Technical University of Denmark

Master Thesis

Personalized Mobile Service:
My Mobile Sports Closet

Student:

Shanshan Zhu

s050879

Supervisor:

Henning Olesen

Technical University of Denmark
Informatics and Mathematical Modeling
Center for Information and Communication Technologies
Building 372, DK-2800 Kongens Lyngby, Denmark

Abstract

The overall purpose of this thesis is to provide a sport apparel manufacturer with new sale channels on mobile commerce. For their customers, as our end users, a personalized mobile shopping client is installed on their mobile phones that will enable them to keep an eye on the season new releases, maintain their own closet, and communicate with each other within the online community. We believe that there is a big potential market in this area. For the sports apparel manufacturers, it helps to keep a circle of loyal fans on their product promotion and stimulate the interactions between fans on the consumption basis. For the end users, it is a novelty to try and an exciting experience to share with friends. This report addresses the mobile interaction design concerns, presents the whole developing process ranging from theme proposal to producing the high-fidelity prototype, and gives a marketing analysis from the business perspective.

Preface

This project is the last milestone of my master's degree in Telecommunication Engineering. Its workload amounts to 30 ECTS credits. It was carried out at the Center for Information and Communication Technologies at the department of Informatics and Mathematical Modeling at the Technical University of Denmark.

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Table of contents

List of Figures

List of Tables

List of Acronyms

2.5G	Second Generation enhanced
3G	Third Generation
AS	ActionScript
BREW	Binary Runtime Environment for Wireless
DLL	Dynamically Linked Library
EDGE	Enhanced Data for GSM Evolution
FLA	A Macromedia Flash source document
FTP	File Transfer Protocol
GIF	Graphics Interchange Format
GPRS	General Packet Radio Service
GSM	Global System for Mobile communication
HTTP	HyperText Transfer Protocol
ID	Identification
IP	Internet Protocol
J2ME	Java 2 Micro Edition
JPEG	Joint Photographic Experts Group
KB	Kilobytes
Kbps	Kilo bits per second
MB	Megabytes
M-commerce	Mobile commerce
MMC	MultiMediaCard

MMI	Man Machine Interface
MMS	Multimedia Messaging Service
MMSC	My Mobile Sport Closet
MSO	Mobile Shared Object
OEM	Original Equipment Manufacturer
OS	Operating System
PC	Personal Computer
PHP	A server-side HTML embedded scripting language
PNG	Portable Network Graphics
RAM	Random Access Memory
S60 v2	Series 60 Version 2
SDK	Software Development Kit
SIS	A format of Symbian installation file
SMS	Short Message Service
SWF	A proprietary vector graphics file format produced by the Flash software from Adobe
TXT	Text File
UI	User Interface
UMTS	Universal Mobile Telecommunication System
URL	Uniform Resource Locator
UX	User Experience
WAP	Wireless Application Protocol
WCDMA	Wideband Code Division Multiple Access
XML	Extensible Markup Language

1 Introduction

This chapter starts out with the initial motivation for this thesis, after which the service scenarios are depicted to envision the proposed mobile service. Problems have been identified before the introduction of the methodology approaches. In the end, it gives a brief overview of the thesis structure.

1.1 Motivation

Today, many more people have access to mobile devices than have access to a desktop computer; people want to find something interesting to kill micro breaks, which might be the waiting time for a friend to show up, the arrival of public transport, the free time on a train or at a café, etc; moreover, nowadays people are getting so addicted to being connected that many of them find it hard to keep away from the web: it is evident that the mobile data service is in a huge demand by current mobile users. At the same time, as the traditional voice market has come close to saturation, many operators have been betting on data services to differentiate and increase revenue [1]. Unfortunately, today's data services more often than not, fail to meet users' expectations because of a poor user experience or a high cost of the data volume.

On the other hand, the popularity of sports gives birth to a huge number of sport fans

all around the world. For many people, "sports" can be the representative of a brave, positive, and encouraging spirit that makes one never give up. Every year, people get crazy about sports, they admire their sports heroes; they care about what they said and how they behaved. The fans are not content by only watching the games, but also try to participate in sports by themselves. Nowadays, an increasing number of ordinary customers can enjoy the professional clothing as their favorite stars do; Meanwhile for the sports apparel manufacturers, they have become aware that the traditional function sports wear can no longer satisfy a broad area of the sport fans, that is to say, a well-developed sport-suitable material combined with a cool sports style can still limit the dressing only within the playing fields. Consequently, they have introduced fashion elements into the design considerations; for example, Nike has promoted the launch of Nike Sport Culture [22], for everyday active wear. It combines the sports heritage of Nike as well as the fashion design. The same policy applies to its competitor "Adidas" as well, namely Adidas classic VS Adidas [23]. All in all, the contemporary sport fans begin to care about their sports dressing, not only functional, but also good looking.

With the advent of diversification of various users' needs, many companies have started to take advantage of individual attentions. Mobile phones are by nature well-suited for personalization outweighing over PCs. The term "Personalized service" in the title should be defined in two levels. First, it means that the users are able to manage their own collections from the product libraries and share their own sports experience with other fans. It not only enriches user experience, but also improves the product promotion on a consumption basis. Then from another point of view, the "personalized service" can also refer to the personalized intelligent service on one's mobile phone. It associates the user profile with the product profile to make recommendations. In this report, the first level is considered as the primary goal of the personalized service, while the second level is perceived as the advanced functionality which calls for a more complicated system.

Stated above, it is believed that a big potential market of mobile service on sport does exist, and is expected to be developed. This project aims to provide a personalized value-added mobile service – A mobile sport closet, which provides the consumers with an enjoyable and engaging mobile experience.

1.2 Service scenarios

The theme proposal chosen, we can envision the service scenarios based on inspiration from the existing service on the Internet, personal knowledge about the online shopping, and the early discussions with end users. The next three service scenarios have covered the most use cases in the original proposal. They are important for us to set the clear goal for this project. Later in this report, the use cases behind the

scenarios will be analyzed from a closer look.

Scenario 1

Maria has just come out from the fitness center. She's waiting for her friend Tina for shopping together. Maria takes a look at her watch. It is 18:00 o'clock now, and Tina should have been here. Suddenly, she receives Tina's SMS saying that she'll be late for a while because of the busy work. At this time, there comes another SMS. That is the update alert for the new arrivals from her favorite sport brand. She then starts "My Mobile Sport Closet" and checks for the new releases. She browses the updated page and quickly finds a special top -- a black dancing corset. She adds it into her "personal closet". In the "closet", combined with her last week choice – a black loose fit knit pant, she "tries" them on together, it looks terrific for the fighter fit class in the gym. Viewing the details, she's glad to know that there is a 10% discount from the mobile purchase. "Hey, Maria!" Tina is coming. "Hi, Tina," says Maria, "You know what, I just found a new dancing corset perfect for my fighter fit class. How do you like it?" "It looks great on you! By the way, it is cool, isn't it? See? It has the special fabric of DRI-FIT that is perfect for gym exercise!" says Tina. "OK, I'll take it. That's just what I've been looking for." Maria makes the ordering in minutes and gets it delivered to her home in the next day.

Scenario 2

Paul has been graduated and gone to work for two years. Every day he has to spend 1 hour on the train. Today on his way back home, he took out his mobile phone as usual, no missing calls, no new messages. Then he started to browse one of his favorite sport portal websites and was suddenly caught by an application called "My Mobile Sport Closet" labeled with his loyal brand. After downloading and installing the application, he registered himself as a new member. Once started the system, he found it quite familiar with the company's website on the Internet, since he goes to visit the website quite often in his spare time, and keeps an eye on the season new releases. He quickly began browsing items and happened to find a tennis warm-up jacket, which is especially his girlfriend's style. He cannot wait to show it to her. Checking from the "Options" popup menu, he found the "Send an MMS" option, after adding a few words to the end, he sent it to her. The train has stopped and it's time for him to get ready for the next stop.

Scenario 3

Jeanette is a Yoga enthusiast. Today she has been working for a whole day, sitting in front of her computer. She is getting quite annoyed by the trifles during the work, and has been totally confused about where she is heading for. Anyway, she's not in the mood to do anything, but only depressed about the present working status. Then she wants to find something interesting and relaxing. She enters into "My Mobile Sport Closet – My story" to read the sports stories from other sport fans. Little by little, she realized that facing the obstacles, she's not alone. There are many people every day to conquer something that she cannot even imagine. And things could only turn better if

not giving up. Jeanette also browses the cool pictures in the story, feeling herself getting closer to those fighting friends. She would also like to be one of them. So she started her own stories. She inputs her information, writes down her everyday Yoga life, and uploads photos during her Yoga exercises. Now she has turned back to a fresh mind and ready to work again.

1.3 Problem definition

This thesis aims to deliver an economical mobile shopping service with a special focus on the good user experience, as is opposed to many high-cost applications with a poor user experience in the current market. That means, we should regard the new service not only from a technical developer's perspective, but also from a user experience designer's viewpoint. Questions are then brought about:

- How to conduct the user experience design with user-centricity in mind?
- What are the important concerns in terms of a mobile design?
- What are the user requirements in terms of this service?
- How to involve users to work on different prototypes?
- How to bridge the application development with the feedback from user tests?
- How to distribute the content to the mobile phones?

Apart from the questions above, we are also curious from the business perspective about the position of this service in today's market and the interplay roles for providing the service. These are the problems that should be made clear in this project.

1.4 Methodology

The report will present a horizontal examination of the conceptual model of the service, and a vertical examination of the physical model. For the conceptual model, the report aims to give a description from the holistic view point, and furthermore to inspire the increasingly more possibilities to the readers being interested in the topic. For the physical model, the prototype goes deep into the practical level to present what the service looks like and how it functions.

In this report, a number of useful theoretical tools have been selected for a considerate and systematic analysis.

- This project is based on the user experience design methodology, where Jesse

James Garret's theory on "The Elements of User Experience" [17] is followed throughout the development process.

- During the user interface design, Shneiderman's "Eight Golden Rules of Interface Design" [14] is applied to improve the usability.
- The "DECIDE" framework [13] is introduced into this project to ensure the evaluations are driven by clear goals and appropriate questions.
- The "Moments of truth - Customer Activity Cycle" [56] contributes to analyze the typical mobile shopping behavior of end users and identify the user requirement accordingly.
- The "Coordinate plots" is an effective tool for displaying the position of different user segmentations.

The resource of the materials covers the web pages and white pages from the Internet, the scientific articles from databases, the reports from previous researches, the lecture slides from courses, and the books on user interaction and user experience design. To learn the development software, online LiveDoc and online technology community can be good guides.

1.5 Thesis structure

This report is comprised of 11 chapters in total, where chapter 2~3 contain project-related discussions, and from chapter 4 the project development process is elaborated. The detailed contributions of each chapter are listed as follows:

Chapter 2 introduces the background information of today's M-commerce, makes comparison between mobile developing platforms, explains the reasons to choose version 2.1, and discusses the challenges that should be considered in the mobile design.

Chapter 3 goes into the market analysis covering the target end users and market players in the current mobile ecosystem. It ends up with the analysis on the market position changing for the sport apparel company.

Chapter 4 gives an overview of the project design process – user experience design, which peels away the layers of user experience and is applied into the next following chapters.

Chapter 5 starts with analyzing users' typical shopping behavior, resulting in the derivative of use cases to be realized in the project development.

Chapter 6 presents the system specification, after which the service architecture is depicted and explained in more detail.

Chapter 7 illustrates the user interface design including defining usability goals and user experience goals before the visual design structure and guidelines are examined.

