appeared online. • Identifying a pool of twelve strategic APIs • Initial focused coding	• Research database • Numerous concepts related to main categories such iOS APIs, Third-party developers, platform ecosystem, and ecosystem strategizing. • Four main APIs were chosen for further investigation.
Paper 4	• Elicited data from the six data sources. • Stored the data in a Qualitative Data Analysis (QDA) software system based on the day/month data appeared online. • Initial coding	• Research database. • Numerous concepts.
Paper 5	• Elicited data from the five primary and secondary data sources, • Stored all transcribed material in a Qualitative Data Analysis (QDA) software system. • Initial coding	• Research database. • Numerous concepts related to main categories such multi-contextual services, third-party development, control mechanism.

Step 2: Data Reduction

Data reduction is a critical step in my analysis process. It involves "selecting, focusing, simplifying, abstracting, and transforming raw data to make it useful" (Romano et al., 2003, p.221). I started this step by selecting data corresponding to the initial categories. This was followed by coding the selected data and establishing codes for the categories that were developed in the selection process. Using my theoretical basis and concepts such as boundary resources, platform governance and micro-strategizing, I identified major key events, activities, actors, and strategic moves across cases. In addition, this step engaged the process of time-stamping the selected data that helps in tracing the historical process and secures a correct timeline of events. Table 7 below presents data reduction tasks and outputs in relation to my papers.

Table 7. Data Reduction in relation to papers

Papers	Tasks	Outputs
Paper 2	• Reduced the massive data material from the broad initial coding categories. • Coded the selected data. • Traced the historical process.	• Timeline of events. • Identified a sequence of events repeated over time.
Paper 3	• Reduced the massive data material from the broad initial coding categories • Coded the selected data. • Traced the historical process. • Applied our conceptual basis including platform boundary resources, platforms ecosystems and micro- strategizing to identify key events, key actors and key strategic moves.	• Timeline of events. • Key actors. • Key strategic moves.
Paper 4	• Used the boundary resources model to reduce and code the massive data material. • Traced the historical process.	• Timeline of events. • Identified a sequence of events repeated over time.
Paper 5	• Establishing relationships between codes. • Coded the transcribed data. • focused on the chronological unfolding of events.	• Timeline of events. • Key actions by platform owner. • Key responses by third-party developers.

Step 3: Data Visualization

Data visualization is the third and final step in my analysis process. It involves the preparation of the organized coded comments from the data reduction process. Visualization includes several display methods as extended text, graphs and charts (Miles and Huberman, 1994). The outcomes of the data visualization are not only the visualizations themselves, but also the "relationships, patterns, and principles that are revealed through meaningful visual presentations of the data" (Romano et al., 2003, p.224). Table 8 below presents data visualization tasks and outputs in relation to my papers.

Table 8. Data Visualization in relation to papers

Papers	**Tasks**	**Outputs**
Paper 2	• Identified and visualized four case episodes. • Used the platform timeline and the process perspective to analyse the case findings.	• Four case episodes. • Platform timeline. • A process perspective of governing third-party development.
Paper 3	• Identified and visualized five main micro–strategies: - Case I: 2 micro-strategies. - Case II: 1 micro-strategy. - Case III: 1 micro-strategy. - Case IV: 1 micro-strategy.	• Four case episodes. • Five main micro-strategies.
Paper 4	• Identified and visualized three case episodes • Used the boundary resources model to analyse the case findings.	• Three case episodes. • The boundary resources model. • Four specialized constructs.
Paper 5	• Identified and visualized three case episodes. • Used control mechanisms and boundary resources perspective to analyse the case findings.	• Three case episodes. • Three components of exercised control mechanisms.

3.6 Assessment of the Research Process

I have chosen to use the seven principles proposed by Klein and Myers (1999) as a basis for making a self-assessment of my research. These principles are well established among IS scholars for evaluating interpretive research.

