THE CHALLENGES OF DESIGNING DIGITAL SERVICES FOR MULTIPLE MOBILE PLATFORMS

Complete Research

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Abstract

The value of digital services is increasingly recognized by owners of digital platforms. These services have central role in building and sustaining the business of the digital platform. In order to sustain the design of digital services, owners of digital platforms encourage third-party developers to tap into and join the digital ecosystem. However, while there is an emerging literature on designing digital services, little empirical evidence exists about challenges faced by third-party developers while designing digital services, and in particular for multiple mobile platforms. Drawing on a multiple case study of three mobile application development firms from Sweden, Denmark and Norway, we synthesize the digital service design taxonomy to understand the challenges faced by third-party developers. Our study identifies a set of challenges in four different levels: user level, platform level, distribution level and ecosystem level. The identified challenges are then illustrated by different design dimensions. For each challenge, we identified set of factors and classified them under three objectives: business, interaction and technology. In doing this, our research extends and complements existing digital service literature and contributes new knowledge about the design of digital services.

Keywords: Digital services, multiple mobile platforms, design, challenges

1 Introduction

Owners of digital platforms increasingly recognize the importance and value of digital services in the form of applications (Eaton et al. 2015; Ghazawneh and Henfridsson 2013; Kim et al. 2010). Digital services have a central role in building and sustaining the business of the digital platform (Evans et al. 2006; Ghazawneh and Henfridsson 2015; Messerschmitt and Szyperski 2003). These services will probably address the heterogeneous needs of users (Adomavicius et al. 2007; Evans et al. 2006), act as an entry barrier for platform competitors, and enable the platform owner to gain distribution and operation benefits, which transforms the business of the platform owner from being a producer of digital services into a distribution channel (Meyer and Seliger, 1998; West and Mace 2010).

In order to sustain the development of digital services, owners of digital platforms encourage third-party developers to tap into and join the digital ecosystem (Baldwin and Clark, 2000; Boudreau, 2010; Ghazawneh and Henfridsson, 2013). In so doing, a multi-sided network is initiated. Value within this network is created through digital services provided by third-party developers (Ghazawneh & Mansour, 2015) and used by different types of users (Evans, 2003; Yoo et al. 2012). The increasing number of third-party developers, digital services and users can be understood through the network effect theory (Uzzi, 1996). Users, for example, prefer platforms crowded with huge number of digital services, while third-party developers prefer platforms full of users.

To motivate and attract third-party developers, owners of digital platforms provide different kinds of technical and social resources that facilitate the development process of digital services (Bergvall-Kåreborn et al., 2010; Ghazawneh and Henfridsson, 2013), establish digital channels in which developers can market and sell their digital services through (Ghazawneh and Henfridsson, 2015), and build a platform environment with healthy network effects (Cusumano, 2010; Eisenmann et al., 2011). Apple's iOS platform, for example, was able to attract more than 272,000 developers, 1.2 million applications and 800 million users (Ghazawneh and Mansour, 2015).

In the last few years, the number of digital platforms has increased dramatically. For example, there are four major platforms in the smart mobile industry: Apple's iOS, Google's Android, Blackberry's OS and Microsoft's Windows Mobile. The diversity in digital platforms creates an opportunity for third-party developers who are willing to tap in and design digital services for multiple mobile platforms (Ghazawneh and Henfridsson, 2013). A recent study by Intel Corporation found that a huge number of third-party developers are designing digital services for at least two major digital platforms and an increasing number of third-party developers design digital services for more than two digital platforms (Boswell, 2013).

A growing body of literature has tackled the subject of digital services in platforms (Barrett et al., 2015; Saarikko, 2015), discussed the digital services evolution (Tiwana and Ramesh, 2001), and the design of digital services (Williams et al., 2008). However, little has been done to understand the challenges faced by third-party developers when designing digital services in platforms. The focus in this paper is therefore on the challenges of designing digital services for multiple digital platforms. Hence, the research question is: *What are the challenges faced by third-party developers when designing digital services for multiple mobile platforms?* In order to address this research question, we embarked a multiple case study of firms based in Sweden, Denmark and Norway.

The paper starts with an overview of related literature and a conceptual discussion on digital platforms, digital ecosystems and digital services. Following that, the research method, case selection, data collection and analysis are described. We later present our findings in four different levels: application level, user level, platform level and ecosystem level. We then present the analysis and discussion of the challenges faced by third-party developers when designing digital for multiple platforms. Finally, the paper illustrates the implications for research and practice as well as outlines key conclusions.