Chapter 8 discusses about the actual implementation issues such as the simplification that has been employed for the project, the degree of realization in response to the functional design, the function modules on both client and server side, the animation producing in Flash Lite, the performance optimization, and finally the distribution of the content.

Chapter 9 is about testing work conducted on usability test, user experience tests and the functional test.

Chapter 10 presents the future possibilities that could be added on the present work to extend the service to a higher level.

Chapter 11 draws conclusions for the thesis and fundamental view from the author's experience with the project.

2 Background

With an introduction to M-commerce today, this chapter focuses on the big picture that the thesis should be placed in. A comparison of the current popular mobile development platforms is presented together with a vertical comparison of the Flash Lite technology. Last, the key mobile design issues have been identified, which sets the stage for the project design work.

2.1 M-commerce today

-- Where are we in the M-commerce today?

With the tremendous advances in mobility and portability, M-commerce has been growing steadily under the influence of rapid development of wireless technology. It roughly refers to conduct business and services over portable, wireless devices and their network connection medium [4].

M-commerce can also be explained by electronic commerce via a mobile phone. As a matter of fact, it is perceived as a special branch of e-commerce, by introducing additional aspects – mobility and portability – to the world of e-business [4]. It is now about where e-business was five to six years ago and expected to exceed the growth

of e-commerce [50][51].

The driving forces that expand the opportunities for M-commerce development include the instant internet access and easy and simple transaction process regardless of time and place. However, it has been held back by the factors such as the the limited attention period of mobile users and the poor interface usability arising from the device physical constraints.

It is evidenced by [4] that M-commerce today encompasses more on the facilitation of instant information access rather than the supporting and realizing transactions. Consequently, the usability of the user interface appears to be a key ingredient for the acceptance of the application.

As M-commerce is about using mobile devices and the network connection medium to buy, sell and promote products, services and information, the M-commerce applications fall into three categories, and is demonstrated as below.
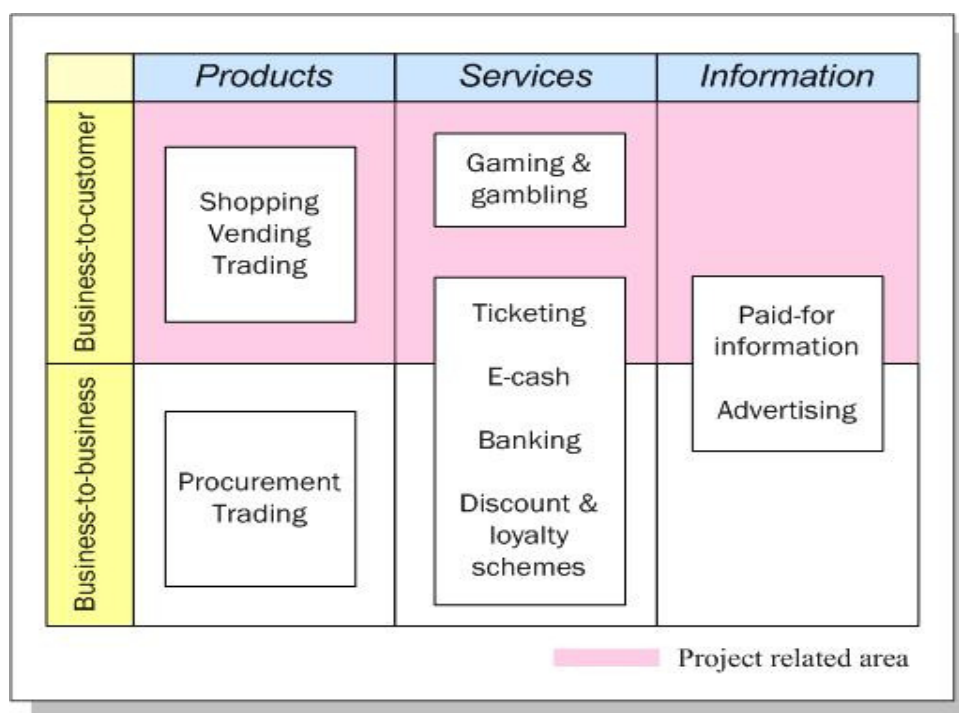
Figure 1   M-commerce applications (Inspired by [52])

As far as this project considered, we are in the B2C layer focusing on mobile shopping. Besides, service applications such as mobile payment in transaction management, together with information applications such as the information browsing and message/E-mail advertising also contribute to the entire framework. As the scope has be narrowed down to the mobile shopping, we can look into its development in a more detail.

In terms of the development of mobile shopping, Japan has played the leading role

world wide since its beginning in 1999 [53]. The market has grown rapidly when NTT DoCoMo introduced the concept. Comparisons (in [5]) between Japan and Western Europe markets identify the key enablers for early success in Japan: the push-based Internet mail and the ability to access sites via URLs. Consumers can find more detailed product information by clicking on the embedded URLs in the mobile internet mail. Later on, multiple alternatives to the existing retrieving method include inputting URLs, photographing 2D bar codes and using RFID tags. Such a service is further developed towards the cross-media integration. However, this type of mobile shopping service can be attributed to the mobile internet shopping category.

On the current mobile shopping market, entirely new ways have been explored by combining the mobile shopping together with the physical shopping [54]. To give a clear vision, when a user walks into a store and find a specific interested item, he can check more information through a mobile shopping client on the mobile phone. It may contain all the detailed information as well as the comparison information from different local stores. If the user has made the buying decision, he can send his wishing list to his e-mail and use the PC Internet to accomplish the purchase process. One important idea behind this type of mobile shopping is to separate the content from the UI framework, which should be preloaded to the device and serves as the template for holding the dynamic content.

The proposed service in this thesis will take advantage of the concept illustrated above. And the importance of the user experience design should be addressed again for a successful service adoption.

2.2 Comparison of mobile developing platforms

Many platforms are out there when considering to develop a mobile application. The comparison between the currently most popular technologies for mobile development is provided in both pros and cons.

Mobile platform	Pros	Cons
J2ME	- Fully object-oriented and mature language; - Sufficient speed to perform most tasks; - Security inspected by JVM; - Local storage supported; - Large community of developers; - MIDP framework to aid in development.	- Device-dependent behavior; - No scalable graphics.
Symbian native C++	- High compiling speed; - Vast libraries of C++ code; - Local storage supported; - Access to all device capabilities.	- Extremely long development cycles; - Inconsistent device behavior; - Not so secure; - Self-memory management for variables and pointers.
Python for Symbian	- Can be compiled into a native Symbian installer; - Supports all of a phone's capabilities.	- Requires a Python interpreter before running it; - No graphics API.
Flash Lite	- Rich user experience; - Visual authoring tool - Consistent content application across platforms - Small deployment file size (SWF) - Rich feature set - Accessible marketplace - Active development community - Integration with other languages	- Only preinstalled in some devices; - Requires integrating more features

Table 1   Mobile platforms comparison (Inspired by [16])

From the comparison in Table 1 we can assign each platform with an overview of the ideal development environment. J2ME is one of the most widely spread mobile platform and is very powerful in functionality. It is ideal for an all-around solution. C++ is the most powerful platform for creating the mobile application for general purpose, but with relatively long development cycles. Python turns out to be the best choice for initial prototyping and concept testing when functionality falls outside J2ME. Flash Lite is especially ideal for graphics-heavy and interactive content

development [35]. Further weighing between Flash Lite and J2ME is carried out.

Flash Lite vs J2ME

Early comparison between the two sought-after technologies gives the winning place to J2ME without doubts for its wider scale availability, more powerful features, bigger development communities, and more matured technology [36]. However, with the advent of new versions engaging enhanced features and broader availability, Flash Lite now can be distinguished for providing a nice user experience to users. The new and emerging viewpoint reveals that "*Flash Lite is now technically as good as, or even better than, J2ME.*" [37] (Eddie McGreal has more than 15 years' experience working on leading-edge technologies, and a strong background in Java/J2EE, RDBMS, and J2ME). Some content development companies choose to port their games from J2ME to Flash Lite [38]. Meanwhile some others would rather hold the viewpoint that Flash Lite and J2ME have some in common and meanwhile pertaining individual characteristics that cannot be replaced by each other. Cooperation will lead to the perfect solution for well-rounded development work.

In terms of this project, the decision was made according to the project goal, the system requirements and what we are trying to do. The purpose of this project is to develop a highly workable prototype of a personal mobile application that can offer a terrific user experience; users do expect fantastic interface and interactions from the application. Flash Lite is better to support rich media content ranging from text, image, video, to animation; it owns diversified drawing APIs and provides an efficient way to visualize the content creation, which will significantly improve our work efficiency. From the basic level, Flash Lite has been able to provide sufficient functions to cover most of the system requirements in this project. Consequently, it is embraced as the developing technology.

2.3 Versions of Flash Lite Technology

Before we go into the project implementation, we should get a general picture about the development of Flash Lite, based on which can we build the software development framework. Flash Lite technology has been through 3 main versions, namely Flash Lite 1.x / 2.x / 3. It is based on and extends Flash towards mobile platform integration.

Figure 2 gives a clear overview between Flash Lite and Flash. It is noticeable to see at the first sight that Flash Lite implements additional functionalities unique to mobile platform. It can refer to the ability for a phone call, a short message service or multimedia message service from the application. The figure illustrates that Flash Lite 1.1, which is based on Flash 4, offers the similar capabilities as Flash 4 on the desktop and partly form Flash 5, while Flash Lite 2 based on Flash 7 covers approximately

80% of the functions from Flash 7. [9] Flash Lite 3 is based on Flash 8.
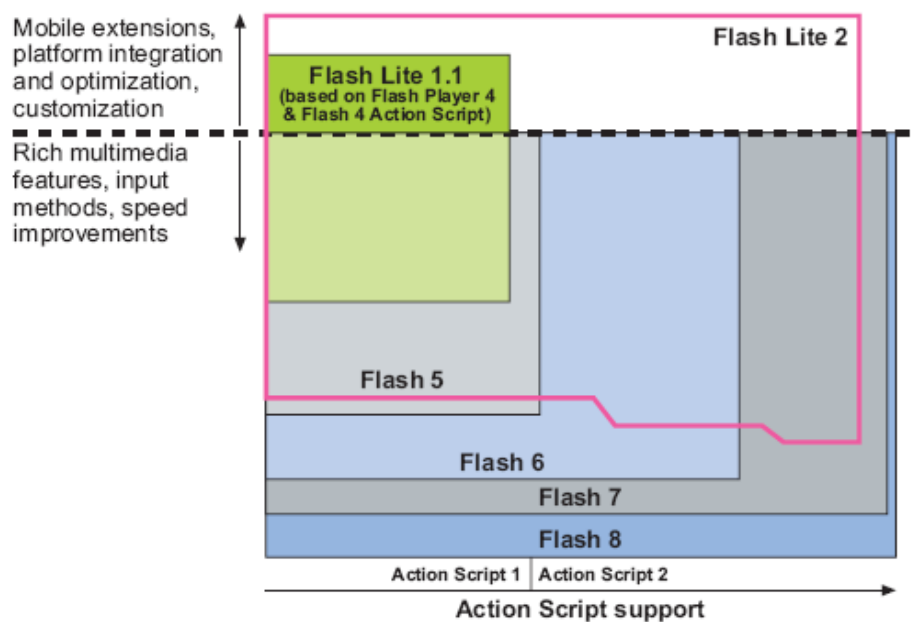
Figure 2   A comparison between Flash Lite and Flash [9]

When we are trying to build the development framework, the following reasons contribute to the final choice of Flash Lite 2.1 in the implementation. The detailed features as well as the availability of different versions of Flash Lite will be illustrated in Appendix A –Features of different Flash Lite versions.