Table 9. Summary of principles for interpretive field research (Klein and Myers, 1999, p. 72)

Principles for interpretive field research
1. The fundamental principle of the hermeneutic circle This principle suggests that all human understanding is achieved by iterating between considering interdependent meaning of parts and the whole that they form. This principle of human understanding is fundamental to all other principles.
2.The principle of contextualization Requires critical reflection of the social and historical background of the research setting, so that the intended audience can see how the current situation under investigation emerged.
3.The principle of interaction between the researchers and the subjects Requires critical reflection on how the research materials, or data, were socially constructed through the interaction between the researchers and participants.
4. The principle of abstraction and generalization Requires relating the idiographic details revealed by the data interpretation through the application of principles one and two to theoretical, general concepts that describe the nature of human understanding and social action.
5.The principle of dialogical reasoning Requires sensitivity to possible contradictions between the theoretical preconceptions guiding the research design and actual findings ("the story which the data tell") with subsequent cycles of revision.
6.The principle of multiple interpretations Requires sensitivity to possible differences among the participants as are typically expressed in multiple narratives or stories of the same sequence of events under study. Similar to multiple witness accounts even if all tell it as they saw it.
7.The principle of suspicion Requires sensitivity to possible "biases" and systematic "distortions" in the narratives collected from the participants.

Principle 1 is the fundamental principle of interpretive research. It suggests that our understanding is achieved through an iterative process between the whole and the parts of the studied phenomenon. This thesis is based on a cover chapter and a collection of five papers. The writing process of this thesis is an iterative process between the thesis and all constituted parts. For example, the main goal of the first paper was to conceptually explore the role of platforms and their components in third-party developments. This exploration led to an investigation of the governance of those platforms in the second paper, with a specific emphasis on their components, namely boundary resources. After reflecting upon the results of the second study, it was obvious that those boundary resources have the ability to be used by platform owners to stimulate third-party development and sustain the platform. These interests influenced the last three papers. Another iterative process of the "hermeneutic circle" in my thesis took place within cases themselves. The "parts" of that process are the various parts of the case story, and the "whole" is the context of the case. The overall understating of the case context reflects my interpretation of the different parts of the case story.

Principle 2 is reflected in all sections describing the *Platforms* in the cover chapter, as well as in the collection of all articles. The main aim of presenting the literature on platforms is to provide the intended audience with theoretical understanding and a background. The social and historical backgrounds were accounted for throughout the thesis when considering the interpretations of the data. For instance, in papers 2, 3 and 4, I comprehensively accounted for the historical story and context of Apple's iPhone platform. All together, these considerations helped in showing how the current situation of the studied phenomena emerged.

Principle 3 emphasizes the role of the interaction between the researchers and the studied subject, participants and material. From the very beginning, I interpretatively reflected on the gathered data. I never looked at the data as raw material that is just sitting in online sources and waiting to be gathered. Focusing mainly on secondary web-based data facilitated this process and the effects of participants interpreting their answers or analyzing their actions in front of IS researchers is lessened in my case. It is true that sometimes as researchers, we ought to miss fresh outlook (Walsham, 2006) or even be inspired by interesting gathered data or interpreting data from the viewpoints of the platform owners. However, looking back at my interpretation, analysis, and the process of writing my articles, I have been able to capture a critical distance and reflections. This enabled me to put away any inspiration toward Apple or their platform and concentrate on developing a piece of research that is plausible and well-grounded in the situated character of the case setting.

My interaction as a researcher with my studied subject is different from that in traditional field studies. The different data types from multiple sources such as Apple, third-party developers, competitors, analysts and journalists, were a key issue in this interaction. The focused text analysis of the multiple data sources enabled me to go beyond the text, where new understanding has emerged overtime. For example, during the text analysis, I put myself in the position where journalists wrote specific articles, or where Apple broadcasted particular information in response to journalists at a specific time. All in all, this new emerged understanding enriched the interaction with the studied subject.

Principle 4 regards abstraction and generalization. It requires relating the interpreted data to the theoretical insights and concepts that have evolved from it. Various theories and methods informed the analysis of my research papers. The details of each paper were related to the theoretical concepts during the analysis process. For example, I have used quotations to link data from speeches, documents or e-mail conversations to theoretical abstractions and generalizations. I have discussed earlier in this chapter the four types of generalizations from interpretive case studies (Walsham, 1995). The first type of generalization is the 'development of concepts'; for instance, the second paper contributes to this type of generalization in which the "platform boundary resources" concept is introduced to understand the actual process of transferring design capabilities to third-party developers while keeping control of the platform. The second type of generalization is the 'generation of theory'; for instance, the fourth paper contributes with theory generation in which the "boundary resources model" develops a theoretical account for specifying relationships between constructs that are useful for analyzing the role of boundary resources in third-party development. The third type of generalization involved the 'drawing of specific implications'. The third paper provides examples of such implications as it draws in five different micro-strategies that can be enacted proactively or reactively, which jointly determine the relative success of a platform owner's efforts to stimulate third-party development. The fourth type of generalization considers the 'contribution of rich insight'. This thesis contributes rich and general insights to studies of platforms and third-party development. It gives insights into boundary resource design in platforms, which provides a coherent basis for further research in the area.

