EXPLORING TECHNOLOGY DESIGN ISSUES IN BUSINESS MODELS FOR MOBILE WEB SERVICES

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ABSTRACT

As IP-based, 3G+ mobile networks are increasingly becoming available, attention in research is shifting towards middleware and service platform related issues (Killström et al., 2006; Popescu-Zeletina et al., 2003). At the same time, web services technology and underlying service oriented architecture have enhanced flexibility and interoperability in service development in the fixed Internet world. Therefore, a logical next step in making mobile services deployment easier, faster and more efficient would be applying web services technology to the mobile domain, i.e. mobile web services (MWS) (Pashtan, 2005).

We see main opportunities for MWS in providing generic service elements like charging, authentication, authorization, accounting, context information, and billing. As such, the technology would compete with IP Multimedia Subsystem (IMS), a standard originating from the telecommunications domain. While IMS strengthens the current strategic position of operators, MWS can be offered by any business actor and may therefore be used by content and service providers to disrupt the current industry structure.

The business model for MWS is not yet clear, as it is still immature technology. The present paper aims to contribute to business model development for MWS, by exploring critical design issues in the technology domain of these business models. In doing so, we extent on and specify earlier work on business models for mobile data services in general (De Reuver et al., 2006; Haaker et al., 2006). We propose that critical design issues in MWS business models include overcoming constraints and limitations of mobile devices and networks; using the SIM card model or web services based mechanisms for user authentication; management of user profiles; security; billing and charging; the technical architecture; the server-client model; and the role division regarding authentication, security, management of user profiles, and billing/charging provisioning. In a small-scale survey among 29 experts from academia and industry, we find support for most of these design issues.

INTRODUCTION

As mobile operators are faced with decreasing profitability in the almost saturated voice market (van Veen, 2006), mobile data services are an essential next step to increase revenue per user, reduce churn, and differentiate from competitors (Jenkins, 2004). Today, IP-based, 3G+ mobile networks are almost rolled out, and the bottleneck for deploying data services is shifting towards middleware and service platform related issues (Killström et al., 2006; Popescu-Zeletina et al., 2003). Opportunities for new approaches to service development are provided by increased intelligence in mobile devices, e.g., Java 2 Platform Micro Edition.

At the same time, web services technology and underlying service oriented architecture have enhanced flexibility and interoperability in service development in the fixed Internet world. Joint efforts of companies (e.g., IBM, Sun, and Microsoft) and organizations (e.g., W3C, OASIS, and OMA) in the IT world have resulted in a stack of XML-based Web services standards (e.g., SOAP, UDDI, WSDL, WSFL), based on principles of interoperability and standardization. As a result, Web services can combine heterogeneous services from different providers and make them appear as one integrated business function.

Given the current challenges in the mobile domain, a logical next step to make mobile data services deployment easier, faster and more efficient would be applying web services technology, i.e. *mobile web services* (MWS) (Pashtan, 2005). While MWS may be used for providing content services to end users, we see main opportunities in bundling new and existing services (Farley & Capp, 2005), and in delivering generic service elements. Generic service elements based on MWS could be charging, authentication, authorization, accounting, security, context information, and billing.

Interestingly, exactly these types of functionalities are also provided by another technology: IP Multimedia Subsystem (IMS), a standard coming from the telecommunications industry (3GPP, IETF) (Camarillo & Garcia-Martin, 2006; Cuevas et al., 2006; UMTS Forum, 2003). The choice between IMS and MWS is not merely technical, but may have considerable impact on the interdependencies between actors in the mobile industry. As IMS is implemented at the mobile operator's core network, content providers will have to negotiate and adhere to operator requirements for using the functionalities. As a result, operators retain control over end users and their privileged position is strengthened. In contrast to that, MWS can in principal be hosted by any party, enabling third parties to take over operator roles such as billing, authentication, and context information provisioning. In an extreme scenario, this could mean operators are reduced to merely connectivity providers. From a broader perspective, the differences between IMS and MWS could be seen as the traditional clash between the open Internet world and the more closed telecommunications sector.