1. **Flash 7 support**. Although Flash Lite 1.1 is in wide-scale device shipping, it is far from enough to implement this service. Based on Flash 7 (and above), new classes and objects can be used for more efficient development. Eventually the client side authoring tool takes use of Flash Lite 2.1 built on top of Flash 8 for developing.

2. **Key Class to handle key events**. In Flash Lite 1.1, the only way to register keyboard input is by listening for key press events on buttons. More than often, the developer will place a button labeled "KeyCatcher" offstage instead of a big ugly button occupying the middle of the application merely for listening keyboard input. In Flash Lite 2.x, it is supported that a listener can be created for the global Key object to listen for keyboard event (press, release). In addition, the brand-new global object – ExtendedKey -- provides the ability to listen for standard soft keys, instead of the traditional key constants introduced in Flash Lite 1.1 [16].

3. **The ability to store data**. In Flash Lite 1.1, there is no direct data storage method on the device with ActionScript. To achieve this feat, it is possible to combine the loadVariables() command with an external and sometimes platform-specific application (the Symbian C++ application or Java socket server) for deployment, not to mention the demand for using third-party applications. The use of

third-party applications is unfavorable in that it introduces extra cost and time into the project. Flash Lite 2.x provides support for storing data locally without some heavyweight Java or Symbian application running in the background. Making use of mobile shared objects (MSOs), one can store relative information about the application in a file locally on the phone. This file will be retrieved and loaded when the application is started next time. [16]

4. **Powerful and dynamic media**. In the applications of Flash Lite 1.1, any attempts to load JPEG image file will trigger invalid content warning. The JPEG image files are expected to be transcoded into Flash 4 SWF files using the server-side SWF generation scripts for file downloading. The script file on the server will encapsulate the JPEG file in a SWF file without any change of the image size or rotation and then it is recognized as the known file format to download. However, Flash Lite 2.x supports for external JPEG image loading in a more direct way by using the *loadMovie ( )* function to load the original image, specified through an URL as the parameter in the method, to the target movie clip on the stage.

5. **New Object *LoadVars***. In the older Flash Lite 1.1, *LoadVariables( )* is the command to read data from an external file normally from a web server and set values for variables in a target movie clip. *LoadVars* in Flash Lite 2.x wraps up the whole specifying name/value pairs into a single object for sending data to and receiving data from a server-side script. Meanwhile, three methods of a *LoadVars* object allow for client-server communication including *sendAndLoad( )*, *send( )* and *load( )*.

6. **Multi-Platform support**. Flash Lite 1.1 only supports Symbian platform while Flash Lite 2.1 provides support for a number of key open platforms in the market, involving Symbian S60 v2/v3, Qualcomm BREW 2.x/3.x and Microsoft Windows Mobile 5 [6][33].

7. **Action Script 2.0 support**. Flash Lite 2.x enables the content developer with the object model (for components), improved event model which 1.1 version feels short of. [6]

8. **In-line text fields**. This is the additional improvement supported by Flash Lite 2.1 which is built upon the 2.0 player. The text field in the previous Flash Lite versions should be tabbed and then pressed by *Enter* button to begin the text input. Unfortunately, it is unfavorable (confirmed as well in the user test observation that many users will start typing immediately when they tab the focus rectangular to the text field) since mobile phone users prefer the way like with a text message: they just tab to it and begin writing. Flash Lite 2.1 addresses this problem and changes the way it deals with text fields. [16] As far as text enhancement considered, Flash Lite 2.1 improves small text readability and provides predictive text support. [6]

Although Flash Lite 3 brings more engaging and even richer user experience, it is not released to OEMs until May 31, 2007 [43], when this project has already been carried out; and in addition, the coding rules from AS 2 to AS 3 have changed in many respects: based on the proven and stable development environment, we have made the

final choice of Flash Lite 2.1 built upon Flash 8 professional as the client side authoring tool.

2.4 Device capability

This application is designed to target at the handsets based on Symbian S60 with the screen resolution at 176 * 208 pixels. To run this Flash Lite-enabled service, there are two essential conditions for the device. First it should have a Flash Lite Player 2.x installed, and second it should have network access for the data communication.

From general point of view, the available devices that can directly use this application include all the devices based on Symbian S60 v2 and v3 with the screen resolution of 176*208 pixels. Such types of devices involve a variety of the leading manufacturers such as Nokia, Samsung, Panasonic and so on. Among them, Nokia phones take up a large part of it. Some of the devices have pre-installed the Flash Lite Player 2.x, however for those without a Flash Lite Player pre-installed, it requires the system to have a free memory at least 450KB for installing the core player DLL files; The minimum RAM requirement is 128KB, and the recommend RAM is 2MB in order to run the application for an optimal performance [6].

Actually the collaboration between Nokia and Adobe has been started since February 2005, and furthermore S60 has been announced as the reference platform for future versions of Flash Lite [9]. Currently, Flash Lite has already been integrated into all Nokia devices based on S60 3rd Edition [9]. Until 7 November 2007, it is announced that 33 models of Nokia S60 handsets based on S60 3rd Edition have pre-installed Flash Lite, and 12 out of them with Feature Pack 1 have pre-installed Flash Lite 2.0 [10]. Attentions should be addressed that most of them have the resolution of 240*320, therefore the content must be scaled to the user interface before the implementation. It is the responsibility of the technical developers to accomplish this task.

In this project, the application has been tested on Nokia 6630. It features with a screen resolution of 176 * 208 (pixels), supports 65536 color displays. The storage contains an internal memory of 10MB and an expansion of 64MB MMC. This device does not have a Flash Lite Player pre-installed. Therefore the Flash Lite Player needs to be installed manually. Meanwhile it has WCDMA and EDGE broadband access [55].

2.5 Mobile design issues

Before we go into the project design, a number of design challenges have to be

identified in terms of the mobile design. It is mainly compared with the traditional PC design. As is evident, the portability of mobile phones comes at the cost of device physical limitations. The following issues are the key elements to consider for a good application design.

2.5.1 Screen size and resolution

The screen size is proved to be the most obvious constraint in mobile phones, and it will continue to be a problem as long as screen displays remain on the devices. Typically, a PC screen is more than 20 times larger than the second-generation Internet phones [58]. Besides the screen size, screen resolution is also considered as the important role in usability. The higher the resolution is, the more room that mobile content can be displayed. Although the screen size is increasing, it cannot compete with the wide and comfortable computer screen. That means it still limits the mobile screen in a relative square to work with. [16]

In order to improve the user experience, the Flash Lite player can display the pages in either the standard (176*144 pixels) or the fullscreen (176*208 pixels) size [49]. Therefore, it is high demanding to present the application within the limited mobile screen. Such challenges can be detailed as the layout of the pages, the size of graphics, the proportion of icons to the text, and so on.

2.5.2 Screen color depth

Since the project is graphic-heavy, we are concerned with the current color display capability of mobile phones. The report from iSuppli's Market Watch reveals that by 2008, the majority of mobile phones on the market will be featured with full color displays. As far as Flash Lite-enabled phones, they can support at least 16-bit color display. That means at least 65,536 colors can be used for display. Such a presentation capability is sufficient to display almost any form of information, ranging from text to graphics, and to animations. [16]

2.5.3 User input

The mobile user input is another obstacle in the physical limitations. It cannot be compared with the PC user input. In the PC input, the user can utilize both the rich keyboard selections and the flexible mouse clicks; While in the mobile phone input, the user basically can only use the keys "0"~"9", "*" and "#" to input and navigate. As a result, some alternatives must be introduced to overcome this obstacle. First, the soft keys at the bottom line and the 5-way keypad should be taken good use of for

selections and navigations. Second, the phone built-in input methods such as "T9 predictive text" can be used for speeding up quantity information typing.

We have considered other design factors such as memory capability and network connectivity. However, they turn out to be easy to tackle in this project. Among all these factors, the screen size and the user input have become the most important elements affecting the user interface design.

3 Marketing

This section will take a closer look into the end service market. Problems should be discussed in this part include:

- Who are our target end users of the service?
- How do the market players fit themselves into the current mobile ecosystem?

3.1 Target end users

In this project, one concept should be claimed about the difference between our customers and our users. We, as the content provider, consider the sport apparel manufacturer as our customers to whom we want to sell the mobile service; while the end users are the real mobile phone users who have an interest in mobile shopping from the sport apparel manufacturer. It is clear that the end users are the actual players who will take this service. As a result, the real end users are regarded as our test users. We believe that with a better understanding of the target end users, we can cater for our customers' expectation at a higher level.
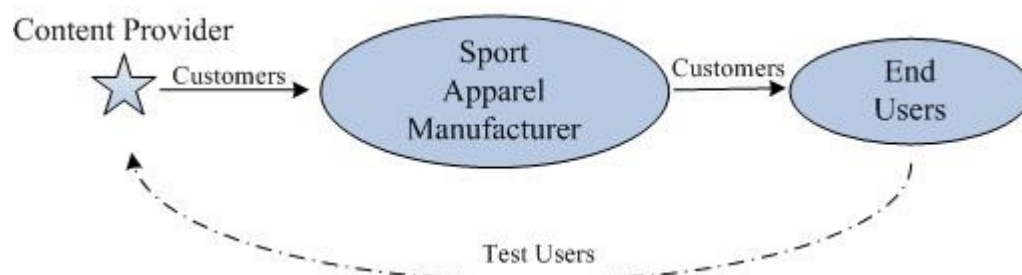
Figure 3   Target users and customers

3.1.1 User analysis

User narratives are introduced to give a detailed description of the target end users. These are the potential user segments who will take interests in the service. It is followed by the discussion about motivations to the end users, trying to exploit possibilities and identify factors having an impact on the service adoption. The typical user behavioral workflow will be examined in 3.1.3.

The youths (15~20)
Position in Figure 4**: (A, b)**
The youths are typically fond of fancy development. They would always like to try something new and comparably easier for acceptance. Generally speaking, they have enough free time but probably limited income to spend; they will find it fashionable to shop through mobile devices and would like to be the novelties. Their shopping is more emotional and price-sensitive. Many of them have personal interests in several kinds of sports, and will participate in some of them. What they care about more is often the style and the color, instead of the fabric and the functionality. The contributions of these users can be accounted on but also restrained to a limit. They may not buy a lot at one time, but the frequency for a new buying can be pretty high. They prefer to browse new products other than paying attention only to the possibly interested ones. If the mobile user interface is fancy with cool flash animation, it will be easier to attract their attention.

The adults (21~35)
Position in Figure 4**: (A, a)**
The adults are more rational in the buying behavior compared to *the youths* user segmentation. They've been always trying to find the suitable one for themselves, not only the design, but also the functionality towards a particular type of sport. Quite some of them tend to be loyal to personal favorite brands and their sport interests come from social communication and fitness. They may not have too much time for shopping but they would like to accept the mobile shopping, if only the security issues are guaranteed. The contributions of this user part can be considered as the main

driving force in the market. They hope to save time and pay special attention to their possibly interested products. They also have the expectation of the mobile user interface to be aesthetically pleasing, but the mobile payment and charges can be more of primary concerns. Besides, their buying frequency can be high.

