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Abstract

Rapid developments in the field of mobile applications, as well as the miniaturization of computing devices, are substantially changing the landscape of organizational computing (Lyytinen and Yoo 2002). Nevertheless, current methods of application development and models for process improvement are not effective for mobile applications development (Baskerville et al. 2002). There is a need to find an approach that does not only facilitate fast cycle time application development in a cost effective way, but also help to reduce risk. This paper proposes that the use of postponement strategies will meet the demands. This paper identifies four postponement strategies for mobile application development: Labeling, Place, Time and Periphery. The choice of strategies is based on a careful examination of previous literature and the nature of mobile application development. Thus, incongruent strategies are identified and excluded. A decision framework is proposed. The framework can be used to assist developers to choose the right postponement strategies, which can then result in a more rapid time to deployment, a reduction in technology risk, and lower operating costs. A case study at the end of the paper endeavors to illustrate the usefulness of the framework.

Keywords: Mobile applications, Mobile application development, Postponement strategies, Framework

1. Introduction

Rapid developments in the field of mobile applications, as well as the miniaturization of computing devices, are substantially changing the landscape of organizational computing (Lyytinen and Yoo 2002). Nevertheless, current methods of application development and models for process improvement are mostly effective for large scale application development (Baskerville et al. 2002). These methods are not suitable for mobile application development, which is often characterized as small scale and fast cycle time application development. As the market is becoming more demanding, there is a growing need of light approaches for application development (Baskerville et al. 2002). Agile methodologies may be useful to facilitate faster development. Speed, however, is not the only concern. Risk of developing mobile application is also an issue, especially when the mobile application market is unpredictable[1]. In view of the lack

[1] Source: Siemens "Mobile Shopping Market Study" URL: http://www.siemens-mobile.de/btob/CDA/presentation/ap_btob_cda_presentation_content/0,2948,59,FF.html

of knowledge in knowing about the market, there is a need to find an approach that does not only facilitate fast cycle time application development in a cost effective way, but also help to reduce risk. This paper proposes that the use of postponement strategies will meet the demands of both.

Postponement strategies, or delayed differentiation, were first proposed in the early 1950s (Alderson 1950; Bucklin 1965). Studies were predominantly material-based (Hoek 1997; Hoek 1999; Brown, Lee et al. 2000; Hoek 2000b; Aviv and Federgruen 2001; Peres and Grenouilleau 2002) and were produced under a static environment. These strategies are based on the theory of risk pooling. This occurs when aggregating demands for many finished goods into a demand for fewer dies. Since the aggregate demand is less uncertain, the firm can hold smaller inventories while providing the same level of service (Brown, Lee et al. 2000). Eppen (1979) has shown that a pooled system cost less than a distributed system. This theory has been widely adopted in areas such as insurance, where to reduce risk is the primary concern. By employing the principle of postponement, it will not only have cost advantages (Zinn and Bowersox 1988) but will also make product proliferation feasible.

The goal of this paper is multi-fold. First of all, major types of postponement strategies found in the literature will be critically reviewed. Strategies that can potentially bring benefits to mobile application developers will be identified. Secondly, since it is useful to know under what conditions certain postponement strategies should play a part, this paper proposes a conceptual decision framework for mobile application developers, based on the literature review and industrial experience. The framework can be used to help developers to choose the right postponement strategies, which can then result in a more rapid time to deployment, a reduction in technology risk, and lower operating costs. Finally, in order to assess the relevance of postponement to mobile application development, a case study is presented.

Following the introduction, section two is an overview of studies on mobile application development, thereby identifying the research challenges. Section three then introduces the postponement strategies. Section four delineates the conceptual decision framework. The case study of a small and medium-sized enterprise (SME) mobile application developer is presented in section five, while section six points out the limitations of the study and makes suggestions for future research.

2. Literature Review

The proliferation of studies on mobile applications has matched the proliferation of mobile applications in recent years.