2 Related Literature and Conceptual Basis

2.1 Digital Platforms and Ecosystems

A design, an idea and a pattern are all examples of the concept of platforms. This concept has been thoroughly tackled and discussed by scholars in various research settings (Baldwin and Woodard, 2009). Researchers in the field of 'product development' use the concept 'platform' in product family projects (Gawer, 2009). The concept is used to describe products that are developed to meet the requirements of core customers, while at the same time are easily modified into derivatives (Wheelwright and Clark, 1992). Gawer (2009) discussed the concept of industrial platforms that goes beyond supply chains and enables individuals/firms that are not necessarily part of the supply chain to develop complementary assets. Industrial platforms are often observed in software development (Baldwin and Woodard, 2009; Franke and von Hippel, 2003; Gawer and Cusumano, 2008; Morris and Ferguson, 1993; West, 2003). This type of platform is referred to as "digital platform" and 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).

Each digital platform incorporates digital modules that extend the platform functionality (Baldwin and Clark, 2000, Sanchez and Mahoney, 1996). These modules are digital services (Tiwana et al., 2010) in the form of applications or "apps", which are designed, developed and deployed by third-party developers. These digital services contribute to the innovation of the platform through the reinforcement of networks effects (Katz and Shapiro, 1994), growing the installed base (Selander et al., 2013) and addressing the needs of heterogeneous users (Adomavicius et al. 2007; Evans et al. 2006). The designed digital services will probably enrich the ecosystem that is formed around the digital platform. This digital ecosystem is seen as a functional unit consisting of a set of actors (e.g., platform owner, third-party developers, platform's partners and users) and a set of technology elements (e.g., software platform, boundary resources) that are mutually interdependent (Ghazawneh and Henfridsson, 2011). These different actors are "inter-linked by a common interest in the prosperity of a digital technology for materializing their own product or service innovation" (Selander et al., 2013, p. 184-185).

To facilitate the exchange of digital services between actors on digital ecosystems, the owner of the digital platform set up a digital application marketplace, referred to as appstore (West and Mace, 2010). This marketplace is defined as "a platform component that offers a venue for exchanging applications between developers and end-users belonging to a single or multiple ecosystems" (Ghazawneh and Henfridsson, 2015, p.200). The digital marketplace plays a considerable role in matching third-party developers, who seek to reach out with their digital services, and users to seek to enhance their computing devices with new functionalities in the form of digital services (Müller et al., 2011). In addition, these marketplaces facilitate the transactions of digital services, in terms of service delivery, payments and related trust features (Amberg et al., 2010; Han and Ghose, 2012; Kazan and Damsgaard, 2013).

2.2 The Evolution of Digital Services

Digital services are services that are acquired through a digital transaction such as software modules (Williams et al., 2008). The method of delivery of digital services is based on the use of the Internet-Protocol (IP) aided by technological infrastructure (Tiwana and Ramesh, 2001). Typically, these services involve parallel transactions executed by the digital service providers. These transactions include identifying, negotiating and handling requests of digital service users. The nature of the participants in digital services is classified based on the *provider* and *user* of the service, and classified as: business-to-consumer (B2C) (e.g., Spotify), business-to-business (B2B) (e.g., SAP applications), and consumer-to-consumer (C2C) (e.g., Popcorn Time).

In the last few years, digital services in the form of applications or apps grow dramatically. Following Ghazawneh and Henfridsson (2013), we refer to digital services in mobile platforms as executable pieces of software that are offered as services to the end-users of the platform. These digital services are deployed to extend the functionality of the digital platform (Sanchez and Mahoney, 1996; Baldwin and Clark, 2000). It is becoming increasingly apparent that evolution of digital services is a significant element of innovation and the creation of technology in marketplaces in which these services are exchanged (Ghazawneh and Henfridsson, 2015; Sako 2009; Vargo and Lush 2014). For example, the institutionalization of digital services was a central element in the success of Apple's iPhone and iPad. This progression in refereed to as a "combinatorial evolution" (Arthur, 2009), of the technological development in the form of *platforms*, market innovation in the form of *appstores,* digital service innovation in the form of *applications*, and hardware innovation in the form of *smart devices*.