Considering that MWS may disrupt the current business logic in the mobile domain, the question comes up what types of business models could be based on MWS. As MWS is still in a premature stage, many issues still need to be taken relating to technology. Therefore, the aim of this paper is to explore what technology related design issues are currently most critical in MWS based business models.

First, we explain what we mean with the term business model and critical design issues. Then, we explore the design issues in business models for MWS, based on literature survey. While discussing these issues, we will present feedback we received from a small-scale web-based survey among 29 experts in industry, consultancy and academia.

BUSINESS MODELS

As discussed in the previous section, MWS may have the potential to disrupt the current way of doing business in the mobile data services industry. However, the value creating logic enabled by MWS remains obscure. The business model construct is useful to explore this area, as they are a means to explicate the logic to create and capture value from technological innovation (Chesbrough & Rosenbloom, 2002).

While we are aware of the many discussions devoted to defining business models, we adopt the definition from Chesbrough and Rosenbloom (2002) here: *"a blueprint that describes how a network of organizations cooperates in creating and capturing value from new, innovative services or products"*. In terms of the components that comprise business models, we distinguish four domains (Faber et al., 2003):

- <u>*Service*</u>: description of the value proposition and market segment at which the offering is targeted.
- <u>*Technology*</u>: description of the technical functionality required to realize the service offering.
- <u>*Organization*</u>: description of the multi-actor value network required to create and distribute the service offering, and the focal firm's position within this value network.

- *Finance*: description of the way a value network intends to capture monetary value from a particular service offering and how risks, investments and revenues are divided over the different actors of a value network.

Currently MWS based business models are not at a mature stage yet. Accordingly, the business models based upon them are in the first stages of their business model life cycle (Bouwman & MacInnes, 2006). Typical for this initial phase is that there are still many unresolved questions about performance and changes and improvements may be admitted, so the business model depicted in this phase may not be the definitive one. Moreover, especially technology related design choices that impact the viability of the business model in the long run are essential in this phase. Therefore, in terms of Faber et al. (2003), this paper focuses on the technology domain for business modes based on MWS.

We are interested which design issues in MWS business models are still undecided in this phase, which at the same time are likely to have a high impact on the viability of these business models. We define such design choices as `critical design issues' (CDI) (Haaker et al., 2006). After exploring CDIs, next steps for future research would theoretically be linking them to critical success factors and ultimately to customer and network value (Haaker et al., 2006).

EXPLORING DESIGN ISSUES FOR MWS

Adopting web services technology in the mobile services domain is not a trivial issue as it may seem. Besides generic constraints and limitations of mobile devices and networks compared to fixed networks, other issues on the edge of business and technology are involved. This section explores possible design issues in MWS business models, based on an extensive literature review on (mobile) web services and mobile business.

To get an idea of the relevance of the design issues we identify, feedback was asked from 29 experts in a web-based survey. To get an idea of the general vision of respondents on MWS and IMS, we asked them first whether they expected the technologies to take off within their company (or in the market when asking experts), see Figure 1. Clearly, respondents were not too enthusiastic on IMS as 24% expected that it would never be used. Respondents were mixed in their response on MWS: 24% said that companies would probably already use the technology, while 41% expected it to be used later than next year. Importantly, some respondents commented they were unsure, as the question was too technical for them or as they were unaware of the exact timelines.