The elders (35 above)
Position in Figure 4**: (B, c)**
This customer segmentation can also be the exploited as potential users for the service. They are typically more featured by the craze for sport. They tend to take one or two kinds of sports regularly, and do care about the quality of the products, such as whether it can create comforts in value of the cost. They care less (relatively) about the design and style. Quite some of them are not interested in the technical stuff, so the mobile shopping may be a little bit far from them. They may prefer the physical store shopping since it seems more reliable compared to the mobile way. Therefore the easy execution can be one of the motivations to them. The security and privacy elements are equally important. Moreover, the prestigious brands will ease them with product quality. Featured above, it is helpful to provide some kind of guidelines for instructions and make an emphasis on the credibility of products. The security of mobile payment and the after-sale guarantee should also be declared clearly.
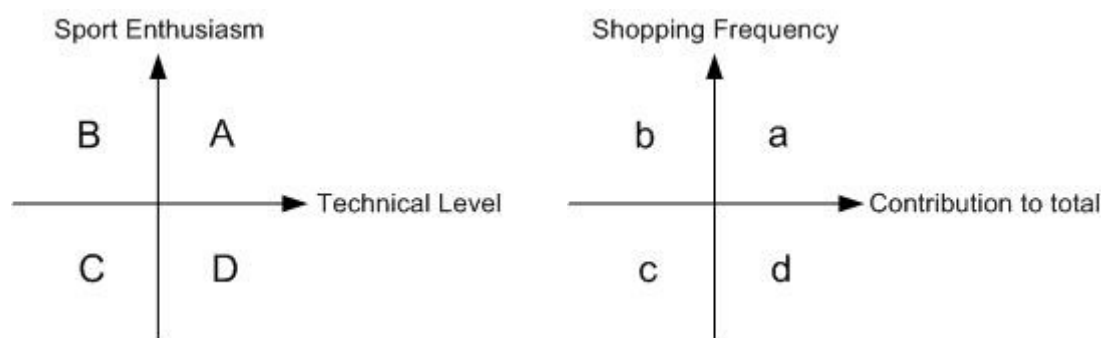
Figure 4   Mappings of user segmentation

Fundamental viewpoints can be made that the "youths" segment is the driving force to start the service promotion. Together with the "adults" users, they will contribute to the main part of the target end users. The elder sport fans are also considered as the great potential consumers for this service.

3.1.2 Motivations to end users

To give an inspiration, issues that should be taken into account indicating whether the users will accept the service are listed as follows.

▪ **Data rate for browsing**
   Example cases: *Can I use the service in a fluid manner? / How long shall I wait*

when it starts downloading and finally get it displayed on screen?

- **Presentation capabilities compared with the Internet**
  Example cases: *Can I see the product in its original color? Is there any difference between the displaying item and the real one?*

- **The complexity of mobile input**
  Example cases: *It is too much trouble for clicking the text field and then can I start input in the popup box. I prefer the in-line input just as easy as writing an SMS.*

- **The service price**
  Example cases: *I prefer to pay the service in a month fee rather than pay it per MB, since it is graphic-heavy.*

- **Too many steps for the operation**
  Example cases: *I find it too complicated to go through the whole process. There are excessive levels of menus to follow and remember, so I give up.*

- **Not supported by my mobile phone**
  Example cases: *I cannot use the service because my mobile phone does not have a color screen. / The memory card in my mobile phone is not sufficient to install the service.*

- **The resource for getting to know the service**
  Example cases: *I come to know the service from my friend. / I happened to find the service through the website.*

- **The after-sale issues**
  Example cases: *What if I want to return the product? / Who should I contact when I find a problem with the product?*

- **The desire to kill boredom**
  Example cases: *I like to use the service during the commute via bus or train.*

- **The desire to be first novelty**
  Example cases: *I'm fond of new gadget and want to have a try.*

- **The desire to share with friends**
  Example cases: *It's great that I can share with friends about my favorites and recommend to him/her immediately when I find an ideal piece. / I will keep an eye on my friend's new collections from time to time after subscribing to the service.*

- **The desire to get to know more sport friends**
  Example cases: *I'm happy to have a circle of sport friends here. / When I'm under great pressure, the sport stories here encourage me a lot. /*

The above factors range from network capability, device capability, usability and user experience, service availability, to user psychology. Such factors further arouse the design considerations and questions to be answered through the communication with end users. Chapter 6 and 8.1 will address the solutions in more detail.

3.1.3 Typical Shopping behavior

Before we go into the further analysis on user requirements, the typical shopping

behavior of a user can be seen from Figure 5 to give a brief overview. The complete process is comprised of three phases: *Pre*, *During*, and *Post*.

Figure 5   User's typical shopping behavior

It starts when the user receives the system alerts and then he launches the application. He updates the content and browses the items. During this time, he may find something interesting, so he adds it to his personal closet. After he selects all the interested items, he will go to the closet where he can match and try the outfits. Whenever browsing the items, he is able to send the product information to friends for recommendation or opinions. And then it is time to decide whether to take it or not.

When the user selects an interested item, he can click into it to see the detail information. The shopping list can be further added with new interested items, and meanwhile some of the selected items can be removed from the shopping list. After the user fills out the detailed product information (such as size, colors) and confirms the shopping list, he begins to input (unknown user) or check (logged in user) the personal information. Signing up the guarantee agreements, the user sends the ordering successfully.

When the order has been accepted, the product will be delivered to the consumer. Sometimes there will be problems at this stage; the user will then contact the customer service. If something goes wrong, the product should be returned. The third party judgment plays an important role when there are conflicts between the consumer and the apparel manufacturer.

In this project, the *Pre* session will be explored for further implementation. This part is of great importance for users to decide whether they will find it interesting and useful to take the service. It requires careful design considerations and paves the way for the subsequent *During* and *Post* sessions. Chapter 5.1 examines the *Pre* process into detailed use cases, which can be considered as the resource of user requirements.

3.2 Actors and Business models

The mobile service can only come into a real success through the collaboration of multiple market players. In this section, we will go into the mobile ecosystem first to identify the interplay actors in relation to the service, and then illustrate the changing position of our customers in the market.

3.2.1 Service Value System
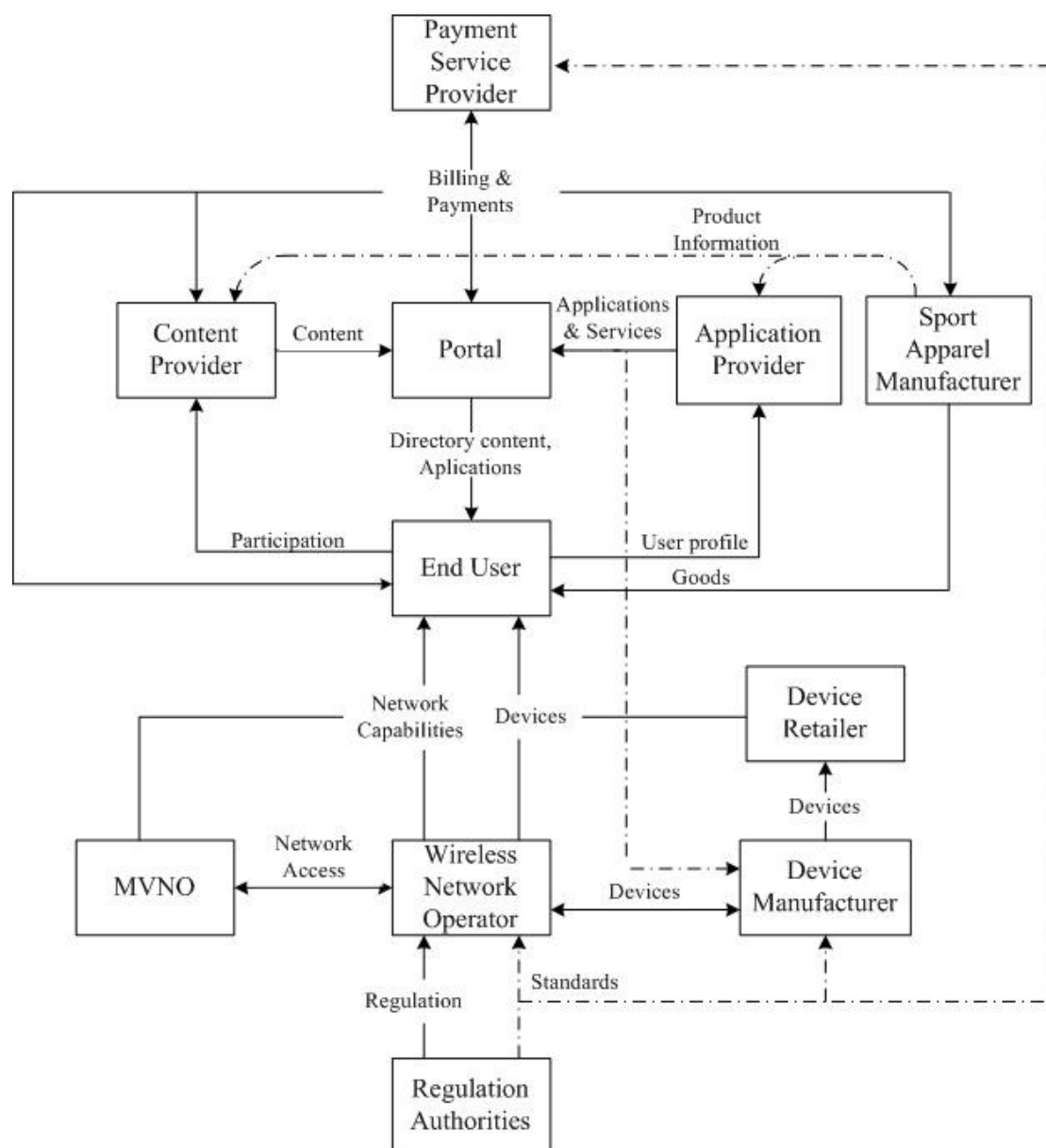
Figure 6   Service Value System (Inspired by [3])

The market actor's overview can be depicted as Figure 6. In this figure, we, as the content provider, together with our customer – the sport apparel manufacturer, and the end user are fit into the overall mobile ecosystem.

The sport apparel manufacturer
Since our service is a branding application, the sport apparel manufacturer plays an essential role in the ecosystem puzzle. It provides the raw information of all the products that the content provider can work with, shares the billing and payments, and delivers goods to the end users. They do not provide the mobile service directly to

users, but through signing agreements with content providers and application providers. Examples can be raised such as Nike, Adidas and so on.

The content provider

This tier is where we are likely to come into play – it is about collecting product information from the sport apparel manufacturer, creating rich and compelling content to add service value, involving end users in the participatory design, delivering the content to middlemen for distribution, and sharing the billing and payments with other entities. A combination of channel distributions can be used to broaden the reach of the application as well as to complement characteristics of different channels. In Figure 6, the mobile portal can be from the network operators, content aggregators or application service providers

The application provider

The application providers provide the applications either developed by themselves (e.g, Adobe Flash Lite) or purchased from other developers (e.g, content providers). They also have a privileged contact with the end users to maintain the service-related user profiles. Associated with the product information from the sports apparel manufacturers, they can extract useful information about the products and send notify-alerts to the end users.

Network operators

Without the network capabilities, the whole ecosystem falls apart. Network operators provide the physical connectivity to the end users and give them access to their network as well as other operators' networks, and the Internet. They will subsidy and distribute handsets from device manufacturers to build their customer base 0. They are regarded as the key role in the mobile business, and maintain extensive partnership with numerous players in the market.

Device manufacturers

Another important role of the ecosystem is the device manufacturer who provides to end users with actual devices to run the application. They distribute their products through device retailers and network operators. They may also partner with the application providers such as Adobe Flash Lite to enrich the device capabilities and promote the handsets adoption. Other activities involve signing up agreements on common standards to ensure the interoperability supervised by regulation authorities and so on.