Principle 5 is referred to as dialogical reasoning. It is related to the theoretical considerations guiding the research and the emerged data through the research process. This was achieved by presenting the underlying interpretive perspective behind the research and illustrating the fundamentals of constructing, documenting and organizing the empirical data. Prior assumptions, beliefs, values and interests of interpretive researchers usually influence the research and the studied phenomena (Orlikowski and Baroudi,

1991). The process of analyzing and interpreting the data was always discussed with engaged fellow researchers in my studies. During these discussions we were alerted to our beliefs and their consistency with our interpretations and relevancy with our conclusions. Further, our understanding has developed overtime, and our interpretations were not limited to specific theoretical concepts as new themes emerged. As this thesis is based on a collection of papers, it is possible that readers realize how my understanding of the research stetting improved and evolved overtime.

Principle 6 concerns multiple interpretations of data. It requires researchers to seek out and document multiple viewpoints. In order to understand and explore the design of platform boundary resources, I included multiple and various actors around the platform. For instance, I collected third-party developers' e-mail messages that often expressed viewpoints that were not necessarily adherent to Apple's interests; typically, they provided a counterview to Apple's official line. In so doing, multiple viewpoints about the use and design of platform boundary resources were obtained.

Principle 7 is referred to as the 'principle of suspicion'. It suggests that researchers should "read" the social worlds and go beyond their understanding of the meaning of data. This principle is the least often adopted by IS researchers and is seldom developed in IS research literature. In addition, there are disagreements regarding the extent to which social research can be critical (Klein and Myers, 1999).

4 Research Papers

This thesis is a collection of peer-reviewed papers published in international IS journals and conference proceedings. This chapter will briefly introduce the papers and summarize their results. An overview of the appended papers is provided in Table 10 below. The papers are introduced in order of appearance.

Table 10. Overview of the appended papers

	Paper 1	Paper 2	Paper 3	Paper 4	Paper 5
Title	The Power of Platforms for Software Development in Open Innovation Networks	Governing Third-Party Development through Platform Boundary Resources	Micro-Strategizing in Platform Ecosystem: A Multiple Case Study	Balancing Platform Control And External Contribution in Third-Party Development: The Boundary Resources Model	Third-Party Development for Multi-Contextual Services: on the Mechanisms of Control
Research focus	Platforms roles and adoption	Platform governance	Strategizing practices in platforms	The design and use of boundary resources	Control mechanisms in Platforms
Research purpose	Explores the roles and platforms for third-party development	Investigates governance process through boundary resources.	Investigates strategizing practices applied by platform owners.	Proposes a theoretical model to understand the use and design of boundary resources	Explores mechanism of control applied by platform owners.
Type of research	Conceptual paper	Empirical paper	Empirical paper	Empirical paper	Empirical paper
Theoretical framework	Platforms Literature Open Innovation Networks	Platform Governance Innovation Networks	Micro-Strategizing Perspective	The Boundary Resources Model	Control Mechanisms Boundary Objects Theory
Method	Literature study	Qualitative case study	Qualitative case study	Qualitative case study	Qualitative case study
Data	Secondary	Secondary	Secondary	Secondary	Primary and secondary
Contribution	Addresses the roles of platforms in software development	A process perspective of governing third-party development	A set of (reactive & proactive) micro-strategies.	A set of specialized constructs in third-party development	Explores control mechanisms in platforms

4.1 Summary of First Paper

The first paper addresses the role of platforms in software development settings. It examines the nature of these types of platforms and how their adoptions stimulate contributions from third-party developers. In this paper the four main elements of platforms (components, processes, knowledge and people) are used as tools to understand the conceptual and practical structure of platforms in software development. This paper signalizes how the platform's offerings and the advantages of adopting them well and efficiently suit the objectives of innovation networks. Based on the analysis of three practical examples of platforms (namely iPhone, Facebook and Twitter), the four elements of platforms were illustrated and their effects on innovation networks and their two dimensions of translations were examined. The analysis demonstrates how firms working in different industries adopt platforms and put them to work within innovation networks.