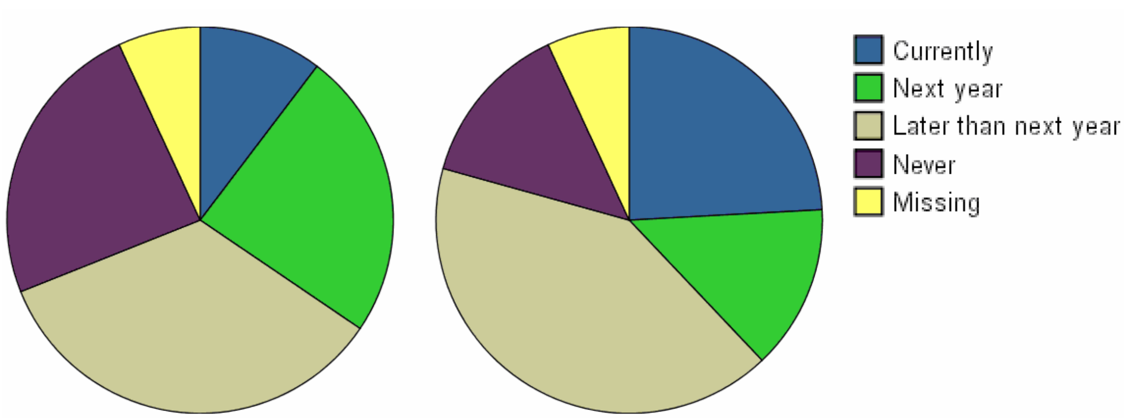

Figure 1: Expected adoption period of IMS (left) and MWS (right), N=29

New web services standards for overcoming mobile specific constraints and limitations

Compared to desktop computers, mobile devices have limited CPU processing power, smaller memory, limited battery capacity, and smaller storage capacities (Berger et al., 2003). Another issue is that the user interface with small screen and keyboard complicates filling in forms, which impacts the usability of MWS (Farley & Capp, 2005). And as bandwidth is still smaller and more expensive in mobile networks than in the fixed Internet, limited data rates are another issue to take care of. Considering that web services technology was designed to run over powerful desktops and servers and to communicate via wired networks (Limbu et al., 2004), this poses performance issues on MWS. An example of these issues are processing XML and SOAP messages, which requires higher processing power compared to HTML messages (Limbu et al., 2004). In addition, XML messages generate a larger overhead than HTML pages as it can reach up to 5 times the size of a content message (Tian et al., 2004). In case bandwidth is indeed limited, or if the user is charged per packet of transmitted data, this may well become a constraining issue.

Although we agree that part of these issues may become less constraining as technology advances, MWS today have to be designed aiming to limit their usage of computation, memory and energy resources (Berger et al., 2003). Several solutions to solve the problem of XML processing and transmission in MWS have been proposed in literature, including faster parsers, data compression, protocol optimizations, reducing the number of SOAP messages exchanges, reducing the size of the messages by removing all unnecessary information from the messages, and translating the plain text XML messages to binary coding (Limbu et al., 2004). For example, Wireless SOAP may reduce the size of SOAP messages by 3-12 times, but at the costs of requiring even higher processing power at the user device, increased server response times and threats to interoperability (Srirama et al., 2006). More advanced compression approaches have been proposed, e.g. the dynamic compression approach by Tian et al (2004) who recommend including the need for compression as a quality of service requirement in MWS standards.

While these solutions serve as illustrations rather than an extensive list, the general trade-off we see is to develop industry-wide, open protocols to solve these issues versus developing own, proprietary solutions.

Authentication

By definition, a difference between a mobile and a wireline device is the portability and the mobility of the device, i.e. a mobile device can move to another location. In case the mobile device is moved, it may well be that users move out of the proximity of a network access point, disrupting the network connectivity temporarily, or, when moving to another network, changing their IP address. Disrupted communication between the mobile device and the remote server is also more likely in the mobile context as mobile networks are more vulnerable to link outages (Pilioura et al., 2003). Because messages in web services technology are exchanged asynchronously, this can lead to errors in the communication. In case of disrupted communication, either due to link outages, changing IP addresses or unavailable network coverage, re-execution of messages when communication is restored is a key issue to consider. Especially for sensitive applications such as mobile payment, one can imagine that erroneous re-execution may generate large unwanted effects (Berger et al., 2003).