Payment service providers

The payment service provider is another important tier in the mobile business ecosystem. Payment agents provide multiple cash-free methods to end users for purchasing the products through mobile phone. They partner with financial institutions such as banks and credit card companies for dealing with the transactions. Furthermore, they maintain and manage the payment platform for ensuring

trust-based security solutions.

Regulation authorities

Regulation authorities contribute to the legal environment between mobile business parties and formulate standardization to ensure the compatibility across different networks, devices, and applications.

End Users

End users are the bottom feeders in the ecosystem. They are expecting a stunning user experience on mobile applications and have the decisive impact on indicating the success of the service. They are in a unique position in the application development process. It is imperative for content providers to put them in forefront and exert efforts to cater for their needs.

3.2.2 Business Model

The business model can be described from two different levels: the network level and the organizational level. The overall description of the business model scenario will be presented first, after which we will focus a little more on the identified centric role – content providers.

On the network level, the "content provider centric business model" will be implemented for this service ([11] also introduces the "network operator centric business model" and "content aggregator centric business model"). The reasons why we choose this type of business model regard:

1. Our service is targeted at a specific brand, so it is not the point to extend the content aggregation.
2. With regards to this project, we should make it clear that it is more of a product-oriented instead of data volume-oriented project. The main purpose is for product promotion and selling among the brand loyal consumers, not to stimulate the browsing data volume for network operators. After all, the sports apparel manufacturer is our target customer.

In a word, the "content provider centric business model" focuses on the content creation, improves the consumer loyalty within a brand, and deals directly with the consumers.

On the organizational level, the business model of the content provider should be examined in a greater detail. As is explained in [3], a business model is comprised of four main elements, namely the value proposition, the customer relationship, the infrastructure and the financial aspects. Among the above aspects, the infrastructure is explored in more detail both from internal activities and partnership network with

other entities.

Value proposition
The content providers are supposed to provide the relevant data and information on the sports apparel manufacturer's products and distribute them through multiple mobile channels.

Target customers
The primary target customer is the sport apparel manufacturer who would like to introduce this mobile service into their mobile business. The secondary target customer includes portal companies that will broaden the reach of the service.

Business partners
Based on the service value system, first, the content provider should partner with the sport apparel manufacturer in order to get preferred access to product information. Second, the content provider should agree with network operators on access and transport services and charges. Third, the content provider will partner with application providers for content management platforms. Other partners may include the payment service provider for a secure and efficient mobile payment service, or various portals for a multitude of mobile distribution.

Core activities & Revenue sources
The content provider is intended to collect the data, process and format it, and then distribute the content to the market. The revenues come from the subscription fees, value-based transaction charges, and airtime usage fees [11].

4 Overview of User Experience Design

Before we go into the practical design, this chapter gives a brief overview of the user experience design methodology. From the perspective of a user experience designer, the application design process is presented. It paves the way for the chapters that follow.

The product design has evolved from the traditional technology-centric design to the user experience design [1], which starts with a focus on users and their needs rather than on technology. That is to say, information about customers is in a unique position to determine how the application should work. As Ben Shneiderman said, "…t*he old computing was about what computers could do; the new computing is about what users can do*" [12]. A user experience involves all aspects between the user and the application, ranging from the primary awareness of the product all the way to the whole interaction with the product to reach their goals. Such a design aims to achieve the feat to going beyond what users demand at the functionality level and furthermore to enable a supportive experience for using the system.

The user experience design can be examined from various perspectives, resulting in different outlooks. From a user's perspective, the user experience design is considered as the assembled puzzle from a range of discipline fields (as is shown in Figure 7) [30]. From an information architecture practitioner's perspective, the user experience honeycomb is developed to illustrate the facets affecting well-rounded experience (as is shown in Figure 8) [31]. From a user experience designer, it is broken down into five planes (as is shown in Figure 9) [17]. It can be seen that there are many ways to

decompose the user experience design, but they all encompass with the idea of a multi-faceted approach aimed at making the application more pleasant to use. Positioned ourselves as the user experience designer, we will use Jesse James Garrett's five-plane diagram as the theory framework to conduct the whole design process.
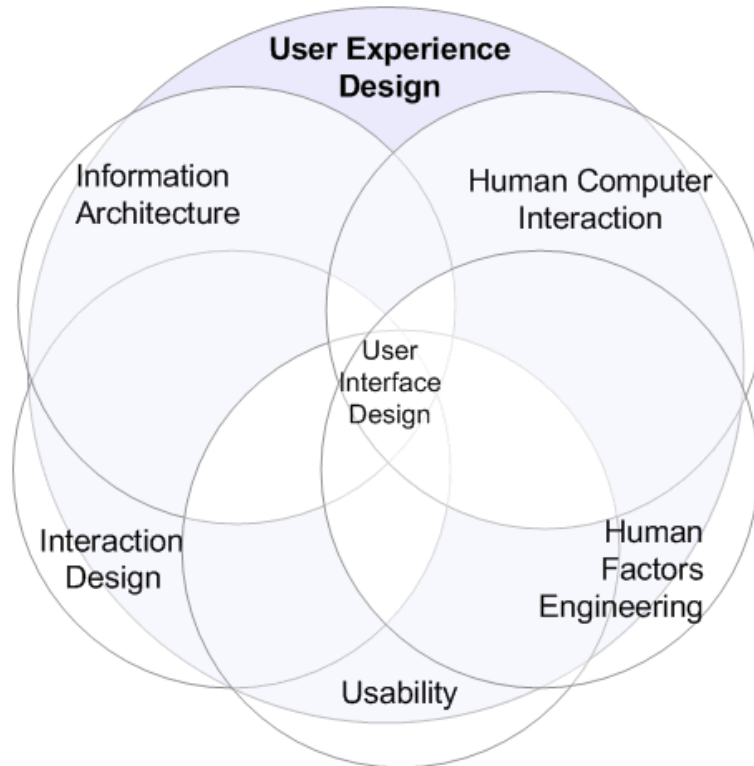

Figure 7   UX design from the user perspective [30]

Figure 8   UX design from the information architecture practitioner perspective [31]
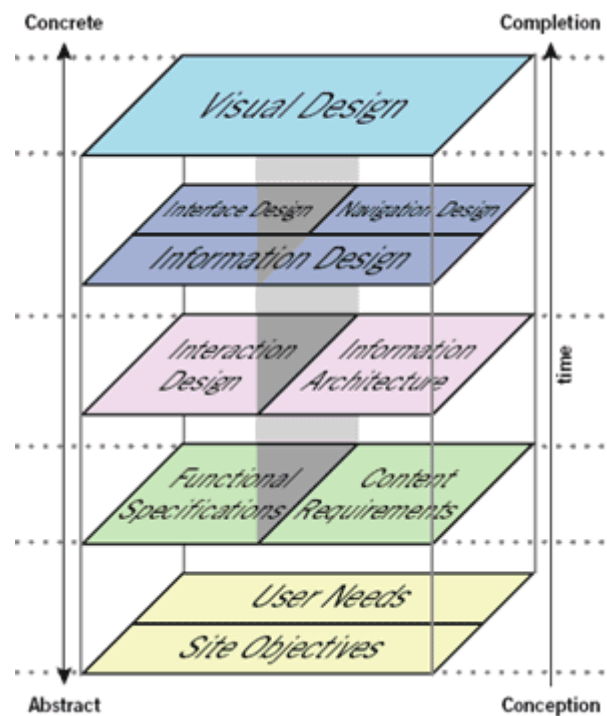
Figure 9   UX design from a UX designer perspective [17]

The model in Figure 9 is the notable picture on "The elements of user experience" from Jesse James Garrett [17]. It is used often to define the key considerations that should be taken into account in the development of user experience on the web today. It should be claimed that the model is originally developed aiming at the user-centered design for the web. In the original model, the web is perceived as either a software interface or a hypertext system, which explains the duality in the nature of the web. The model is introduced in this project because the application shares similar characteristics with the web application. It helps inspire us with process of the user experience design. And the basic duality of the web is not the focus to concentrate on.

On each plane in Figure 9, the issues that we should deal with become a little more concrete, and a little closer to the final completion. On the lowest plane, we only care about how the application can meet the end users' expectations, and leave out the concerns for final shape at all. On the highest plane, we only focus on the concrete details of the appearance of the application. Each plane depends on the planes below it; and plane by plane, the output becomes more specific [17].

This project is based on user experience design with the working flow shown in Figure 10. The theme proposal begins with the inspiration from the online websites and the early conversations with users for synthesizing the user requirements, bridging the original proposal with the real user needs. Thereafter comes the preliminary user requirements and system specification accordingly. The system specification is then used as the foundation for building the low-fidelity prototype. In

this project, the low-fidelity prototype was created using Microsoft PowerPoint. It gives users a clear view of how the system looks like and navigates. During the first round user test, some constructive recommendations have inspired us to reconsider the user requirements, refine the system specification, and carry out iterative design on the low-fidelity prototype. After the low-fidelity prototype is acceptable, we move on to the high-fidelity prototype. It is built on Flash Lite, Apache, and MySQL. Some of the previous user requirements that can not be fulfilled in the low-fidelity prototype are now available to implement in this operational system. At this stage, some visual design in terms of user experience is accomplished. The second round user experience test was conducted then with several more rectifications of user requirements, refinement of system specifications and redesign on the prototype. Finally, we derive the high-fidelity prototype.

The rest of the report looks at the elements plane by plane. We will take a closer look at the derivatives out of each plane in this project. Plane 1: user requirements (Section 5.1); plane 2: functional design (Section 5.2); plane 3 and 4: user interface design (Section 6.2); plane 5: visual design in design guidelines (Section 6.2 and Section 7.5).
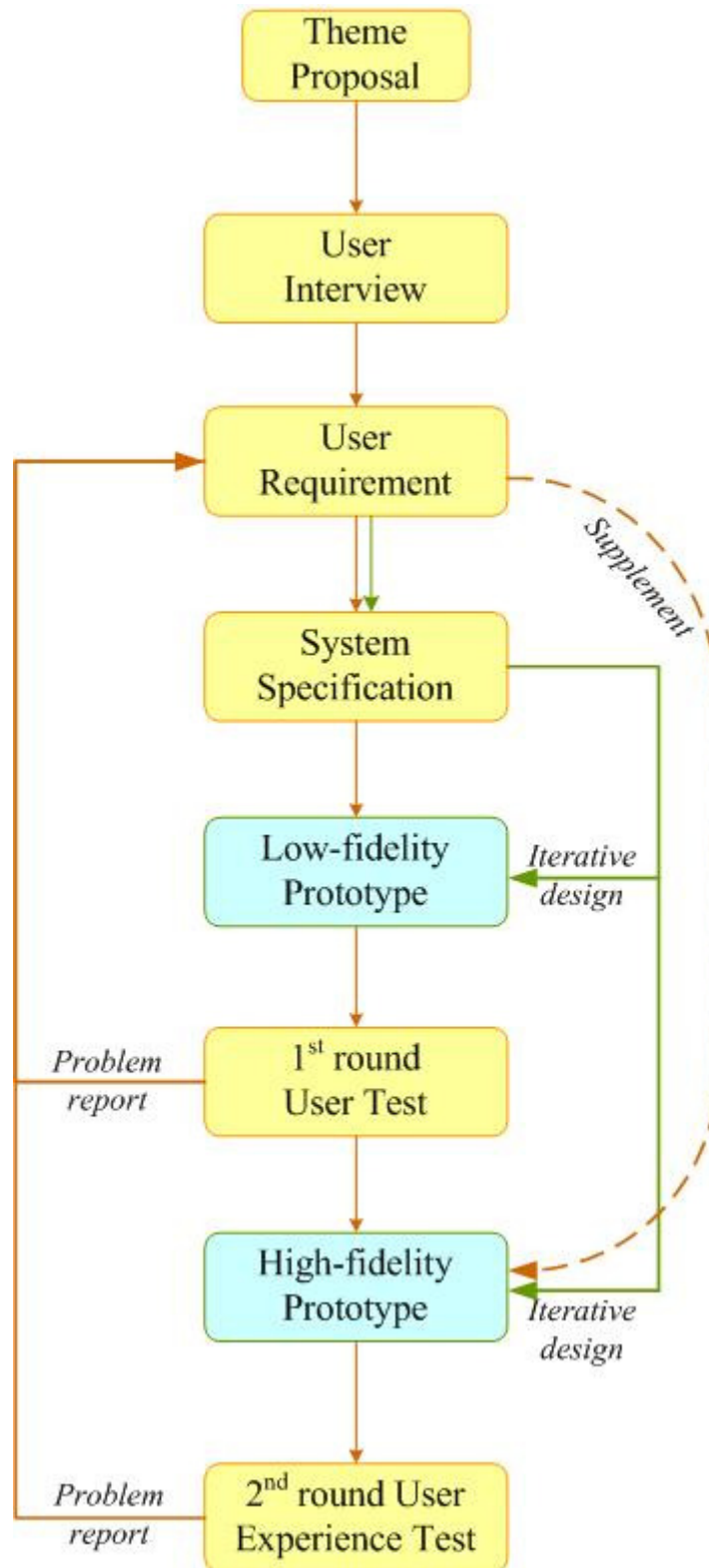
Figure 10   User experience design process (Inspired by [57])