Mobile application technologies have been evolving so fast that many people are still trying to understand the logical impact of this rapid evolution on the market. For example, Carisson and Walden (2002) tried to explore the business opportunities in a general sense, while Giaglis et al. (2002) went further by pointing out the potential value of applying mobile applications in the indoor environment, such as libraries and museums. Mobile applications seem to be ubiquitous, so it has been an increasing challenge to track customer behavior. Greater attention should therefore be paid to Customer Relationship Management (CRM) as m-commerce takes off (Kushchu 2002). New approaches to CRM may also be needed.

Technology adoption is the most frequently discussed area. While the study by Hung et al. (2002) is based on the theory of planned behavior and innovation diffusion theory, the study by Tung (2002) based its theoretical foundations on SERVQUAL, a model proposed by Parasuraman et al (1988). Both studies assumed that the behavioral intention to use mobile applications was the variable of interest. The context in which the studies were conducted was also diverse (for behavior at work, Beulen and Streng 2002; for WAP, Hung et al. 2002; and for SMS, Tung 2002). A topic that is related to adoption is technology diffusion. Vrechopoulos et al. (2002) identified two critical success factors: business strategies and technological outcomes. One common characteristic of all these studies is that they adopted the same viewpoint, that of the users. Thus, approaches that enable effective management of the supply side have been largely disregarded.

Based on interviews with top management people from the Application Services Providers (ASPs), it seems that ASPs are facing two critical challenges. The first is how to sustain business in a rapidly changing environment. While product proliferation seems to be one possible strategy, the ASPs face a second challenge, which is the integration issue. Hence, studies that tend to treat mobile applications technologies as separate individual components (Wong and Hiew 2002), or that assume developers will collaborate under one m-commerce infrastructure, are not preferred (Munusamy and Hiew 2002). Within the context of the heterogeneous assemblage of technological and social elements, the challenge of product proliferation is obvious. For this reason, the Open Mobile Alliance was established, but some ASPs pointed out that manufacturers were still trying to differentiate themselves by providing incompatible infrastructures or mobile devices.

In fact, few studies have focused on managing mobile application development. In particular, approaches that are both cost efficient and relatively risk free are needed for building fast cycle time applications to meet the unpredictable market. As Information Systems researchers are uniquely positioned to understand how to integrate diverse technological, social, and managerial issues, while managing the nomadic environment[2] (Lyytinen and Yoo 2002), the author endeavors to propose the use of postponement strategies to close the research gap.

3. Postponement Strategies

Postponement is based on the principle of seeking to design products using common platforms, components, or modules, but where the final assembly or customization does not occur until the final market destination and/or customer requirements are known (Christopher, 1998, p. 136). It is an operating concept (Hoek 1998). It was the subject of further research efforts in recent decades as the success stories of Dell and Hewlett-Packard started to attract attention (Edward and Lee 1997; Hoek 1998; Chiou, Wu et al. 2002). The rationale behind postponement strategies is that risk and uncertainty costs can be reduced by the differentiation of goods (Bucklin 1965).

Bucklin (1965) proposed that such differentiation of goods could be classified into three types: form, place, and time. Place and time postponement occur when the organization centralizes its inventories so that total inventories can be reduced and product availability can be improved, while form postponement occurs when the configuration or customization is delayed as long as possible, preferably until purchase orders are received. Zinn and Bowersox (1988) extended the model by developing a normative cost model, which was used to justify five postponement strategies that could be useful. The five strategies were: Labeling, Packaging, Assembly, Manufacturing, and Time. All except the Time postponement strategy were form postponement strategies. This classification was based on the nature of the activities, e.g. the costs of carrying inventory, the processing costs for labeling, transportation costs, or the costs of loss sales. Appendix 1 shows the operational definition for each of the five postponement strategies.

[2] According to Lyytinen and Yoo (2002), a nomadic environment is the heterogeneous assemblage of interconnected technological and social and organizational elements that enable the physical and social mobility of computing and communication services between organizational actors both within and across organizational borders.