2.3 Design of Digital Services

The design process of digital services is different from other types of design due to the new available digital infrastructures and associated possibilities (Lyytinen et al., 2004; Williams et al., 2008). This suggests that designing digital services goes beyond software design where third-party developers need specific requirements to design digital services. To understand the science behind the design of digital services, we have adopted Williams et al.'s (2008) design taxonomy as in Figure 1 below.

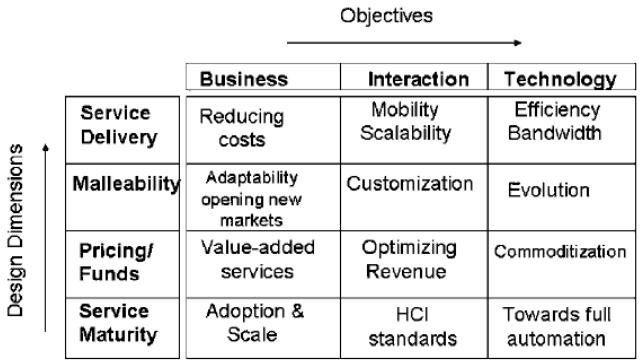

Figure 1. Digital service design taxonomy (Williams et al., 2008)

The taxonomy has four fundamental design dimensions: service delivery, service maturity, malleability (provider and user), and pricing/funding. The *service delivery* describes how the service is provided to the user and the needed requirements from the user to participate in. The *service maturity* considers the different development phases and the required technical skills. The third design dimension, *malleability*, describes the ability of the designed digital service to be malleable to changing market needs and user requirements. The *pricing/funding* dimension considers the value proposition in digital services and the associated different approaches to capture revenues.

The taxonomy derives three service provider objectives: business, interaction and technological objectives. The *business objective* not only concerns the financial side of the digital service but also customer loyalty and brand establishment and marketing. The *interaction objective* concerns interaction design of the digital service and the design for user experience design. The last objective is *technology* which describes the choice of technology and technological components of the digital service.

This taxonomy is seen as a useful tool for third-party developers when designing digital services. It provides them with an overall understanding of the science behind designing digital services. It helps in developing a structured scope to the evaluation factors by the designer of the digital service, and understanding the impact of the business, interaction and technical objectives on the design.

3 Research Method

3.1 Research Context and Case Selection

This research is based on a multiple case study method (Yin 2009) of three mobile application firms from Sweden, Denmark and Norway. A multiple case study method is desirable for theory building, theory testing and descriptive research studies (Benbasat et al. 1987). This method is also powerful for extending a theoretical perspective, conducting cross-case analysis (Eisenhardt, 1989), and yield to more general research results (Benbasat et al. 1987). According to Yin (2009) evidences from multiple case studies are considered more compelling, and therefore the overall study is more robust.

The first case in our research study is *Alpha*, a mobile application firm based in Sweden. The second case is referred to as *Beta* that is based in Denmark, and the third case is *Gamma* a Norwegian mobile application development firm. Table 1 below shows general information about the studied cases. The selection criteria are based on the number of years the firms have been working with mobile application development, the number of developed applications, the number of platforms and the specialization type and the expertise of the third-party developers.

Case	Origin	Headquarter	Founded	Number employees	Platforms	Number of apps	Apps Specialization
Alpha	Sweden	Malmö	2011	12	iOS, Android	5	Entertainment
Beta	Denmark	Copenhagen	2011	19	iOS, Android, Windows Mobile	7	Education & Business
Gamma	Norway	Oslo	2014	8	iOS, Android Windows Mobile	3	Health & Fitness

Table 1. Case Studies

3.2 Data Collection and Analysis

As the study employs a qualitative research approach based on case studies (Yin, 2009), data was collected through interviews, meetings and documentation. The total number of interviews at the three firms was 23. Table 2 below shows a summary of interviews as a primary data source.