Traditionally, authentication of moving devices has been supported by operators using the SIM card model. SIM cards provide information on the user to the network, a secure link between the subscriber account and the operator bill, and allow personalization and localization of services (Microsoft, 2003). However, the SIM card model might not be the ideal solution to the problems above. In addition, for providing location based services, localization via SIM cards is not too accurate as precision is restricted to the user’s current cell. Moreover, its security has been doubted (e.g. Ahmad et al., 2003). And finally, the information given by the SIM cards can only be accessed by operators, creating a potential conflict with content providers that are interested in delivering context aware or personalized applications (Farley & Capp, 2005). Therefore, a design choice here is to keep using the traditional SIM card method for authentication or to search for MWS based alternatives that provide more reliable mobility management and improved possibilities for location based services to content providers. Interestingly, most of our experts in the survey preferred using web services for authentication (mean = 4.93, sd = 1.12, n = 28) over the currently used SIM card model (mean = 3.43, sd = 1.37, n = 28), see Figure 2. However, they also largely agreed that single sign-on technologies should be implemented (mean = 5.36, sd = 1.52, n = 28). This indicates that indeed MWS may have potential for fulfilling authentication services as long as it provides single sign-on functionality.

While operators have traditionally fulfilled the position of authentication provider through their GSM network techniques, MWS open the possibility to authenticate users via a generic web service. Hence, for MWS based business models this role could also be fulfilled by third parties, e.g. ISPs, service providers, or content providers. A design choice is thus whether the authentication provider role is fulfilled by the operator or a third party. The opinion of the experts was very mixed on whether they would choose for having a third party fulfilling the role of authentication provider (mean = 4.37, sd = 1.668, n = 27). This difference in opinions implies that this issue is far from decided yet.

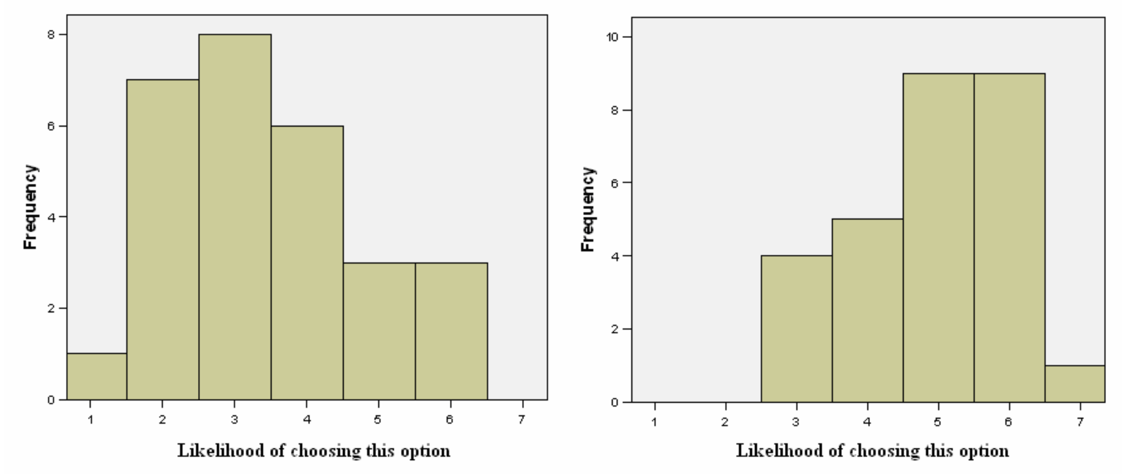

Figure 2: Likelihood of choosing to implement authentication using SIM card model (left) and web services (right)

Management of user profiles

User profiles containing information such as preferences, personal data, interest and context need to be gathered, stored, and maintained. Several approaches to storing user information exist, involving more or less active involvement of the user (Pashtan, 2005). Sometimes, user information is spread among various companies and sharing information among them is not always legally possible (cross-domain profiling) (Ali Eldin, 2006). Most experts in the survey agreed that having a policy on how to share customer information would be important in business models for MWS (mean = 5.39, sd = 1.52, n = 28). Another choice is between automatic user profile generation versus active user involvement. Disagreement was found among our experts in having automatic user profile generation (mean = 4.5, sd = 1.45, n = 28).

Besides, web services be run on mobile devices, so user information can be stored decentrally on the device and can be requested by any service provider. This introduces a design choice between decentralized and centralized storing of user profile information. Among our experts, high disagreement was found regarding whether user profiles should be stored centrally (mean = 4.43, sd = 1.38, n = 28) (i.e. at the service provider) or decentrally (mean = 4.36, sd = 1.56, n = 28) (i.e. at the user device), see Figure 3. This indicates that this is a specifically critical issue, as no common answer has been given on it.