3.1 Favorable Conditions

Extensive studies have been conducted to identify the most favorable conditions for implementing postponement strategies. Droge et al. (1995) and Hoek et al. (1998) identified that a strong relationship between Information and Communications Technologies (ICT) and the application of postponement was a critical requirement for implementing postponement strategies. Without ICT, Dell simply could not sell its kinds of products, since it had virtually no physical retailing chain.

The second condition that favors postponement strategies concerns the nature of the markets (Pine 1993; Droge, Germain et al. 1995; Gilmore and Pine 1997). The more demanding the market was, the more likely it was that companies would move towards postponement. The variability in demand often led to increasing product variety on the one hand, while the unpredictability of demand caused inventory risks on the other. Hence, as customers became more and more demanding, the viability of postponement increased.

The third condition favoring postponement strategies is the nature of the products being produced. When product parts had a high commonality (i.e., there was high interchangeability between products) (Hoek 1998), the cost of producing semi-finished goods could be significantly lowered. In particular, Hoek (1998) further argued that the more complex the activities involved in the production processes, the more relevant the postponement strategies were. Delaying the complex activities until customer orders were received meant that companies avoided the risk of performing these expensive activities for products that would never be sold. Even though re-working obsolete inventories might be one way to solve the problem, it was usually very expensive and thus impractical.

A supporting infrastructure, high variability in the market and complex products with high commonality form the three major conditions for implementing postponement strategies, thus bringing potential benefits to companies that implemented them.

4. The Framework

In this section, this paper will begin by assessing the relevance of postponement strategies to mobile application development, based on the literature review. Then, this paper will critically review the strategies identified so far. Drivers for implementing postponement strategies that lay down the foundations of the decision framework will be identified.

4.1 Mapping the Favorable Conditions

Each of the three conditions for implementing the postponement strategies will be examined in this section.

The purpose of creating a supporting infrastructure is to enable the seamless integration of many development processes, without abrupt changes or substantial adjustments when bringing modules together to complete a product. For example, any disruption in the supply chain would seriously affect a supplier's responsiveness to customers' demands. The initiative to place mobile communications under one umbrella by adopting the GSM platform exemplifies the first move towards a single globally supported infrastructure. The delay in integrating different SMS protocols in Hong Kong, on the other hand, meant that applications could not be freely applied in the network; resulting in significantly low SMS-based data traffic in the Asia-Pacific region (Mobinet 5 2002). There is no technology champion at the moment. Different regions around the world have different communication platforms or standards for wireless data transfer. Even within a single region, competing infrastructures exist. For instance, different Multimedia Messaging Service (MMS)[3] infrastructures are incompatible with each other. Integration efforts must be made in order to allow MMS messages to be sent across networks. As various kinds of devices were developed well before the concept of having one global wireless market evolved, the challenge to provide applications compatible with a variety of devices was obvious. There is also an opportunity and a need to provide applications compatible with a specific brand of devices. For example, Nokia has developed four series of user interfaces. Within each series, specifications can be different for different Nokia handsets. Unlike the Internet, browsers for mobile devices do not have a standard. Appendix 2 gives a summary of the major interoperability issues currently facing developers of mobile applications.

As noted previously, the mobile applications market was immature. People rarely found compelling reasons to use mobile applications. In such an early stage of development, developers were in a position to educate the market, rather than be driven by the market. Developers were thus not pulled by a demanding market, as was the case with postponement. Nevertheless, the unpredictability of the mobile applications market makes postponement strategies suitable for mobile application development. Since unpredictability leads to high inventory risk, postponement will help to aggregate demand, thereby reducing risk.

Mobile computing is, to a large extent, based on existing programming techniques. Applications development is often broken down into functional components and modules. Thus, they exhibit a high level of commonality. Furthermore, mobile application development can be complex. The development cycle can consist of as many as eighteen stages (Edwards 1984), with most of the development activities occurring towards the end of the development cycle (McKeen 1983). These characteristics conform themselves with the commonality condition.