Ghazawneh, A. (2011). "The Power of Platforms for Software Development in Open Innovation Networks," in *International Journal of Networking and Virtual Organisations, Vol. 9, No. 2, pp.140–154, 2011.*

- An earlier version of this journal article was presented at the 43rd Hawaii International Conference on System Sciences (HICSS) "Ghazawneh, A. (2010), "The Role of Platforms and Platform Thinking in Open Innovation Networks," *Proceedings of the 43rd Hawaii International Conference on System Sciences (HICSS-43), Kauai, Hawaii, Jan 2010.*"

4.2 Summary of Second Paper

This paper investigates the governance process by which proprietary platform owners simultaneously maintain platform control and stimulate third-party development through platform boundary resources. Drawing on a study of Apple's iPhone platform, this paper demonstrates that platform boundary resources enable platform owners to maintain platform control and govern the practices of third-party development while at the same time transferring design capability to third-party developers. The analysis shows that governing third-party development can be seen as cyclical pattern of actions across platform boundary resources. The pattern is mainly driven by the platform owner and its responses to changes in the emerging innovation network. The findings show that the platform owner constructs new platform designs, secures platform control through agreements compatibility, increases knowledge heterogeneity through distribution channels, and counteracts foreign boundary resources designed to infringe on the platform.

Ghazawneh, A. and Henfridsson, O. (2010). "Governing Third-Party Development through Platform Boundary Resources". *In: Proceedings of the 31st International Conference on Information Systems, ICIS 2010. St. Louis, USA. Dec 2010.*

4.3 Summary of Third Paper

This paper investigates the strategizing practices used by platform owners in attempts to create and sustain platforms through boundary resources. Drawing on a multiple case study of Apple's use of four application programming interfaces (namely push notification, in-app purchase, voice over IP, and flash APIs), this paper demonstrates that in order for platform owners to leverage platforms through boundary resources, they should identify, configure, enact, and practice several micro-strategies that are conducted to create value in an ecosystem context. The comparative analysis identifies and explores five different micro-strategies: counteracting, monetizing, resourcing, securing, and sustaining. These micro-strategies can be enacted proactively or reactively, and are part of the platform owner's core competence that helps to increase the viability and value-creation of the ecosystem in building the capability of timely responses to other actors' strategic moves within the ecosystem.

Ghazawneh, A. and Henfridsson, O. (2011). "Micro-Strategizing in Platform Ecosystems: A Multiple Case Study". *In: Proceedings of the 32nd International Conference on Information Systems, ICIS 2011. Shanghai, China. Dec 2011.*

5.4 Summary of Fourth Paper

This paper aims to gain an understanding of the role of boundary resources in platform owners' efforts to stimulate third-party development and the theoretical accounts of this relationship. There are few, if any, theoretical accounts of the relationship between the use and design of boundary resources in maintaining platform control and transferring design capability to third-party developers. Drawing on a detailed case study of Apple's iPhone platform, this paper proposes a theoretical model (the boundary resources model) that centers on two drivers behind boundary resource design and use (resourcing and securing), and how these drivers interact in third-party development. The findings show that there are four specialized constructs for understanding the actions taken by stakeholders in third-party development: self-resourcing, regulation-based securing, diversity-resourcing, and sovereignty securing.

Ghazawneh, A. and Henfridsson, O. (forthcoming). "Balancing Platform Control And External Contribution in Third-Party Development: The

Boundary Resources Model," *in Information Systems Journal, forthcoming (DOI: 10.1111/j.1365-2575.2012.00406.x).*

4.5 Summary of Fifth Paper

This paper aims to understand the adopted control mechanisms by platform owners for multi-contextual services in third-party development settings. The paper attempts to put in a new perspective, and gain a greater understanding of how organizations attempt to control the development efforts through platform boundary resources. Drawing on a detailed case study of a software platform released by a public transportation company in Sweden, this paper explores and illustrates the exercised control mechanisms by platform owners and their outcomes within the context of third-party development. The findings show that the platform owner exercised an *outcome control* type, while a third-party *self-control* was employed to deal with the heterogeneity of users. In addition, it was found that the degree to which third-party development practices freedom is mitigated through boundary resources (namely APIs).