Similar to the authentication role, operators have traditionally fulfilled this position, but web services technology enable third parties to easily deploy similar user profiles, constituting the first trade-off here. Our experts disagreed in the survey regarding the use of a third party to store the user profiles (mean = 4.15, sd = 1.59, n = 27), see Figure 3.

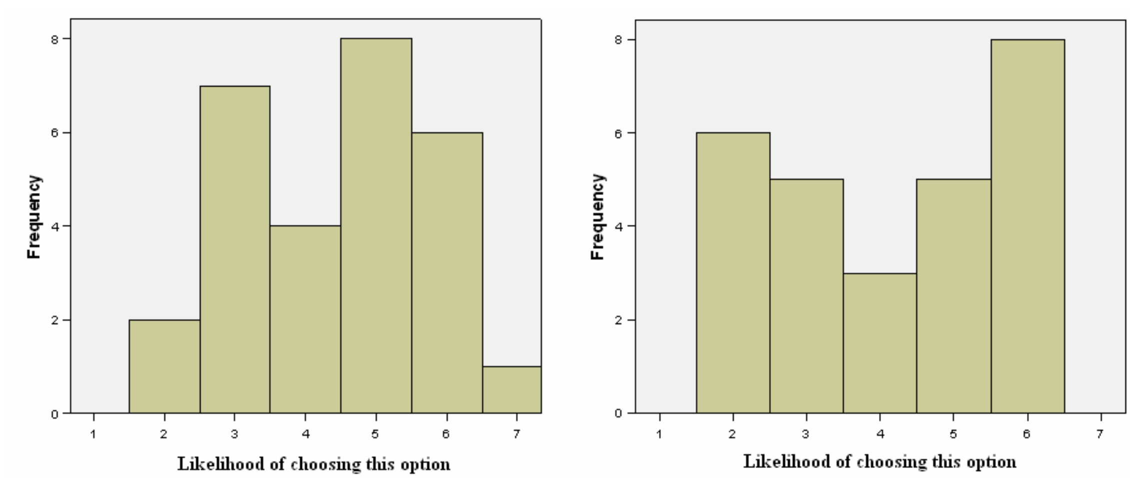

Figure 3: Likelihood of choosing for creating a third party to administer user profiles (left) and centralizing user profiles (right)

Billing and charging

Traditionally, the billing system has been one of the most critical components in the operator's infrastructure. Since the development of MWS and other advanced 3G services, new billing and charging schemas have to be developed to fit their special characteristics, such as pre/post-paid convergence (AtosOrigin, 2006). About advanced billing schemes such as generic billing schemes (mean = 4.86, sd = 1.51, n = 28) and personalized billing (mean = 4.21, sd = 1.45, n = 28), disagreement was found in our survey among experts.

While many operators take their billing role for granted, third parties could deploy billing web services that allow them to take over this role. In this sense, MWS again implies a design choice in the role division. We think that operators will try to struggle to fulfil those positions due to strategic interests. On the other hand, content providers and other third parties may be looking to use MWS to take over the role of billing provider, reducing the revenue shares of operators. When asked about the importance of making decisions on who should bill the end user, most of our experts agreed that this is a critical issue (mean = 5.36, sd = 1.44, n = 28), see Figure 4.