As noted above, the only condition that does not conform in full is the lack of a supporting infrastructure. While the constraints created by the heterogeneous technologies are formidable, opportunities for implementing postponement strategies still exist. Mobile applications can be developed based on existing integrated infrastructures, e.g., the SMS infrastructure. It is usually the case that the integrated infrastructure yields the most usage, hence reducing the risk of application development.

4.2 Mapping the Strategies

As Hoek (1997) pointed out, postponement strategies need not be applicable to all industries. The question now becomes: What kind of postponement strategies will be suitable for mobile application development?

Based on the postponement strategies proposed by Bucklin (1965), Zinn and Bowersox (1988), and the industrial experience (TIF 2002), this paper has identified three generic postponement strategies that are not adaptable within the mobile application development context. They are: packaging, assembly, and manufacturing. A packaging postponement strategy is excluded because it is applied to products with different packaging sizes. In the case of selling mobile applications, if users want to buy more, they will buy licenses rather than a package of applications. Hence, this paper asserts that a packaging postponement strategy is not suitable for mobile application development. Assembly and manufacturing postponement strategies, on the other hand, have taken

[3] MMS is a global standard that will be used to deliver messages containing text, audio, graphics, photographic images, and even video clips between mobile devices

a manufacturing standpoint. The critical determinant of these two is the cost of transportation, which is far less significant when considered within the mobile application development context. Hence, they are excluded from this paper.

The strategies adopted in this paper are therefore: labelling (form), place, and a more general definition for the time postponement strategy.

- ***Labelling postponement*** refers to the postponement of labelling processing. This is adopted because mobile applications such as gaming can be branded with the names of different mobile carriers and then sold independently to different carriers.
- ***Place postponement*** refers to the positioning of inventories upstream in centralized manufacturing or distribution operations in order to postpone the forward or downstream movement of goods (Bowersox and Cross 1996). This is adopted because existing ring tone or screen saver applications can be sold independently or centrally through one single portal. The average maintenance cost and risk are lower in the latter case.
- ***Time postponement***, as illustrated by Zinn and Bowersox (1988), focuses more on cost efficiencies gained by centralizing distribution. In other words, cost of delivery matters. Distribution costs, however, do not significantly vary from one location to the other for mobile applications distribution. Hence, this paper adopts a more general definition for the time postponement strategy, which involves the delaying of the development of applications until customer orders have been received.

There is one other form of postponement strategy: periphery postponement. ***Periphery postponement*** refers to the strategy of delaying the development of parts that are of non-central importance, but that remain necessary for the completion of the applications. This strategy is adopted because various kinds of gaming, betting, and communication services are increasingly developed based on an existing core engine. This strategy is in line with the theory of risk pooling, in that it involves aggregating demands for many additional features or variations of the same applications. Hence, demand is less uncertain. ASPs can then develop fewer core engines for the same level of services.

4.3 Drivers for Implementation

Bucklin (1965) hypothesized that inexpensive products will include low levels of postponement. Based on this assumption, Hoek (2000a) identified two further important drivers for implementing postponement strategies: efficiency and responsiveness. Efficiency means reducing costs through shorter product life cycles. Naylor et al. (1999) also supported the notion that the ever-decreasing product life cycle is one of the main drivers for implementing postponement strategies. Responsiveness, on the other hand, refers to the ability to fulfil customers’ requests in dynamic markets (i.e. unpredictable markets) (Hoek 1998).

Even though it is possible to casually construct a framework based on the three drivers discussed above, the author has chosen to restrict the assumption and definition of the drivers so that the framework will be more useful. The tradeoff is that some circumstances are not covered by the framework. It is true that mobile application developers have to deal with many situations. Nevertheless, integration efficiency and marginal benefit are two essential considerations when deciding whether to give the green light to a development project (Farhoomand and Yuen 2003).

The author has therefore decided to relax the assumption about product value as hypothesized by Bucklin (1965), and will restrict the definition of efficiency to integration efficiency. Since being able to respond to the dynamic market is particularly important in mobile application development, responsiveness will be retained as a key driver for implementing postponement strategies. In this way, the framework can focus more effectively on the major issues taking place in the industry.