Case	Number of Interviews	Informants (# number of interviews)	Description
Alpha	7	Founder & CEO (1), Business developer (1), Senior developers (2), Business manager (1), UX designer (1), Marketing manager (1)	All interviews were: • Face-to-Face. • Semi-structured. • Average time: 80 minutes. • Recorded. • Transcribed. • Verified.
Beta	10	Founder & CEO (1), Marketing manager (1), Senior developers (4), System analyst (1), Business manager (1), UX designer (1).	
Gamma	6	Founder & CEO (1), Business analyst (1), Senior developers (1), Business manager (1), UX designer (1), Marketing manager (1)	

Table 2. Summary of Data Sources (Interviews)

The data analysis followed the inductive analysis approach (Strauss and Corbin, 1990). In so doing, the current state of affairs was understood without necessarily forcing the researchers' preconceptions on data while maintaining scientific integrity (Eisenhardt 1989). This was followed by establishing relations between codes and a detailed image of the current challenges faced while designing digital

services by third-party developers. After that, the focus was on unfolding events of the cases chronologically (Langley 1999), while understanding how each firm dealt with different challenges (Kirsch 1996). The last stage was based on analyzing through the views of third-party developers, how the challenges were understood and dealt with from a design capability perspective.

4 Results

User Level

Fragmentation of Users: There is a significant fragmentation of users in a particular platform and across multiple mobile platforms. The huge number and variety of users in digital platforms create a design challenge. Consequently, third-party developers have to cater to a variety of these users. Our findings revealed several factors that affect the fragmentation of users across multiple mobile platforms. A senior developer at Alpha discussed the aspects of *age* and *location* of users:

> *We are designing apps for users of different ages and it's hard. Let me tell you a fact; users of iOS platform are slightly younger than users of Android……We are facing another issue here; users are distributed among different countries and continents, it's hard when you design the same service for example for users from Sweden, South Africa or Honduras.*

Another important demographic factor that is discussed by most of our participants is users' *buying power*. Users of particular platform have more average household income than users of other platforms. A marketing manager at Beta emphasized:

> *Apple's iOS users are richer than all other users. They spend more money on apps, they download more … Android is for poor users, it's not a joke, there are a lot of statistics and studies about this.*

Engagement and *propensity* of users are crucial factors when designing digital services for multiple mobile platforms. Users engage differently in digital platforms. Users of particular platforms are more engaged in content than other platform users and the number of engaged users differs from one platform to another. Our findings revealed that this is a dilemma for third-party developers. A business analyst at Gamma stated:

> *Android has a greater number of users of content while iOS users are more engaged in content. For us, this is a challenge. We ask ourselves a question, do we need a higher number of users or more engaged users in our service.*

Platform *satisfaction* and *loyalty* are differentiating factors that third-party developers should consider since they determine market share of the designed digital service. Users of particular platforms are more highly satisfied and loyal to their platform than others. A senior developer at Beta explained:

> *Do we want to design an app with flash sales for a couple of days, or we want continuous app sales over time with happy and loyal users. To answer this question a lot of things have to be taken into consideration. You can't make sure that you will have loyal users for both iOS and Android at the same time. There is a lot of hard work and lot of luck maybe.*

User experience: There are two types of users across digital platforms: *normal* and *enterprise* users. Normal users use digital services for personal and entertainment purposes. Enterprise users use digital services in the workplace, to assist their organization in solving enterprise problems and carry out daily tasks. Third-party developers face a major challenge designing digital services for different types of users across multiple mobile platforms. This challenge has been *user experience*. Third-party developers design digital services without realizing that there are vastly different behaviours and user interaction among both normal and enterprise users. A UX designer at Alpha explained:

> *When we have an application with low adoption and usage we ought to think it's about our marketing strategy. In most cases, we were wrong. It's about user experience…… We have hard job understanding user behaviour and the way they interact with their screens, with the platform, with their device. We can't treat a mobile device or a tablet PC as just another screen…… Technology is changing and so users.*

Platform Level

Fragmentation of Operating Systems: There is a significant amount of fragmentation of operating systems in digital platforms. Consequently, third-party developers face a challenge to design digital services that work across different operating systems that are circulated across multiple mobile platforms. Our informants agree that the *type* and the *version* of the operating systems are two major factors to consider when designing digital services. A senior developer at Alpha noted:

> *We can't close our eyes, develop and design apps, we have to consider the OS. For example, currently there are ten different versions of Android in circulations among users in their devices. This is a major challenge faced by all developers while we design, deploy and test apps.*

Fragmentation of Boundary Resources: Owners of digital platforms supply third-party developers with variety of resources that help access particular functions in platforms. There are two types of boundary resources: technical resources, such as APIs, and social resources, such as platform documentation. The availability of a specific boundary resource in a particular platform and not others create a challenge for third-party developers designing digital services for multiple mobile platforms. A system analyst at Beta explained:

> *Simply, without an API there is no app. If Apple isn't giving us the API to access particular censors in the iPhone we can't design an app that communicates with that censor. Apple is very popular in realising APIs based on their strategies and not ours. This means, you might have a great idea for an app but you can't design it for iOS, while at the same time if the API is available in Android we can design it. Simple, in such situations we are stuck.*

Types of Development Technology: Third-party developers are required to choose a development technology when designing digital services. There are three types of technologies across platforms: native, hybrid and HTML5. Choosing a particular technology is a challenge for third-party developers. Our findings revealed that there are four main aspects to be considered when choosing a development technology: budget, skills, time-to-market and portability across platforms. Table 3 below illustrated the four aspects at various levels based on the development technology.

Type	Definition	Platform	Budget	Skills	Time-to-market
Native	Specific to a single platform and using its associated development tools.	Single	High	Advance	Long
HTML5	Uses standard web technologies such as HTML, JavaScript and CSS.	Multiple	Low	Basic	Short
Hybrid	Combination of HTML5 and native technology.	Multiple	Average	Intermediate	Intermediate

Table 3. Types of Development Technology Across Digital Platforms

Security: Security around digital services is a major issue for third-party developers. Each digital platform has its own security *regulations* and *standards*. The ability to access information via digital services can bring great value to users, but a lot of third-party developers are concerned of this information being misused. This creates a challenge for third-party developers when designing digital

services that work across multiple mobile platforms and adapt different security regulations and standards.
Third-party developers are concerned that if digital services are improbably designed because of security issues, this can lead to a poor user experience and inappropriate adoption by users. A manager at Gamma explained:

> *The iOS platform is very secure and they have a strict review process of our apps. Android is less secured and there are a lot of security holes and loose review process. Designing for both iOS and Android at the same time with such different levels of security is a nightmare especially for us working in enterprise apps*

Distribution Level

Marketing: The marketing of digital services is an essential element of the design process. Third-party developers are facing a hard time marketing their digital services across multiple mobile platforms. There are several factors that make marketing hard for third-party developers while taking their digital services to the digital marketplaces. Our findings revealed that one of the main factors is *increasing competition.* The number of designed digital services across multiple mobile platforms is dramatically increasing with no signs of slowing down. Not only will there be more third-party developers but more resources that help them design competitive digital services. A marketing manager at Beta added:

> *Marketing an app is the hardest. Planning our marketing and setting the strategy starts with day one, when we have the app idea… … This is why it's embedded into the design process. We can spend a lot of ads money into an app that isn't designed probably based on user needs… … And when you are marketing to two or three different platforms this is even harder and harder.*

The other factor that is illustrated by most of our informants is marketing format. There is a shift of direction of advertising in digital platforms and advertising formats. The new marketing format becomes part of the design of digital services. This requires third-party developers to design their digital services in accordance with the platform's particular marketing format. For example, iAD is the mobile advertising platform for the iOS platform, and AdMob is Android's advertising platform. A marketing manager at Alpha explained:

> *We have to design our app in a way that works with the platform ad format… … We have to design an app that is flexible to work across different ad formats in different platforms… … Sometimes we can use external ad format but this doesn't work always across all platforms that we design our apps to.*

Transparency: Distribution of digital services is handled through digital application marketplaces or so called "Appstores". These distribution channels serve all different stakeholders of the digital ecosystem. They provide third-party developers with resources to host, deploy and market their digital services. Yet, they apply a review process to ensure that the submitted digital services are reliable, secure and free of copyrighted and offensive material. Our data revealed that third-party developers design digital services in accordance to the "review guidelines", however, these guidelines are not transparent enough and they differ from one digital platform to another. A senior developer at Gamma clarifies:

> *We read the all guidelines from appstores. We design our apps to meet their points and we end up having our app rejected from one appstore and accepted from the other store. It's not fun at all. Each one of those platforms they have their own agenda that affect us.*

Pricing: There are three dominant pricing strategies for digital applications: fermium, premium and subscription. Fermium digital services are provided to the users free of charge. However, some features inside the digital service might be unavailable until the user pay for them. Contrast this with premium, where the user has to pay in advance before they can download and user the digital service.