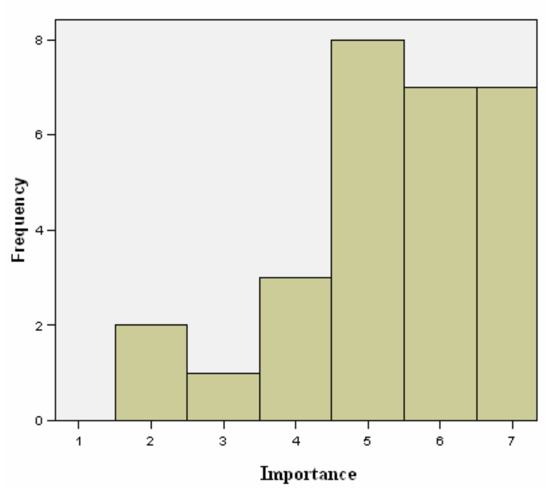

Figure 4: Importance of taking decisions who should bill the end user

Security

Success in the demand of a service offering highly depends on the level of security perceived by consumers. Wireless networks have security issues with respect to over-the-air transmissions and additional gateways between wireless and wired domains. Standard organizations such as 3GPP and IETF deal with those security concerns.

However, the original W3C specification for Web services standards provides no security. That means external mechanisms or standard modifications have to be arranged, and the issue is how to implement these security requirements into MWS technology (Pashtan, 2005). Association between mobile device and user ID has been traditionally implemented by the SIM card model, which is not a very sophisticated system. The design choice is therefore to go for security in web services technology or to opt for more generic network based security. Security based on web services technology was not a solution commonly supported by the respondents (mean = 4.75, sd = 1.50, n = 28, scores ranging from 2 to 7).

Technical architecture

To take full advantage of the potential of MWS, it is relevant to develop an architecture building on standard technologies and protocols (XML, SOAP, UDDI, WSDL) and using Internet transport protocols (HTML, HTTPS, SMTP). A design choice here is to build proprietary solutions, e.g. that of Nokia and Vodafone (Nokia & Sun, 2004) or to go for open solutions, e.g. the Open Mobile Alliance MWS architecture. We expect actors to bet on open solutions, as interoperability may generate value for all of them. Moreover, consumers would not feel attached to a company and they would have access to a wider service offer. However, we could also expect big companies to choose proprietary solutions (especially with regard to the technical architecture), as they already control a big part of the market that they do not want to share. A design choice is thus to choose between open and proprietary architectures for MWS.

Much of the MWS functionality identified such as authentication, billing, and security, are also offered by IMS. Two giants in the industry lead both trends: Nokia leads MWS (Nokia & Sun, 2004) and Ericsson leads IMS (Levenshteyn & Fikouras, 2006). According to North (1990), sometimes competition amongst technologies is based more on the traits of the firms representing the technologies than on the technologies themselves. Therefore, we think both MWS and IMS may be coexisting in the near future, although most operators are nowadays betting on IMS instead of MWS. Hence, interoperability is required to pull down technical barriers that restrict user's access to services and to expand the number of services available.

An important discrepancy is that MWS is based on asynchronous communication, while the IMS domain requires continuous SIP sessions that are not supported yet in most WS applications (Levenshteyn & Fikouras, 2006). While approaches have been proposed to tackle this issue, e.g. gateway mechanisms (Levenshteyn & Fikouras, 2006), a strategic choice remains whether or not to implement and develop these types of interoperability mechanisms between IMS and MWS. If not, MWS will probably have low viability in the end. Interestingly, our experts were moderate about the need for interoperability mechanisms between web services and IMS (mean = 4.82, sd = 1.2, n = 28), see Figure 5.