Another consideration is the compatibility of the three drivers. The author has adopted the view of Hoek (1998) that it is possible to implement multiple types of postponement, which can be combined and used at multiple points along the development chain simultaneously. Some competing strategies will be avoided when constructing the framework. To sum up, the three drivers for implementing postponement strategies are: responsiveness, integration efficiency, and marginal benefit.

4.4 The Decision Framework

In this paper, the author has adopted a top-down processing approach when constructing the framework. Firstly, the paper will examine each driver and identify which postponement strategies are likely to be most useful. Secondly, the paper will cross-examine the strategies to uncover the inherent strategies adopted. The results are listed in Table 1. A diagram is presented on the next page (Figure 1).

Table 1. Matrix of Strategies Driving Postponement

Type of Strategy	**Responsiveness**	**Integration Efficiency**	**Marginal Benefit**
Labeling	High	Low	High or Low
Place	High or Low	High	Low
Time	Low	Low	High
Periphery	High	High	High or Low

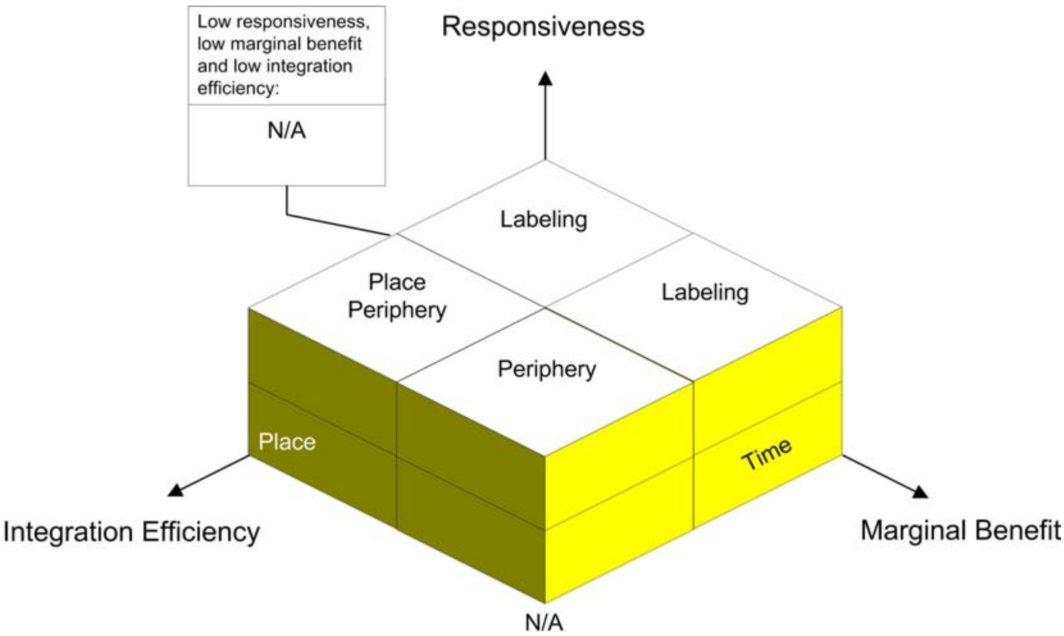
'Responsiveness' refers to the rapid deployment of mobile applications upon customers' requests. A labeling strategy is useful when there is a pressing demand from the market. Companies can produce generic products and differentiate with different labels to cater to different types of customers. One example is gaming: two mobile carriers across the region may require the same gaming applications with their own brand names on the label. So the product can be labeled differently after it is developed, and can then be sold to more than one party. Responsiveness is not relevant when deciding whether a place strategy should be used. Market demand fluctuates no matter where the mobile applications can be obtained. A periphery strategy can be used when time to market is important (i.e., high responsiveness). A time strategy will not be used when responsiveness needs to be high.