Rudmark, D. and Ghazawneh, A. (2011). "Third-Party Development for Multi-Contextual Services: On the Mechanisms of Control". *In: Proceedings of the 19th European Conference on Information Systems, ECIS 2011. Helsinki, Finland. June 2011.*

5 Discussion

The overriding aim of this thesis is to create an understanding of platform boundary resources and their influencing roles in platform control and third-party development. This chapter illustrates the findings from the five appended papers. It starts with presenting the role of a software platform as a developing environment that connects platform owners, third-party developers and other actors in the platform ecosystem. Further, it discusses how governing software platforms through boundary resources are perceived as cyclical processes of multiple patterns and actions that are driven by the platform owners. The chapter then discusses how governing a software platform requires a platform strategy involving third-party development. It concludes by discussing the boundary resources model (BRM) that helps in understanding the actions taken by platform-owners in third-party development.

5.1 Software Platforms as Innovation Engines

Software platforms provide various distinctive advantages for innovating firms. They enable firms to develop a variety of third-party applications and services that use resources efficiently (Meyer and Lehnerd, 1997; Robertson and Ulrich, 1998; Sawhney, 1998; Ulrich, 1995; Meyer et al., 1997) and help firms to compete more effectively and satisfy the needs of customers by providing innovative technologies over time. In this thesis, the advantages of adopting software platforms have been thoroughly discussed. This includes the simultaneous improvements in speed, cost, design quality, coherence, referenceability, and option value. (cf. Sawhney, 1998). This thesis discusses these advantages in basic innovation networks and shows that the adoption of software platforms outfits the objectives of open innovation networks effectively.

This thesis, through the illustration of three examples of software platforms (iPhone, Twitter and Facebook), shows how innovative firms adopt, operate and put software platforms into use. The common structure of software platforms that is divided into four main elements – components, processes, knowledge and people (Robertson and Ulrich, 1998) – is used to analyze and discuss the three practical examples. The four main elements are used extensively to understand how firms adopt software platforms and harness the collective power of third-party developers that is enabled by providing specific

platform boundary resources and granting access to complementary development (West, 2003).

Moreover, this thesis details how software platforms emerge in the dimensions of translation in innovation networks. First, it shows how software platforms enable and facilitate the translation of new ideas and solutions into software applications and services. It then shows how software platforms act as environments for collaboration that connect platform owners, third-party developers and other actors in the platform ecosystem.

5.2 Software Platform Governing as a Process

This thesis shows how software platform owners can govern third-party development through platform boundary resources. This governance is seen as a cyclical process of multiple patterns and actions that are driven by the platform owner. This thesis identifies four different patterns that are constructed by platform owners in attempts to govern third-party developers. The findings show that this governance process involves series of actions that are repeated over time. These actions involve two acts: (1) maintenance of control, and (2) transfer of design capability to third-party developers to stimulate their contributions. Table 11 lists these patterns and the associated actions taken by platform owners.

Table 11. Patterns of governing third-party development

Pattern	Action
Boundary resource design	Constructing new boundary resource design
Agreements	Secures platform control through agreements compatibility
Distribution channels	Increases knowledge heterogeneity through distribution channels
Foreign boundary resources	Counteracts foreign boundary resources designed to infringe on the platform

The findings show that each governance cycle starts with a new boundary resource design constructed by the platform owner. The construction of a new design is usually a response to insufficiency in current boundary resources that is recognized by the platform owner. Platform owners recognize such issues through feedback from third-party developers, other partners, and users of the software platform. Platform owners respond to the perceived insufficiency by

improving the current boundary resources through the introduction of boundary resources that provide new capabilities and functionalities to third-party developers.

Securing platform control through agreement compatibility follows the first pattern. Software platform owners typically maintain agreements with third-party developers to secure the platform. In order to continuously control the platform, these agreements can be cancelled and/or updated, and new agreements can be introduced if needed as well. The findings show that the compatibility between newly introduced boundary resource designs and agreements is critical to ensure that third-party developers do not exploit weaknesses in newly introduced boundary resources.