5 Functional Design

This Chapter begins with the use cases analysis for describing the behavior of the system. After that, a clear overview of the system functionalities will be presented which has been prioritized according to the design considerations. The service architecture is then depicted based on the defined system specification. It should be pointed out that the whole functional design process was kept upgrading with continuous integrating of user requirement changes.

5.1 Use cases

Keeping user-centric at the forefront, the use cases explicitly illustrate what the user can do when interacting with the system. The use cases behind the described scenarios and typical shopping behavior circle can be listed as follows, it is settled down after several iterative designs. The analysis corresponds to the plane 1 in the Figure 9 for better understanding the user needs. From a holistic point of view, the system enables the users to: log in and sign up, check new arrivals, match outfits in My Closet, share sport stories, and manage user profile. Each of them will be examined in a greater detail in the following text. In addition, these functionalities will be discussed in Chapter 5.2 in terms of prioritization when it comes to implementation.

5.1.1 Log in and Sign up

a) *New user signs up*: An anonymous mobile user is expected to sign up before starting the application. It takes a short time for users to input his/her personal information which will be delivered to the system database. Then we can take advantage of the user profile to recommend the relevant products that may cater for the user's interest.

b) *Registered user logs in the system*: A registered user is identified by his/her user name and password. When he/she logs in the system, all his/her personal data will be loaded from the server.

5.1.2 Check the New Arrivals

a) *Get alerts by SMS*: The user will get system alerts when there are new releases for the next season. The system will also notify the registered user about his/her personal interested products by SMS.

b) *Update the new releases*: When the user goes into "New Arrival", the client-side will display an overview of the recent releases including the primary product introduction: a thumbnail, product name, product type, and its available colors.

c) *View an item in detail*: When the user wants to explore more details about a product, he/she can "Open" the product for further information such as price, overview of design and function, and fabric description. One can also view the product in front or back side in amplified pictures.

d) *Add favorites to My Closet*: Since the items from "New Arrival" are temporary, the user is enabled to collect the item into his/her own closet for further operations.

e) *Recommend to friends via message service*: Users can share his/her favorite products with friends by sending messages. Filled with the product information, users can select the friends from the device built-in "Contacts".

5.1.3 Match outfits in My Closet

a) *View an item in detail*: In this phase, users can still "Open" the product for further information, the same as described in the previous function.

b) *Delete items from My Closet*: It is essential to allow users to delete items from closet.

c) *Add the item to try out*: If the user is interested on how it looks, he/she can send it to the tryout page. The item will be assigned to the corresponding group such as "Top" or "Bottom" for display.

d) *Change another top/bottom for outfits*: Here users can switch their top or bottom

picks for matching. Each page contains one top and one bottom with their necessary introduction information.

e) *Share my collection with friends*: Similarly with "*Recommend to friends*", one can share his collection list with friends through message service.

f) *Change the target item with another available color*: It allows users to view one style in various colors, since most users will put the style and color at the primary concern.

g) *Order the items*: If the user decides to take it, he/she can start the purchasing process from selecting detailed information (such as quantity, size etc.), confirming the shopping list, reviewing of user information, and ultimately to submitting the order.

5.1.4 Share sports stories

a) *Search stories from index*: Users can browse the stories from types of classification, ranging from personal friend circle, types of sports, top ranked, location of sport fans, etc. Stories are listed with basic information including a thumbnail, the story-teller's name, his/her country, and one slogan for the title of the story (*Iterative design 1-1* in Table 3).

b) *Read stories*: After going into one story, the user can simply browse the four parts of one story. Each part contains the time, the activity, the story, and the photo.

c) *Vote for My favorite stories*: Users are always welcome to vote for his/her preferred story for promoting the interaction in this online community. The voting result can be leveraged in the top ranked classification. The more the story is supported, the easier for the story to be exposed to a broader range of users.

d) *Add to My friend list*: Users can add one sport fan into his/her friend list. All the friend's public information can be retrieved such as, name, country, sport stories, and personal collection lists. Other private information for instance, the email address, the mobile numbers, etc. will not be revealed to others. Such information can only be accessed by system technicians and will be strictly protected.

e) *View My friend's closet*: This functionality is also inspired during the user test for the low-fidelity prototype. (*Iterative design 1-1* in Table 3) Users can pull their friends' collection through this functionality. [5] shows that it is pretty effective and reliable if from familiar friends' recommendation.

f) *Edit My story*: After viewing others' stories, users can edit their own story. Following the simple working flow, users can complete the story. Consequently it can be listed within the community and be shared by other sport fans. This function can integrate the built-in phone gallery for uploading the personal images.

5.1.5 Others

a) *Be informed about the status*: After each operation, there should be a system board indicating the success or failure of the operation. Such feedback information is vital to offer users a better use experience.
b) *Turn to system help information*: The help information is essential for users to understand how the system functions. It is proved during the test that, only the navigation and the status information are not enough for users to conduct the operation. The fact is that the system should provide multiple ways of instruction especially the system help.
c) *Update user profiles*: Users are more than welcome to update their personal information for letting us know their interests. In that way, they can be provided with a better personalized service.

5.2 System Specification

The system specifications are achieved based on the following process: first, a small user interview was conducted for the very first communication between the real users and the designers. And then we draft the system specifications which act as the basis for the preliminary development work. After the round of user test on low-fidelity prototype, it is refined according to the improved user requirements. Such a refinement is also carried out after the user experience test of the high-fidelity prototype. The system functionalities are implemented in steps. The low-fidelity mock-up is tested for the interface design, demonstrating some of the main functionalities indicating how the system works. Later on the high-fidelity prototype, a complete set of functionalities has been implemented with real data models to function the system.

The functionalities behind the description in section 5.1 can be structured as the Figure 11 shown below. Each function in the diagram is a sub-function of the upper level function, and can furthermore trigger a number of sub-functions in the next level. They are logically divided into 4 levels. A mobile user either logs in or signs up the system and then comes to the first level to view the main menu. It is followed by the second level functions after users choose one menu option from the main menu. Each second level function may furthermore trigger the third level functionalities. The fourth level functions extend from the third ones, ending with either the interaction with other existing functionality or the outside system (such as payment system).
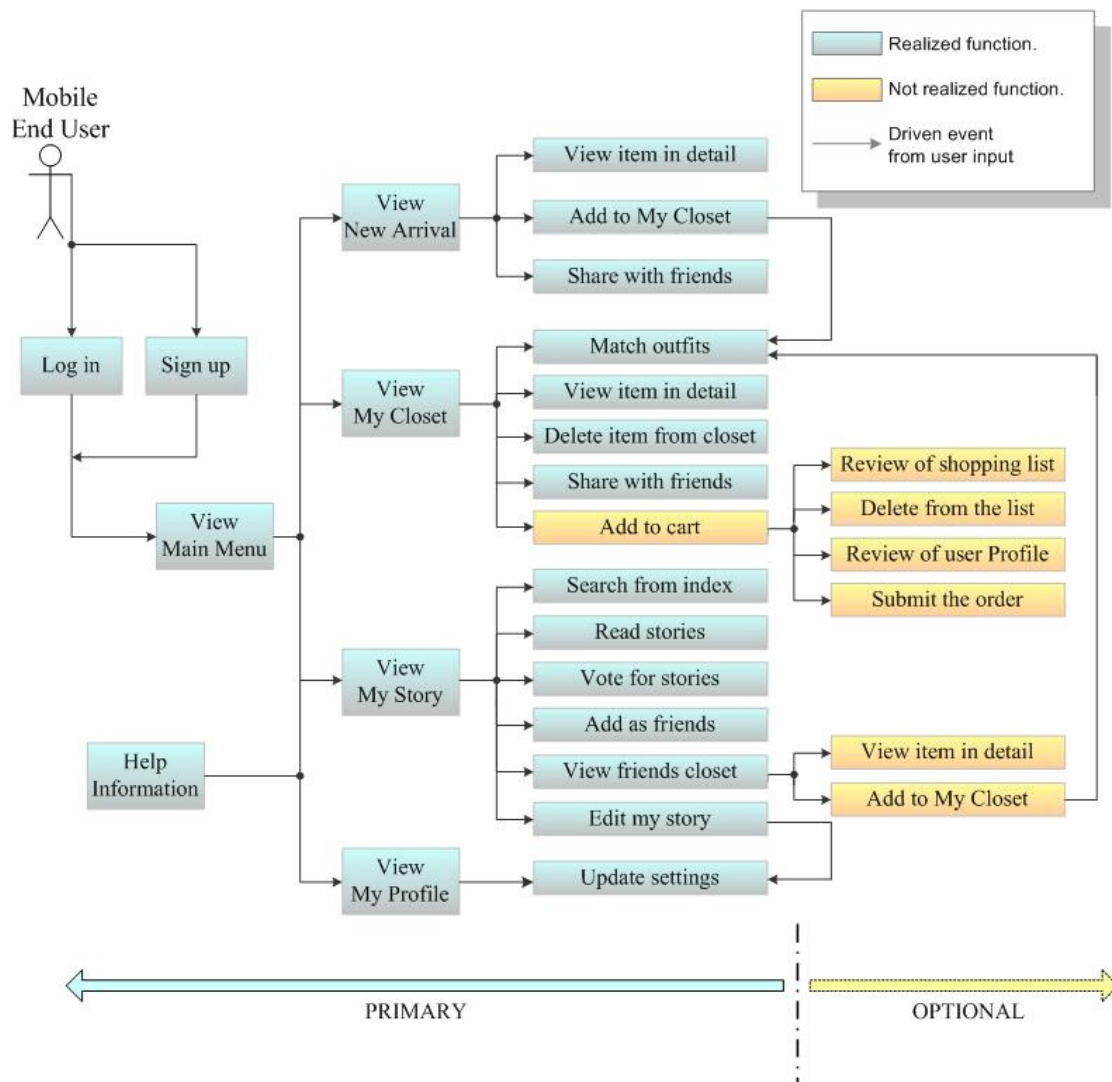
Figure 11   System behavior diagram

Taking time, user requirements and complexity into consideration, we have planned the four level functionalities into primary and optional groups. Functionalities from level one to three are primary ones, while the fourth-level ones are optional. During the project development, new version of Flash Lite has been released with new features integrated. Some functions still need time for implementation, partly because some can only be carried out on the desktop Flash, while they cannot be rendered by Flash Lite yet. Such a case can be referred to uploading pictures from the client-side to the server.