'Integration Efficiency' deals with how efficient it is to integrate applications in the targeted infrastructure. A labeling strategy can be used when the integration efficiency is low. This is because what is essentially the same product can be sold to different mobile carriers employing different infrastructures. A place strategy is useful when the infrastructure is fully integrated. As the cost of developing applications for a heterogeneous infrastructure is high, companies will usually wait until demand for this is evident. Hence, a time strategy is more useful when integration efficiency is low. A periphery strategy is not suitable if integration efficiency is low, because an expensive existing core engine may not be compatible with different infrastructures.

'Marginal Benefit' refers to the expected share of the profit for any mobile applications that are developed. A time strategy is very cost-inefficient, so only products with a high marginal benefit will be suited to a time strategy, in order to compensate for the associated high development costs. When applications are developed centrally, the average cost of maintenance is lowered, thus lowering the marginal benefit. 'Marginal benefit' is not a relevant determinant in the case of a labeling or periphery strategy.

In order to illustrate the application of the framework, a case study is presented in the next section.

Figure 1: The Decision Framework



5. The Case Study[4]

While the world saw how successful Japan was in launching its mobile Internet four years ago, most of the rest of the world had a different context to start with. In particular, the historical disparity in consumers' quality expectations in relation to mobile applications made it more difficult for developers to sell applications in places other than Japan. For the purposes of this paper, Hong Kong was chosen as the background of the case study. There are several reasons for this decision. First, Hong Kong has major attributes that the rest of the world also possesses, e.g., it is relatively free of regulatory controls;, there is ease of exit; the dominant players in Hong Kong are also dominant players in other parts of the world, and there is a GPRS-based infrastructure for mobile data transfer (and Hong Kong is currently working towards the W-CDMA standard). Hence, the challenges that Hong Kong faces are comparable to those found in other areas. Secondly, Hong Kong has attributes that many other places are likely to have in future, e.g., there is a high mobile phone penetration rate (86 percent), and voice charges are lower than data charges

[4] This case was prepared according to the guidelines given by Yin (1994) with regard to case design, case study protocol, and case analysis. Unstructured interviews were conducted with the CEO of Imoeba Ltd. The interviews serve to understand how postponement strategy varies under different circumstances. Information was also collected from archival records.

(as a result of the increasing competitiveness of the marketplace). These attributes have made competition in mobile application development fiercer, and such competition will no longer be based on the number of customers a company will win, but on the revenue the company can earn from each customer. Finally, according to a report by the International Telecommunication Union (ITU 2002), Hong Kong topped the Mobile Internet Index, which measured the readiness of various places around the world to join the mobile Internet market, and how likely it was that each place would take advantage of the market. Thus, the conclusions of this paper are likely to have important implications for the development of mobile applications in other parts of the world.

The subject of the case study was a Hong Kong-based SME called Imoeba Ltd., which also had businesses in Macau, Singapore, Taiwan, and Greater China. Its mobile applications had been widely adopted across Asia, and its clients included internationally respected companies such as China Mobile, Orange, Mobile One, and Cathay Pacific Airways. In addition to the large coverage of its businesses, Imoeba had also been recognized for its innovative product I-Date U. It won the "Wireless Asia M-apps Awards - Runner-up in SMS Category", presented by *Wireless Asia* magazine in 2001. It was also frequently ranked top in eRating for WAP software in the Asian Internet Community[5]. Its 2002 release, "Super Stable", was the first cross-border mobile game worldwide. As such, the results of this case study may shed some light on the opportunities that are open to SMEs in mobile application development.

5.1 Product Popularity

Imoeba's products were popular. According to Chief Executive Officer Mr. Sunny Kok, the "Super Stable" generated more than one million short messages for New World Mobility in its first month. Some users spent over HK$4,000 (About € 490) on the game[6].