The third pattern concerns digital distribution channels, commonly known as AppStores. Located at the interface between the platform owner and all other actors (e.g., third-party developers, platform partners and users), their main functionality is to distribute applications on behalf of third-party developers to the platform end-users. They support basic functionalities of marketplaces, such as payments and commissions, enabling the platform's actors to be identified and their transactions to be executed. The platform distribution channels work as platform control points that can be used by platform owners to determine which applications are eligible to be deployed into the platform users and distributed and marketed to end-users.

Finally, platform owners counteract foreign boundary resources. These foreign boundary resources are designed and developed by external parties and might be used by the platform competitors to infringe on the platform. It is significant that platform owners decide whether to enable foreign boundary resources or not. On the one hand, allowing the intermediation of foreign boundary resources increases the impact of the platform; on the other hand, this impact is gained at the expense of a more distributed platform control and might break the overall governance strategy.

5.3 Software Platform Governing as Micro-Strategies

This thesis shows that governing a platform requires a platform strategy involving third-party development. This type of strategy is about dealing with emerging issues within the platform's ecosystem. Platform owners need to make strategic moves in response to actions taken by third-party developers, competitors, authorities and other actors of the platform's ecosystem. In this

thesis, the series of seemingly minor strategic moves made by platform owners is regarded as micro-strategizing.

This thesis has identified and explored five different micro-strategies that can be enacted proactively or reactively by platform owners. The first strategy is referred to as *resourcing*. The findings show that *resourcing* is a strategy that is implemented by platform owners to enrich the platform with new capabilities through the provision of platform boundary resources. Platform owners usually introduce new boundary resources to enhance the platform and extend the functionalities that can be used by third-party developers. This type of resourcing is labeled as *proactive resourcing*. At the same time, the findings show that platform owners might resource their platform with new boundary resources as a response to other actors' strategic moves in the ecosystem. This other type of resourcing is labeled as *reactive resourcing*.

The second strategy that is identified is referred to as *securing*. Platform owners adopt this strategy in attempts to secure the platform by acting on other ecosystem members' strategic moves that would risk infringing the platform. The findings show that platform owners continuously predict strategic moves by other ecosystem actors and take actions on this basis. This type of securing is labeled as *proactive securing*. If actions are taken on the basis of realized platform-infringing strategic moves, then the strategy is *reactive securing*.

The third strategy that emerged from the data analysis is referred to as *monetizing*. This strategy involves generating new business opportunities through platform boundary resources. Such *monetizing* is proactive when platform owners create a new line of business and revenue streams by releasing particular boundary resources. The findings show that platform owners conduct *reactive monetizing* by taking actions against other ecosystem actors and trying to monetize from the platform and apply strict regulations on their use of platform boundary resources.

The fourth strategy that is revealed by the data analysis is referred to as *sustaining*. This strategy represents attempts by platform owners to maintain existing ecosystem relationships through platform boundary resources. This strategy helps platform owners to develop and sustain partnership relations with key ecosystem actors and deal with both competitors and authorities within the ecosystem. *Sustaining* is proactive when it involves maintaining ecosystem relationships through platform boundary resources. This strategy targets mainly close and strategic partners of the platform owner. At the same time, the findings show that platform owners have to maintain their relationships with competitors and governmental agencies. This can be accomplished through *reactive sustaining*, as it involves actions taken by platform owners in response to concerns raised by authorities and competitors.

The last identified strategy is referred to as *counteracting*. This strategy enables platform owners to deal with meta-platforms and external boundary resources, which try to bypass the main platform and the control mechanisms that are set by platform owners. Platform owners have to carefully implement such a strategy to avoid having the platform infringed by competitors. The findings show that *counteracting* is usually proactive and takes place when a platform owner initiates a series of strategic actions and moves to block meta-platforms' attempts to infringe the original platform. Although the analysis did not reveal any evidence, it is believed that reactive *counteracting* can be envisioned, too.

5.4 The Boundary Resources Model

This thesis proposes a theoretical model referred to as the "Boundary Resources Model". This model is seen as a framework with which to make sense of third-party development and the processes by which the actions of a platform owner and developers are mediated by boundary resources. The model clearly defines constructs with significant implications on third-party development and platform ecosystems (see Table 12 below).