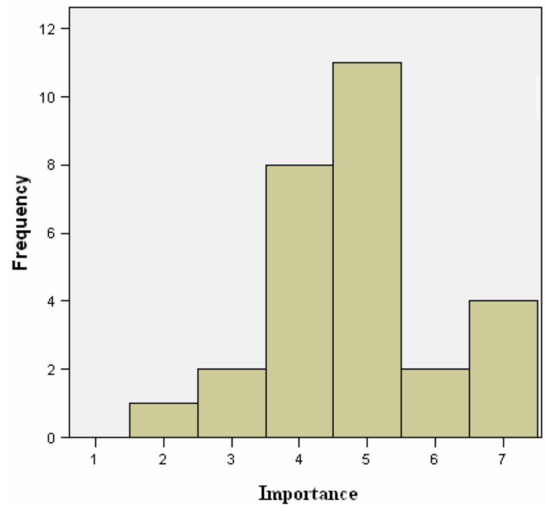

Figure 5: Importance of taking decisions on interoperability between IMS and MWS

Client-server model

According to the service oriented architecture, three main roles need to be played: requestor, provider and broker. In case the mobile device is the service requestor, one can choose between thick or thin client solutions. In thick client solution, the mobile device acts as the service requestor, and a remote web server as the service provider. The mobile client invokes the service from the provider via SOAP messages, and processes the XML messages by itself. Benefits of this approach are that the protocols to implement on the mobile device are readily available to install for handset manufacturers, and that the applications are free to invoke any service from any service provider based on the user's context and preferences (Pilioura et al., 2003). However, there are many challenges to solve for the thick client model such as limited processor power to process the XML messages, limited bandwidth to transmit the large-overhead SOAP messages, limited memory in the mobile device, a limited display, finite battery power, and unavailability of the network necessitating iterations in service discovery (Pilioura et al., 2003).

The *thin client model* eliminates the XML communication with the mobile device by installing a proxy or `personal agent' that represents the mobile device (Cheng et al., 2002; Chu et al., 2004; Pilioura et al., 2003) This proxy server takes care of the XML communication with the service provider and communicates with the mobile device via a traditional WAP gateway using simple HTTP requests and HTML or WML responses (Chu et al., 2004). This eliminates the transmission and processing of the `heavy' XML messages by the mobile device. In addition, the proxy could get tasks as content adaptation, content conversion, bookmark management, cache management and other `housekeeping tasks' (Pilioura et al., 2003). Disadvantages of the thin client approach are that it introduces a single point of failure in the network which makes denial of service attacks easier, introducing security issues (Pilioura et al., 2003). In addition, the proxy becomes a central element in the system, putting the party in charge of the proxy in a dominant position. As Pilioura et al (2003) note, this may well lead to a new situation of walled garden business models. A more technical disadvantage is that the thin client model can lead to unpredictable response times in case of fluctuating data rates (Chu et al., 2004). Hybrid models that are in between of thin and thick clients have also been proposed, for example the smart client model from Chu et al. (2004), which provides dynamic, reconfigurable and adaptive choices between local and external execution of applications.

Besides the traditional client-server models discussed so far, the mobile device can also play the role of service provider. In that case, the mobile device offers the web service to the outside world instead of consuming it. There are roughly two ways to implement an architecture in which the mobile device acts as a service provider. One is to have the mobile device as the party that provides the web service, and the central web server as the receiver, i.e. the provider and requestor roles in the thick and thin client model are reversed (Berger et al., 2003). The advantage of this approach is that it could solve firewall problems, it removes the problems of managing a proxy in the thin client model, and users gain more control over the services they use and the information that they disclose as they have the option to turn off their device (Berger et al., 2003). Berger et al. (2003) mention a large number of applications of this approach. For example, the provider of a content service to the end user could request information stored on the mobile device, such as context information, location information or personal information. Another application they mention is mobile payment, for example a store can request the credit card number from the mobile device when a transaction takes place.

The other approach to having the mobile device providing the service is in mobile ad hoc networks or peer-to-peer networking (Gehlen & Pham, 2004; Srirama et al., 2006). In these networks there is no central server that can provide web services to clients, so the devices themselves have to be both requestors and providers of the web services. Applications include mobile gaming (Gehlen & Pham, 2004), renting content such as songs to other mobile users, or exchanging personal information about the capabilities of the person carrying the mobile device which could be handy in case of an emergency situation (Berger et al., 2003).

There are several issues involved when the mobile device provides the service rather than consuming it. These include that the service has to be tolerant to longer response times and to temporary unavailability as mobile devices might be switched of due to limited power supply and as their connectivity may be disrupted due to the nature of the mobile network (Berger et al., 2003). To take care of changing IP addresses, WSDL files have to be regenerated and UDDI registry has to be updated. However, these updates pose a severe security risk as location updates in the UDDI may be forged (Pilioura et al., 2003). A related issue is that because mobile devices may shut down, the garbage in UDDI registries can be expected to be even higher than with traditional web services (Berger et al., 2003). In addition, trust between devices, installation of new web services on the mobile device and firewalls could be issues hindering this architecture as well (Berger et al., 2003).