5.2 Major Products[7]

The award-winning and popular mobile application I-Date U was based on the concept of virtual dating. It imitated the real dating situation, using highly integrated SMS infrastructure (the technology used was Interactive Short Message Services, ISMS), and currently WAP. There were seven virtual mates to choose from. The idea was to gain marks by initiating dialogues (by sending SMS messages) that had been prepared in the database, dating the mate in different places or sending gifts to the mate. Incidents would be pushed to players to increase the challenge. Top players would be announced periodically through a Website. Players had to keep playing in order to "win" the game. In this way, mobile carriers benefited from the frequent SMS messages sent by players.

Since the game was so popular in Hong Kong, localized versions of I-Date U were launched in Taiwan, the PRC, and Singapore, through cooperation with local mobile carriers. Another game, U-Date Me, an extension of I-Date U, was launched only three months after I-Date U was launched. The new game, targeting female mobile phone users, featured two virtual guys who "dated" users.

Super Stable was the first mobile game that allowed multi-players to compete with each other in a virtual horse-racing arena. It was also the first mobile game with a cross-border feature, enabling users in Taiwan and Hong Kong to play the game simultaneously. It was also developed based on a highly integrated infrastructure using ISMS, WAP/GPRS etc. Customers from different networks

[5] Source: CMAsia.com URL: http://www.cmasia.com/index.asp?CatID=1963
[6] URL Source: http://www.mbusinessdaily.com/story/WORLDWATCH/MBZ20020401S0005
[7] Source from Imoeba Ltd. unless stated otherwise. URL: http://www.imoeba.com

in Hong Kong could communicate with each other in the game by buying pre-paid cards. In order to play the game, players needed to purchase a physical “Horse Master Game Card” to own their horses. Each horse card represented one horse with unique attributes. Players needed to train their horses and participate in various races. The goal was to have a champion horse. Again, players had to keep playing in order to “win” the game.

Other products included SMS logo downloads for Cathay Pacific Airlines and other mobile carriers. Imoeba would first receive requests from respective companies’ Websites, then it would process the requests in its centrally administered application.

In the next section, this paper will examine the postponement strategies adopted.

5.2 Development Strategy – Postponement Strategies

As shown, all the subsequent products developed have striking similarities with I-Date-U. The analysis for each of the applications is presented in Table 2.

I-Date U was developed when the SMS market was still immature. Few people knew about mobile gaming. Hence, the need to respond to the market was low. The integration efficiency was high because the game was based on a popular infrastructure, SMS. The marginal benefit was high because the game was original. Imoeba shared the profits with the mobile carriers. The application was a completely new application. In this case, no postponement strategy was adopted.

Super Stable, on the other hand, was similar to I-Date U, except in the area of responsiveness. In fact, after the launch of I-Date U, customers were familiar with that style of game. The market was more demanding by that time (i.e., there was high responsiveness), and players understood that the playing mechanism of Super Stable and I-Date U was the same: they had to send lots of SMS messages to win the game.

The localized versions of both I-Date U and Super Stable were developed in response to requests by overseas customers. The network was different from that in Hong Kong. Hence, the integration efficiency for both cases was low. The languages, the names of the games and even the characters were changed (labeling strategy).

The marginal benefit for U-Date Me was reduced as the game was only a slight variation on I-Date U. It was only by using the Periphery strategy that U-Date Me was able to be quickly deployed within three months after the successful launch of I-Date U, thereby significantly lowering the development costs and reducing the development time.

The SMS logo downloads were also based on a highly integrated SMS infrastructure. The responsiveness was high because if their requests were not entertained immediately, customers would immediately go to other ASPs. The marginal benefit was low because there were so many logo-downloading services that they were increasingly treated like commodities. It was also beneficial to build one application and process the requests for these services centrally.