Table 12. Constructs of the Boundary Resources Model

Construct	Action
Platform	"The extensible codebase of a software-based system that provides core functionality shared by the modules that interoperate with it and the interfaces through which they operate" (Tiwana et al., 2010, p. 676)
Boundary Resources	The software tools and regulations that serve as the interface for the arm's length relationship between the platform owner and the application developer
Third-Party Application	Executable pieces of software that are offered as applications, services, or systems to end-users of the platform
Boundary Resources Design	The platform owner's act of developing new, or modified boundary resources as a response to perceived external contribution opportunities and control concerns
Boundary Resources Use	The third-party developer's act of developing end-user applications drawing on boundary resources offered by the software platform owner
Resourcing	The process by which the scope and diversity of a platform is enhanced
Securing	The process by which the control of a platform and its related services is increased

The model centers on two drivers behind boundary resource design and use and details how these drivers interact in third-party development. The first driver is referred to as *resourcing,* and is seen as the process by which the scope

and diversity of a platform is enhanced. The second driver is referred to as *securing,* and is seen as the process by which the control of the platform is increased. It is argued in this thesis that it is important that platform owners give attention to both of these drivers to stimulate third-party development. The empirical data has shown that this attention should be based on a balance act of the two drivers, as singular, one-sided attention to one of these two drivers is a dead-end.

This thesis shows that the boundary resources model is useful for understanding this balancing act. It provides a coherent model with well-defined constructs for examining the actions of stakeholders involved in third-party development. The empirical data revealed that there are four insights related to resourcing and securing: self-resourcing, regulated securing, diversity-resourcing, and sovereignty securing. These insights can be manifested within particular stages of the evolution of an ecosystem. Table 13 describes these insights and their usefulness on platforms and third-party development.

Table 13. Insights of the Boundary Resources Model

Insight	Description	Usefulness
Self-resourcing	Third-party developers' act of developing new boundary resources as a response to perceived limitations in existing boundary resources	Investigating cases where the governance of a popular platform leans too much in a securing direction
Regulation-based securing	Platform owners' act of exercising control over the platform and its related services through administrative legislation, captures control actions that rely on regulative measures rather than technical restrictions to resourcing	Understanding application review procedures in third-party development.
Diversity-resourcing	Denotes deliberate action taken by a platform owner to diversify the platform in a way that stimulates new application areas.	Exploring how third-party development can enable a platform owner to transform its enterprise beyond its traditional industrial settings.
Sovereignty securing	Actions taken by a platform owner to maintain control of the platform's evolution and avoid becoming a substitute platform for application developers.	Investigating the responses of platform owners when other platform owners attempt to scale their own platform and ecosystems.

6 Conclusions

The aim of this concluding chapter is to briefly discuss key issues, themes and implications for theory and practice and a number of limitations that can be addressed in future studies.

6.1 Implications for Research

This research complements and extends the literature on software platforms (Baldwin and Woodard, 2009; Franke and von Hippel, 2003; Gawer and Cusumano, 2008; Morris and Ferguson, 1993; Tiwana et al., 2010; West, 2003; Yoo et al., 2010). First, the insights derived from the boundary resources model enhances previous research on third-party development (Bergvall-Kåreborn et al., 2010; Bosch, 2009; Boudreau, forthcoming; Evans et al., 2006; Messerschmitt and Szyperski, 2003; Remneland et al., 2011) by providing a focused theoretical account of the interfaces between the software platform and components developed by external parties. This thesis argues for conceptualizing the interfaces between the platform and its developers as boundary resources. This provides a means to more closely study the actions taken by stakeholders in third-party development. It enables an analysis that is geared towards appreciating boundary resource design as strategizing rather than understanding interfaces as standards.