5.3 Service Architecture

The system is comprised of the client side and the server side. Figure 12 demonstrates the system service logic based on the client-server model.
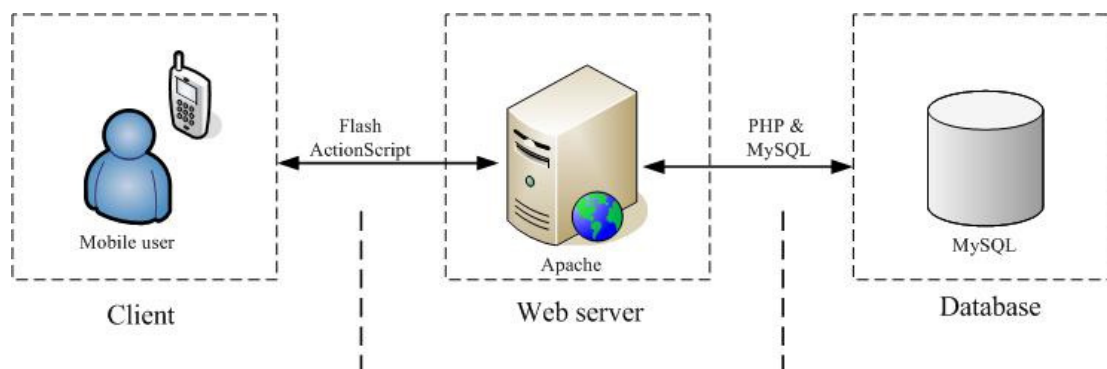
Figure 12   The service architecture

5.3.1 Content management and delivery

The mobile user is required to pre-install a client on the mobile phone, serving as the template providing all the necessary components and functions, including the scrolling bar, animations, action scripts, and so on. The content server stores the service logic files and image files, connecting to a database keeping the user and product profiles. The data information about the product and users is expected to be delivered over the network.

The running concept of this service is different from the traditional mobile web pages because this solution definitely saves the fees spent on downloading, and significantly reduces the time for the content delivery. It allows easier running logic to be performed at the server side, and maximizes the local processing capability in the mobile phone. It leaves only the request-and-respond communications to the network, reducing the network processing and responding time.

With regards to the browsing cost, if there are 20 new clothes to be updated for example, the total data volume for product overview is estimated at the average size of 50KB including all the text and image information. There are 2 items on each page, that means each page displays at the cost of only 4~6KB (a thumbnail image is about 1~2KB, and the text introduction for one item is less than 1KB). When the user clicks into one item, and views it from both the front side and the back side, the file size will be around 7KB ~ 9KB (the large image is about 3~4KB, plus a text introduction about 1KB). Such a small number, in comparison with the UI file size which is over 100KB, effectively saves the data volume to be downloaded.

Alert messaging
Associated with a database for keeping the data tables of both user profiles and product information, the content server will send the recommendation messages to users through SMS/MMS/E-mail. The working flow is: the server extracts the personalized information from the two related data tables, deriving a list of related

user id, all of whom are expected to be notified, and then initiates the recommendation messages back to the end users.

Data downloading
When a user sends a request, the content server responds to it with the query result from the database. More often than not, it is a list of IDs indicating either related products or friends. And then the client retrieves the content and displays it in place on the screen identified by ID numbers.

5.3.2 Development tools

The client side is referred to a mobile user who runs Flash Lite player on his/her mobile phone. In this project, the mobile phone is detailed as NOKIA Symbian 60 2nd edition, with the screen size of 176 * 208. The typical device for developing the application in this project is NOKIA 6630.

On the other hand, the server side is composed of a web server and a database. The database maintains two tables for keeping the information about the user profile and the product profile. The server is responsible for responding to the client request, pulls information about the product and user profile from the database, and then returns it back to the client. The Apache server and the MySQL database management system are introduced for developing on Microsoft Windows operating system. Both of them are open source and free software, and notable for its high popularity.

A number of scripting languages are introduced to enable the interaction between various entities. Flash ActionScript is used for the client-side to send request to and get response from the web server. PHP, a widely-used reflective programming language that is originally designed to create dynamic web pages, is used as the server-side scripting to interact with the database to provide dynamic content to the client from the server. [25] Combined with MySQL query, it enables the server to connect to the database, edits information, extracts information, and sends it back to the client-side.

6 User Interface design

This chapter is related to plane 4 and 5 in Figure 9 and gives answers to the questions below, in the aim for a user-friendly interface design.

1. How to lay out the information logically?
2. How much information is appropriate for a trust-based shopping?
3. How to attract users with qualified pictures?
4. How to instruct user to operate the system in a natural way?

Mobile phones have small displays and besides, they are often used when being on the move. To arrange the text information in a logical way is not easy. Users tend to get irritating if the information is too much, and feel boring or useless if it is not enough. The application is not only text-based; graphics are even more vital elements to take into consideration. During the user tests, it is proved that, they have a high expectation of the images. It is eye-catching and conveys rich potential information compared to plain text. (For example, a brand loyal buyer can easily identify the special fabric that may have a special functionality through the high quality pictures.) In addition, components such as buttons, scrolling bars, movie clips that enable users interacting with the system are also expected to incorporate into the screen design.

According to the consumer survey conducted by Harris Interactive on behalf of Macromedia [26], increased use of mobile data services have been held back by poor

user experiences. The poll confirms that 81% U.S. adults currently own a mobile phone, but a combination of user experience factors serve as barriers to the service penetration including download speeds, confusing menu interfaces, poor graphics quality, and lack of relevant information. Among those surveyed, 22% would complain connecting to network-based services is too slow, 19% would claim menu options are not user-friendly, 13% would attribute to the poor quality of graphics. It is obvious that the user interface design takes an important role among the factors that affect the customer experience.

6.1 Design Goals

This section tries to define the design goals addressing both on usability and user experience. These design goals result from the user interviews, Ben Shneiderman's "*Eight Golden Rules of Interface Design*" [14] as well as the text book [13]. The defined goals have been kept in mind during the developing work for a good user interface design. Detailed design guidelines encompassing the design goals will be explained in the next section.

Usability and user experience are two key factors affecting the degree of system acceptance by users. An optimal usability contributes to providing one part of a good user experience; in other words, user experience goes far beyond usability. Figure 13 reflects the relationship between usability and user experience in different domains: website design and business folks. Several other ingredient elements have to be integrated into the user experience zone. The factors, besides usability, vary with the specified discipline field. Therefore we have to take both usability and user experience into consideration towards a successful user experience design. Usability goals are largely considered to meet specific usability criteria, while user experience goals are more concerned with explicating the quality of the user experience. [13]

For this project, the usability goals and user experience goals can be depicted as Figure 14.
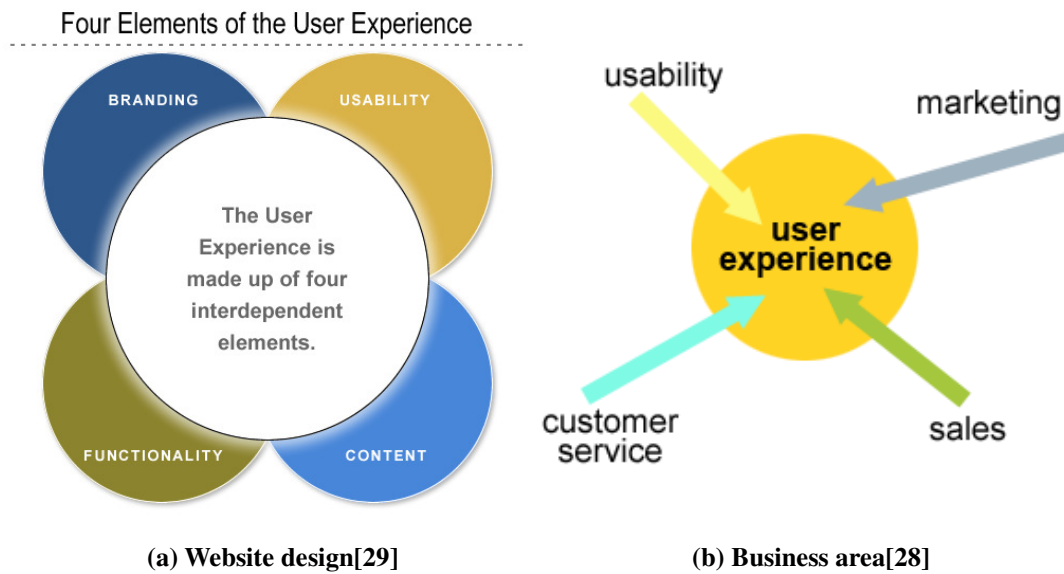
(a) Website design[29]   (b) Business area[28]

Figure 13   User experience and usability

6.1.1 Usability goals

The international standard, ISO 9241-11 defines the term "Usability" as:

"*The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.*" [41]

It is about:
- Effectiveness – can they achieve a particular goal by going through a certain number of tasks?
- Efficiency – how much time and effort do users spend on a specific task?
- Satisfaction – how do users perceive the ease of use about the system?

In the context of this project, usability refers to the simplicity and clarity of end user interaction. As depicted in Figure 14, this project defines the five main usability goals: efficient to use, good utility, easy to learn, safe to use, and easy to recall.
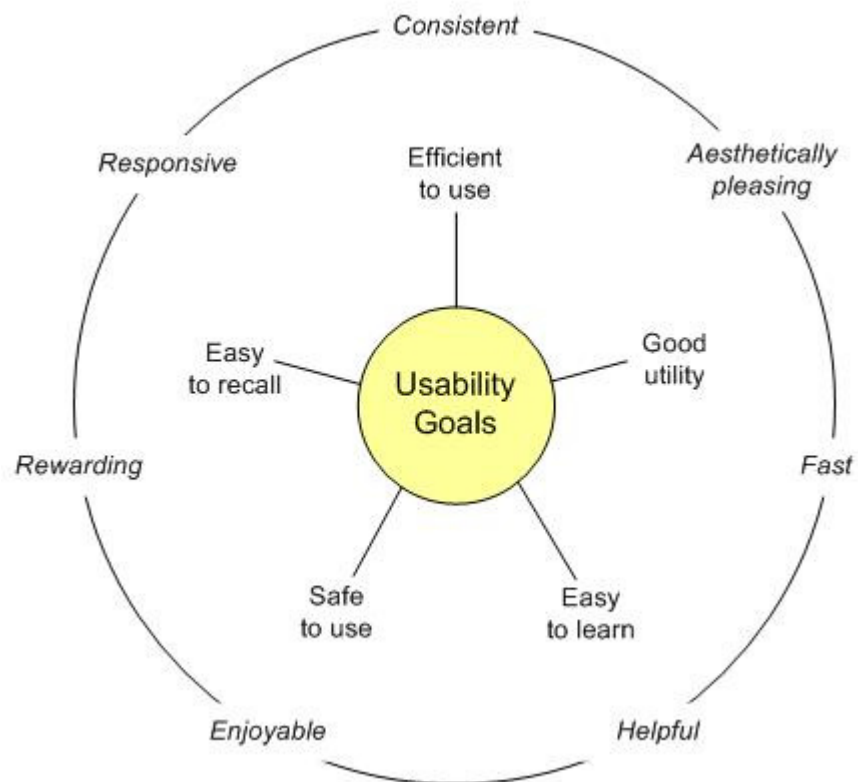
Figure 14   Usability goals and user experience goals (inspired by [13])

6.1.2 User experience goals

Although usability addresses the satisfaction of users in a specific context of use, it is far from enough in today's and future mobile market. As Don Norman describes the term "user experience",

"*It is about dealing with all aspects of the user's interaction with the product: how it is perceived, learned, and used.*" [1]

It starts from an awareness of the product and includes every aspect of the user's interaction with the service to reach their goal. A good user experience goes beyond what users say they want as far as features concerned, and in addition provides what they actually need, in a seamlessly supportive and integrated manner.