Table 2. Summary of Applications Characteristics and Their Postponement Strategies

Mobile Applications	Responsiveness	Integration Efficiency	Marginal Benefit	Postponement Strategies Adopted
I-Date U	Low	High	High	N/A
Localized versions of I-Date U in Taiwan, the PRC, and Singapore	High	Low	High	Labeling
U-Date Me	High	High	Low	Periphery
Super Stable	High	High	High	Periphery
Localized version of Super Stable in Taiwan	High	Low	High	Labeling
SMS logo downloads	High	High	Low	Place Periphery

One mobile application does not conform to the proposed framework, however. It was proposed in the framework that the Place strategy should be used for U-Date Me, in addition to the Periphery strategy. One possible reason explaining this is that product quantity may be a determinant to the use of Place strategy. If product quantity is low, the efficiency gained from centralized administration and maintenance may be negligible. This may explain why SMS logo download services, which involve more than 10,000 downloads a day, may use Place strategy but not for U-Date Me, which involves only a few thousand times of data transfer.

6 Conclusions, Limitations and Future Research

To conclude, this paper has contributed to the research by identifying postponement strategies that can meet the demands of facilitating fast cycle time application development in a cost effective way, and helping to reduce risk in development. The proposed decision framework can also help developers to choose the most appropriate postponement strategy; resulting in a more rapid time to deployment, a reduced technology risk, and lower operating costs. However, the usefulness of the framework is based on products within one company, so it may not be valid for all companies. Future research should include data from more than one company. In this paper, the author has shown that different relationships exist between developers, mobile carriers, and handset manufacturers in different markets. While the supplier network has been identified as a critical factor in implementing postponement strategies (Edward and Lee 1997), future studies could explore the different networked relationships formed within different mobile application development contexts.

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Appendix 1. Postponement strategies proposed by Zinn and Bowersox (1988)

Type	Definition
Labeling	1. Firms market/produce products under several brand names; 2. High-unit-value products produced 3. High product sales fluctuations present
Packaging	1. Firms sell products in several package sizes 2. High-unit-value products produced 3. High product sales fluctuations present
Assembly	1. Firms sell products with several versions 2. Firms sell products whose cube is greatly reduced if transported unassembled 4. High–unit-value products produced 3. High product sales fluctuations present
Manufacturing	1. Firms sell products with a high proportion of ubiquitous materials 2. High-unit-value products produced 3. High product sales fluctuations present
Time	1. Firms have a large number of distribution warehouses 2. High-unit-value products produced 3. High product sales fluctuations present

Appendix 2. Major interoperability issues

Component	Interoperability issues
Multimedia Messaging	• There are deployment difficulties in integrating a mobile network infrastructure, mobile terminals, content, and service development tools and applications. • The MMS interconnection agreement and technical implementation made MMS a truly mobile mass-market service in Finland, while the rest of the world is still working hard to develop one global MMS infrastructure. 3GPP and WAP-MMS specifications have been introduced to create one global standard[8].
Browsing	• Difficulties can be found in two areas: firstly, pulling different types of document into a single browser and having them sensibly styled; secondly, pulling the same document into different browsers and having them sensibly styled. • Existing technologies included WML, iMode HTML, and are now moving towards XHTML
User interface	• The challenge is to keep the user interface as simple as possible. • Every vendor was trying to design its own state-of-the-art user interface, so mobile devices became more diverse and could not communicate with each other.
Mobile Wireless Operating Systems	• A wide variety of operating systems, including but not limited to Palm OS™, WisdomOS™, J2ME™, Nokia OS, Symbian©, Pocket PC™, and Windows CE™
Digital Rights Management	• It controls, creates, markets, and maintains business rules for the use of digital content • The challenge is in format-level interoperability. • For instance, not all digital content providers comply with the meta-tag standards, making it more difficulty for parties involved to protect copyrights and revenue generation. Agreement on business rules is another challenge (Sun Microsystems 2002)
Gaming	• The challenge is to enable game developers to produce and deploy mobile games that can be distributed across multiple game servers and wireless networks, and played over different mobile devices. For example, defining application programming interfaces (APIs) will allow game developers to produce and deploy mobile games over wireless networks in a client/server model[9].

[8] MMS Deployment Milestone. Source: http://www.mobilemms.com/sample_yes2mms.asp
[9] Source: Mobile Games Interoperability (MGI) Forum