Other digital services are usually subscription-based where it overall with either fermium or premium pricing strategies. The pricing model is one of the main factors that third-party developers have to deal with while designing digital services. For example, a user might find a digital service free of charge in a particular digital platform while paid on another digital platform. A business manager at Alpha explained:

> *One app we have is free for Android users and paid for iOS users. It's the same app, we designed it differently to accommodate variety of users in those two mobile platforms. In Android, we run ads inside the app so this how we make money. In iOS, its not free, it costs users 1,99 USD and we run no ads on this version.*

Ecosystem Level

Fragmentation of Devices: The amount of fragmentation of devices across multiple mobile platforms is huge. For example, the four major digital platforms has the following number of devices associated to their ecosystem: Apple's iOS (23 devices), Google's Android (8,580+ devices), Blackberry's OS (33
devices) and Microsoft's Windows Mobile (132 devices). Consequently, third-party developers have to deal with a variety of these devices while designing digital services. Our findings revealed that one of the main factors of this challenge is designing *several versions* of the digital service to work in different devices across multiple mobile platforms. A senior developer at Gamma clarified:

> *The number of mobile and tablet devices is increasing in a daily base. This force us in a way or another to design multiple versions of our apps so they can work on at least the newest devices on the market and we cover as many users as we can.*

This requires developers to *test* their digital services in accordance with different: (1) screen sizes, (2) device hardware (processor and memory) and (3) network connectivity (offline/ Wi-Fi/ 3G/ 4G) as a business developer from Alpha pointed out:

> *Simply, it's a hassle, working for multiple mobile platforms. You have to make sure that what works on the newsiest iPhone works on the oldest Samsung device or HTC. When we were studying at the university we learnt that we have to work to come up with the greatest user experience. I feel in the mobile world this is a great challenge.*

Fragmentation of Technology Partners: Third-party developers rely on a series of technology partners when designing digital services. There are four main services that are provided by technology partners: advertising, messaging, payment and analytics. The fragmentation of technology partners and their services across multiple mobile platforms create a challenge for third-party developers.

Advertising network is a technology partner that connects third-party developers (publishers) to advertisers. The technology partner will aggregate ad spaces supply and match it with the demand. These networks provide technologies that should be integrated to the digital service. Third-party developers encounter a challenge when designing ad-based digital services for multiple mobile platforms. A marketing manager from Alpha explained:

> *Some ad networks work in one specific platform, others work with two platforms. When we design our apps we have to choose which network we will be using and the integration strategy. We also think about profitability and we have to decide at the end.*

Messaging partner integrates digital services to SMS, MMS and Emails gateway and allow users to send messages through the digital service. A popular messaging partner is Ericsson. Dealing with a lot of messaging partners that use distributed infrastructure require third-party developers to adjust their strategy when designing digital services for multiple mobile platforms. *A payment partner* is another

technology that aims at integrating payment services to digital services. This will facilitate the transactions that take place inside the digital service and manage all backend processes. Our findings revealed that third-party developers are concerned about the payment partner as senior developer from Alpha mentioned:

> *When you integrate services like Paypal, GSI Commerce, MBlox or others you need a clear plan. These are external providers. You might ask which is better for what platform, external payment gateways of platform-based gateways. All matter from integration, easiness or strategy perceptive.*

Analytics partners provide statistics on digital service usage, users' usage, advertisement usage, page views, and interactions. Third-party developers face the same challenge as in "payment partners". Choosing between different external partners or platform based partner while designing digital services for multiple mobile platforms. A senior system architect from Gamma noted:

> *Sometime the external analytics tools are extremely better than those provided by the platform.*

5 Discussion

Providers of digital services face challenges when designing services for multiple platforms. Here, we develop an empirical based understanding of a set of challenges at four different levels: user level, platform level, distribution level and ecosystem level. The identified challenges are then illustrated by design dimensions based on the digital service design taxonomy (Williams et al., 2008). Also, we identified a set of factors for each challenge. These factors are then classified under the three service provider objectives provided by the taxonomy: business, interaction and technology factors.