So, according to literature, choosing between the mobile device or the service provider to host MWS might be a critical issue. However, our experts hardly agreed on this. Most found it not such a critical issue after all (mean = 3.3, sd = 1.3, n = 28), see Figure 6.

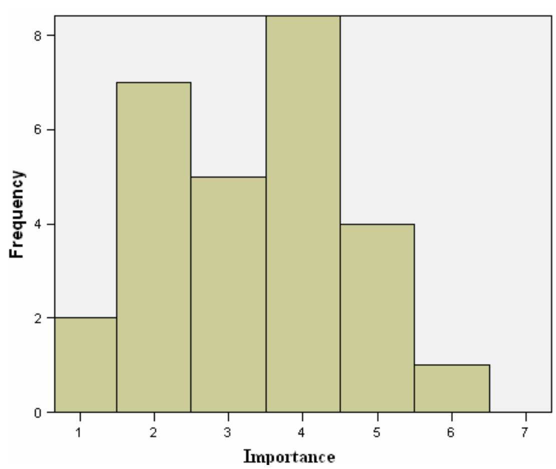

Figure 6: Importance of deciding between the mobile host or service provider hosting MWS

CONCLUSIONS

MWS have the potential of changing the current value networks in the mobile services industry, as they allow service and content providers instead of operators to offer generic service elements such as authentication, security and billing. However, our paper shows that there are a set of technology related critical design issues in the current phase of business models based on MWS that need to be solved before moving on to more mature stages, and really unlocking the value of the technology. These issues include overcoming constraints and limitations of mobile devices and wireless networks; role division regarding authentication, billing, and management of user profiles; choosing between SIM cards or web services based authentication; interoperability mechanisms between IMS and MWS; and the exact scenario of service delivery to be implemented. A summary of the issues is given in Table 1.

Table 1: Technology related critical design issues for MWS based business models

Critical design issue	Main questions	Main trade-offs
Adaptation of web services protocols	How to improve web services protocols in order to overcome constraints and limitations of mobile devices and wireless networks?	Developing proprietary solutions vs. adding new standard protocols to the web services stack
Authentication	Which technology should be used to identify the user's device in a secure and single-sign one approach	SIM card model vs. Web services based authentication Operator as authentication provider vs. third party
Management of user profiles	How to generate user profiles?	User involvement vs. automatic generation
	How to store user profiles?	Centralized vs. decentralized storing
	Who owns and manages the user profiles?	Operator vs. third party owning the information
Security	How to comply with basic security requirements? How to adapt WS protocols to support security?	Web services based security vs. generic mobile network based security
Billing and charging	How to implement a reliable real time billing system?	Prepaid-post-paid convergence vs. separated schemas
	Who should bill end users?	Operator billing entity vs. third party
Technical architecture	How to assure interoperability between IMS and MWS?	WS technologies vs. IMS
	Which technical architecture should be chosen?	Proprietary vs. open solutions
Client-server model	Should be mobile device host or provide web services?	Mobile devices hosting web services vs. traditional client-server model Intelligence in the network vs. intelligence in the device Thick client vs. thin client solutions

LIMITATIONS AND NEXT RESEARCH STEPS

We have to take into account that MWS is a relatively new technology which has a high expectation around but still have not been much implemented. We have to deal with the fact that maybe the industry is not familiarized yet with this technology and may not exactly know what we are referring to. Some respondents indeed commented that they were not exactly sure on the more technical topics.

The present study should be regarded as a first, exploratory step in our research. We used the survey with experts from industry and academics to get first feedback on our ideas rather than as an extensive validation. The results should thus be interpreted with care, especially considering that we had about 30 respondents. In addition, the survey items were developed by ourselves and were not pre-tested, so interpretation may have been an issue and reliability of scales cannot be assured. Next steps in our research are to refine the survey questions based on initial results and comments from respondents and executing with a larger respondent base. Then, we aim to link the design issues to critical success factors, and ultimately to business model performance.

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