Secondly, detailing governance in the context of software platform ownership shows that governance involves a delicate balancing act for the platform owner, trying to keep control of the platform while simultaneously seeking to expand the diversity of potential developers. These two conflicting goals need well-planned governance strategies to maintain a balance. The governance process model reported in this thesis presents new insights about this process. It details how platform boundary resources are used to transfer design capability to third-party developers while at the same time maintaining control over the platform. In this regard, the reported governance process perspective contributes to the body of knowledge developed around using tools for user innovation (Franke and von Hippel, 2003; von Hippel, 2001). This gives new research insights for open platform governance as well (Dahlander and Magnusson, 2005; de Laat, 2005; Demil and Lecocq, 2006; Markus, 2007; O'Mahony, 2005; West, 2003).

Thirdly, applying a strategy-as-process view (Chia and MacKay, 2007; Johnson et al., 2003; Jarzabkowski, 2008; Whittington, 2006) to software platforms shows that platform strategy emerges through the engagement and enactment

of multiple strategies as the platform owner discovers new opportunities or reacts as a response to strategic moves by ecosystem members. The identification of such strategies provides a perspective on the nature of strategy in the context of platform ecosystems. These strategies need to be exercised and combined in practice to deal with the software platform ecosystem properly. The implementation of such strategies is taking place through the use of platform boundary resources, located at the interface between the software platform owner and other actors in the software platform ecosystem.

Finally, this thesis contributes to the continued investigation and research of digital innovation in information systems (Eaton et al., 2011; Henfridsson et al., 2009; Kallinikos et al., 2010; Svahn et al., 2009; Tilson et al., 2010; Yoffie, 1997; Yoo et al., 2008) by illustrating a new way to conceive boundary resources as digital technology with the capacity to trigger innovation driven by multiple and uncoordinated third-party developers. In addition, this research illustrates how software platforms and business strategies are interwoven. The information systems discipline makes a clear distinction between business strategy and IT strategy. Evidently, platform boundary resources are a means by which strategy may be exercised in both domains.

6.2 Implications for Practice

This research has shown that platform boundary resources enable platform owners to maintain platform control and govern the practices of third-party development while at the same time transferring design capability to third-party developers. In so doing, there are a number of practical implications concerning platform owners.

An important issue for platform owners is to establish a clear platform strategy. This strategy should be neutral enough to facilitate the involvement of third-party application developers and attract them to join the software platform ecosystem. Based on the data analysis throughout this thesis, platform owners are advised to align their established strategy with all actors in the ecosystem such as platform users, developers, partners and even competitors.

Platform owners need to comprehend the importance of boundary resources design to the platform strategy. There should be key drivers behind the design process. Platform owners should design boundary resources to extend the scope and diversity of their platform, while at the same time, allow third-party developers to use these resources in their application development. Still some kind of balancing act should be implemented to secure the platform and response to perceived control concerns. However, this raises yet another concern of counteracting foreign boundary resources over time to avoid that

the platform getting infringed by competitors. It is therefore imperative to make a balance between platform resourcing and securing.

In addition, platform owners need to be aware of the importance of distribution channels (e.g., AppStores) to their platform strategy. These distribution channels are located at the interface between the platform and all other actors in the ecosystem. They are the exclusive and official gateway that gives actors access to the complementary assets. Platforms owners therefore have to facilitate the access of third-party developers to the distribution channels and allow them to distribute software applications through the distribution channels. At the same time, platform owners ought to use these distribution channels as checkpoints to stay in control of the ecosystem

6.3 Limitations and Future Research

This thesis involves a number of limitations that can be addressed in future studies. First, it draws on extreme cases that were chosen for generating new theoretical insights (Gerring, 2007). However, it would be difficult to argue that these cases are representative. Consequently, it would be useful to conduct studies using representative case selection techniques. This will increase generality rather than plausibility and increase the nature of knowledge across various empirical settings. Secondly, it would be useful to compare the results reported in this thesis with investigations of other platform owners' (e.g., Android platform and Windows Mobile platform) attempts to govern and strategize platforms through platform boundary resources. Thirdly, another direction for future work would be to engage in theory-testing research for creating variance theories about this topic. These studies could adopt a variance perspective that would develop a causal model for testing different perspectives reported in this thesis. Finally, this thesis investigated the role of platform boundary resources from the perspective of platform owners, and another direction for future work would be to investigate such roles from the perspective of third-party developers and other core actors in software platforms. Even with these limitations, this thesis offers important contributions to IS and platforms literature. The findings in this thesis highlight the need for more extensive research on platform boundary resources and platform owners' practices to accumulate third-party development.

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