<table>
<tr><th rowspan="2">Level</th><th rowspan="2">Design Dimensions</th><th rowspan="2">Challenges</th><th colspan="3">Factors</th></tr>
<tr><th>Business Factors</th><th>Interaction Factors</th><th>Technology Factors</th></tr>
<tr><td rowspan="5">User Level</td><td rowspan="5">Malleability</td><td rowspan="4">Fragmentation of Users</td><td>Buying power</td><td>Engagement</td><td rowspan="4">N/A</td></tr>
<tr><td>Loyalty</td><td>Location</td></tr>
<tr><td>Propensity</td><td rowspan="2">Age</td></tr>
<tr><td>Satisfaction</td></tr>
<tr><td>User Experience</td><td rowspan="2">N/A</td><td>Normal users</td><td rowspan="2">N/A</td></tr>
<tr><td rowspan="5">Platform Level</td><td rowspan="5">Service Maturity</td><td rowspan="2">Fragmentation of Operating Systems</td><td rowspan="2">N/A</td><td rowspan="2">N/A</td><td>Type of OS</td></tr>
<tr><td>Version of OS</td></tr>
<tr><td>Fragmentation of Boundary Resources</td><td>Social boundary resources</td><td>N/A</td><td>Technical boundary resources</td></tr>
<tr><td rowspan="3">Types of Development Technology</td><td rowspan="3">N/A</td><td rowspan="3">N/A</td><td>Native</td></tr>
<tr><td>Hybrid</td></tr>
<tr><td>HTML5</td></tr>
<tr><td>Security</td><td>N/A</td><td>Regulations</td><td>Standards</td></tr>
<tr><td></td><td></td><td></td><td>Marketing</td><td></td><td></td></tr>
</table>

Distribution Level	Service Delivery	Marketing	format	N/A	N/A
			Increasing competition		
		Transparency	N/A	Review process	N/A
	Pricing/ Funding	Pricing	Revenue streams	N/A	N/A
Ecosystem Level	Service Maturity	Fragmentation of Devices	N/A	Several versions	Testing
		Fragmentation of Technology partners	Payment partners	N/A	Analytics
			Ad networks		Messaging partners

Table 4. Challenges of Designing Digital Services for Multiple mobile platforms

User Level: Malleability

Digital services are required to have the ability to be able to adapt to changing user requirements and needs. They have to be malleable enough to cope with the changing market (Williams et al., 2008). Third-party developers face two main challenges while designing digital services, and at the same time, maintaining a desirable quality to meet user needs across multiple mobile platforms. The first challenge is the *fragmentation of users* where there are a huge number and variety of users across multiple mobile platforms that third-party developers have to deal with. There are four main factors that affect the business objective of the design dimension of malleability: buying power, loyalty, propensity and satisfaction of users. These factors determine building a successful business around the designed digital service. The other essential objective of the service provider is the interaction objective. At the user level, two factors are identified of the interaction between the provider of the digital service and the users, which are engagement and age and location. Non-technology factors are identified associated with the fragmentation of users challenge.

The second challenge is the *user experience* where third-party developers have to deal with different attitudes and aspects of users across multiple mobile platforms. There are two main factors that affect the interaction objective: normal users and enterprise users. This determines the practical, experiential and affective aspects of fundamental service provider objective. No business factors or technology factors are found associated with the user experience challenge.

Platform Level: Service Maturity

Service maturity in digital service design considers the different development phases and the required technical skills (Williams et al., 2008), where the interaction between service designers and service users change based on the used technologies in digital service design. Third-party developers face four main challenges at a platform level: fragmentation of operating systems, fragmentation of boundary resources, types of development technology and security challenges. The first challenge, *fragmentation of operating systems,* deals with two technology factors: the type of the operating system used by the user of the digital service and the version of that operating system. These two factors determine the service maturity based on the backend that is supposed to operate the digital service.

The second challenge is the *fragmentation of boundary resources*. The availability of boundary resources determines how a digital service to be designed. The two types of boundary resources are identified under the technology and business design objectives. The social boundary resources are seen

as business factor that determines the relation between the provider of the digital service and the owner of the digital platform. The technical boundary resources are seen as a technical factor that determines the relation between the platform itself and the provider of the digital service. The third challenge of this level is the *types of development technology.* While designing digital services, third-party developers, have to decide the technology type(s) of their digital services. Native, hybrid and HTML5 are three service provider objectives. They describe the choice of technology and technological components of the digital service. The last challenge at this level is *security*. It has a technology factor that deals with the security standards and how these standards are integrated into the design of digital services. It has also an interaction factor that deals with regulations of the digital service.

Distribution Level: Service Delivery & Pricing

The distribution level constitutes of two design dimensions: service delivery and pricing. Service delivery is a design dimension that describes how the digital service is provided to users (Williams et al., 2008). There are two challenges associated with service delivery at the distribution level. The first challenge is *marketing*, where third-party developers need to determine which marketing format will be adopted for their digital service across multiple mobile platforms. The other factor is the competition between service providers that makes it challenging to distribute the services across multiple mobile platforms. Both factors (marketing format, competition) are business objectives of the service provider. The second challenge is *transparency*. This challenge handles the process in which digital services are reviewed by owners of digital platforms. It is referred to as the review process, and is seen as a business objective of the service provider as it determines if the digital service will be made available for users or not. The second design dimension at the distribution level is pricing. The main challenge that third-party developers face is in their ability to determine their pricing model and revenues streams across multiple mobile platforms.

Ecosystem Level: Service Maturity

The ecosystem level is the holistic level that is associated with different stakeholders and entities of the digital ecosystem. Similar to the platform level, service maturity is a design dimension at the ecosystem level that considers the different development phases and the required technical skills (Williams et al., 2008). There are two challenges associated with service maturity at the ecosystem level. The first challenge is the *fragmentation of devices*, that is, there are many devices across multiple mobile platforms that third-party envelopers have to take into consideration when designing digital services. The huge amount of devices is seen as an interaction objective of the service provider, while the other objective is the "testing" of digital services across devices and is considered as a technical objective.

The second challenge at the ecosystem level is the *fragmentation of technology partners.* There are four different factors associated with this challenge. Two of those factors are seen as business objectives: payment partners and ad networks, while the other two factors are technology objectives: analytics and messaging partners.

6 Implications and Conclusions

There are a number of implications of our research. First, our perspective on digital services complements the literature on digital service innovation (Barrett et al., 2015; Lyytinen et al., 2004; Williams et al., 2008) and extends the literature on digital platforms (Tiwana et al. 2010; West 2003). Second, our research provides a new perspective on digital services agenda need for mobile platforms and ecosystems. Our study shows challenges at different levels that can be faced by service providers when designing digital services for multiple mobile platforms. Third, the results of our study suggest that owners of mobile platforms need to advise providers of digital services while tapping into their digital ecosystems. Finally, we contribute into the on-going research stream in digital innovation (Eaton et al. 2011; Henfridsson et al. 2009; Yoo et al. 2010) by illustrating the challenges faced by

third-party developers when designing digital services for multiple mobile platforms, which is for future studies of the dynamics of digital services.

In this paper, the design of a digital service perspective (Barrett et al., 2015; Lyytinen et al., 2004; Williams et al., 2008) was synthesized to study the challenges faced by third-party developers while designing digital services for multiple mobile platforms (Ghazawneh and Henfridsson 2013; Tiwana et al. 2010; West 2003). We identified a set of challenges in four different levels: user level, platform level, distribution level and ecosystem level. The implications of the challenges found at the *User Level* can be used by third-party developers to study the *Fragmentation of Users*. This has to be done by communicating the appropriate digital service to the right users. In addition, third-party developers have to study the *User Experience* among every mobile platform they target regardless of the idea behind their digital service. The implications of the challenges at the *Platform Level* suggests that third-party developers have to conduct analysis for technology they are to use (*Types of Development Technology*), the host environment (*Fragmentation of Operating Systems*), the available resources (*Fragmentation of Boundary Resources*) and the all associated regulations and standards (*Security*). All these challenges have to be taken into consideration, as they are diverse across multiple mobile platforms. At the *Distribution Level,* there are two essential challenges that determine the success of delivering any digital service across multiple mobile platforms: *Marketing, Transparency and Pricing*. Third-party developers have to extensively work on using the different marketing channels and strategies for each mobile platform, using the appropriate transparency measurements and base their pricing on proved studies and statistical facts. Last, at the *Ecosystem Level*, third-party developers have to be aware of the number and properties of the devices they develop their digital services to (*Fragmentation of Devices*) and choose their technology partners based on the type and quality of services they provide across multiple mobile platforms.

Future studies could address several limitations to out work. It would be useful to study how third-party developers face the challenges and what actions are taken to overcome them. Another direction for future work would be to investigate decision-making process that is adopted by third-party developers when designing digital services for single or multiple mobile platforms.

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