The project pays much attention on the user experience and aims to build a system that is not only useful, but also user-friendly. The user experience goals in this project are specified:

1. *Consistent.* The system should use consistent style, consistent sequences of

actions in similar situations, and identical terminology throughout.

2. *Aesthetically pleasing.* The system offers proper but legible font size and colors, good quality pictures, logical mapping between actions and effects, clear icons, structured layout, etc.

3. *Fast.* The system should enable the user fast content delivery. Elements such as download speed and run time are expected to be taken into account.

4. *Helpful.* Whenever the users get confused, they should be able to turn to system help.

5. *Enjoyable.* It must be enjoyable for users to take part in the service and meanwhile motivating for them to explore new features.

6. *Rewarding.* The system preferably involves rewarding part to encourage more interaction among users.

7. *Responsive.* The system provides feedback information and makes users feel they are in control of a responsive system.

6.2 Visual Design

In this section, the final interface will be presented together with user instructions and design guidelines. Some of them have been redesigned based on the users' feedback. It is mentioned here for showing how we approach to the design goals.

6.2.1 Structure trees

The Figure 15 below demonstrates the structure trees of the application. They are implemented as the static pages during the system development.

The user cannot use the system until he/she signs up or log in the system. The "Main Menu" page displays four menu options for the user to choose.

By choosing the "New Arrivals", users can achieve a list of product items that have been released recently in "NA_Overview". By clicking into a specific item, one can view more details about the item, including the detail information in "NA_Detail" and closer images from both front-side and back-side in "NA_Image". Either at the overview page or the detail page, users can open the popup menu and add their favorite item into their own closet. The system board appears after each adding action to inform the current status of his/her closet.

By choosing the "My Closet", users are capable of managing their collections in the closet. In the closet, he/she can match the outfits, delete items from closet, and share with friends. Similarly, users can go into the detail page to read the additional

information in "MC_Detail" and view the pictures in "MC_Image". If they find satisfied items, they could send them to shopping cart for further purchase process.

By choosing the "My Story", users can read sports stories from other sport fans, meanwhile also contribute their own story, sharing it with other friends. In "MS_Community", stories are classified by different categories (in the project, "friends" and "sport" are the examples). If selecting one story to read, "MS_Reading" will show up with one part of the story (total is four parts) containing both information and photo. Users can scroll down to the next part repeatedly until going over them all. If the user wants to take a look at the personas closet, by selecting to view his/her closet, the application goes to and play "MS_FriendCloset" page containing the friends' collections. Here the user is also enabled with detail viewing of the product, and adding the item into his/her own closet. The user can further edit his/her sport story in "MP_MyStory".

By choosing "My Profile", users will review the information in "MP_UserInfo" that has been input at sign up phase, update the profile and submit it to the remote server.
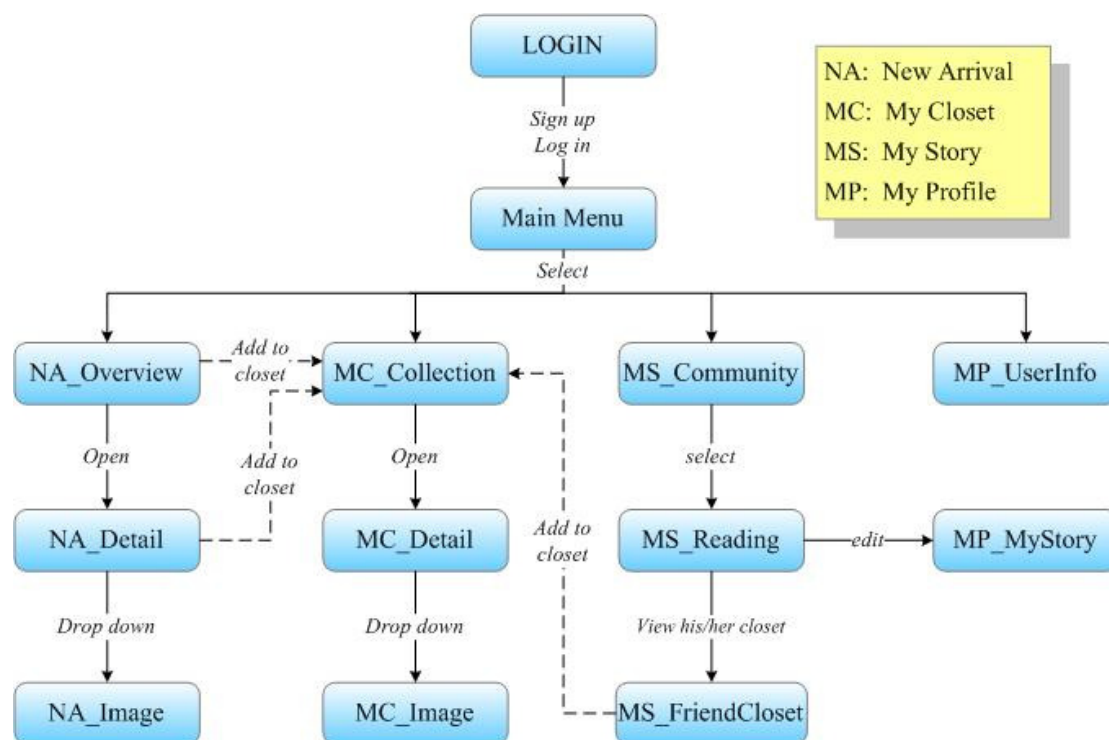

Figure 15   User interface flow

6.2.2 Design guidelines

In this section, the design guidelines will be listed based on the visual design guidelines of Flash Lite [7], Ben Shneiderman's "*Eight Golden Rules of Interface*

Design" [14], and the user feedback.

Design guideline 1: Choose the right colors for our customer
Most of the mobile devices in the market emphasize blue tones [7]. And most cool sport apparel manufacturer (for instance, Nike [22], Adidas [23], Reebok [27], etc.) have been setting black or dark grey as their website background. Conforming to our clients' consistent branding style, this application takes advantage of dark grey and a hue of blue colors. It is commented by the user that

M1: "..*the dark background gives way to the striking clothes images*".

Design guideline 2: Use clear focus [7]
Users tend to have a sense of control of the system, they are always expected to be indicated where they are and what options they have. To achieve this feat, a clear focus is a must. Flash Lite have a built-in automatic highlight rectangular, however, it depends whether to use it or not. In every page, the focused item is highlighted with a light blue rectangular. And it is necessary to have an item preselected on the page from which the user knows where to start.

Design guideline 3: Employ a consistent style [14]
To keep simplicity and consistency as rules, the page layout can be extracted as the Figure 16. The navigation bar hangs at the top of the page with action paths centered. It also keeps some device information. Next there comes the tab bar, if any. It is followed by the main body containing the graphic and text content. Finally the soft key bar lies at the bottom of the page.
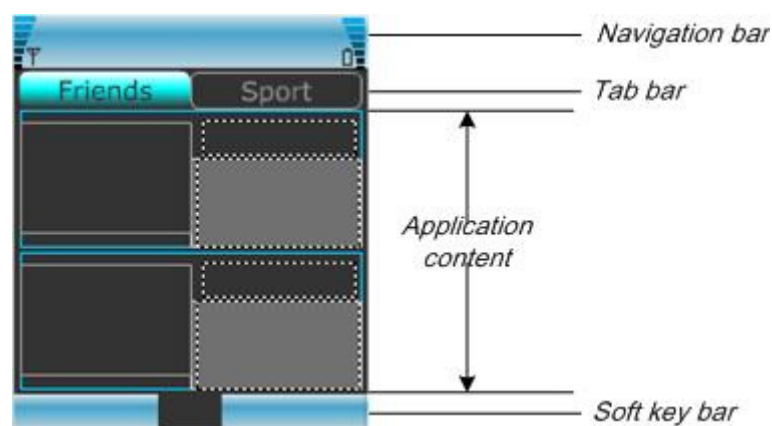

Figure 16   Page Layout

Design guideline 4: Respect the UI conventions of the NOKIA Symbian 60 platform [7]

People are accustomed to a certain interaction style when using different brands of mobile phones. Nokia s60 devices have an extensive market and own a consistent UI

style that makes users feel safe with. In this project, several potential design elements are inherited from that style.

1. Options for exiting and going backwards are behind the right soft key. Menus and other kinds of options are behind the left soft key.
2. Scrolling is constrained to one direction unless secondary scrolling cannot be avoided. The story reading part (as shown in Figure 17-b) is designed for repeated down scrolling that allows users to see all the content. However, the tryout page (as shown in Figure 18) contains images that should be displayed with secondary scrolling for switching. The availability of secondary scrolling is indicated by the visibility of the direction button.
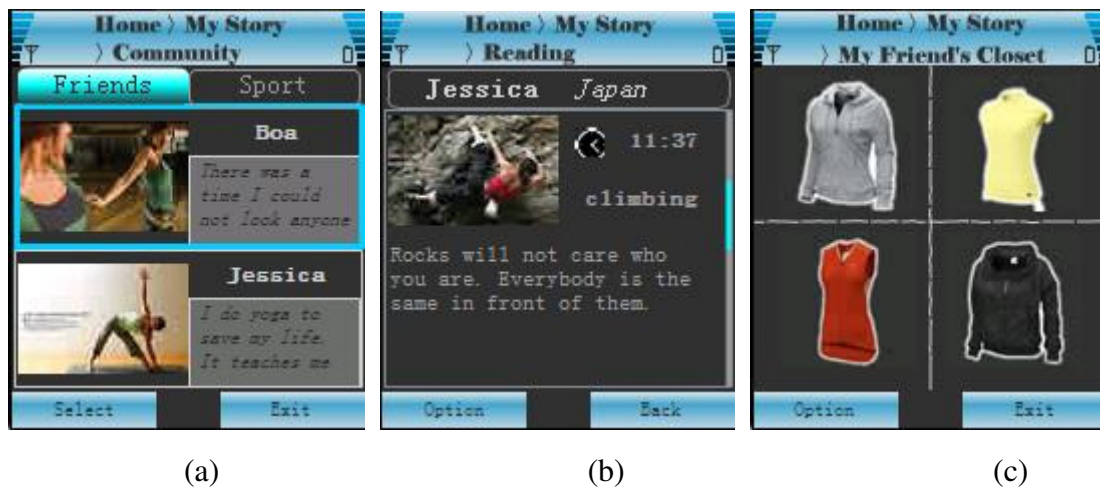

| (a) | (b) | (c) |

Figure 17　My Story pages

3. Navigation keys and user actions on the screen share a logical mapping. The application navigation design follows list navigation and tab navigation design patterns. [15] For example, the story community page (as shown in Figure 17-a) is easy to indicate users to browse vertically through story list, while horizontally between different tabs.
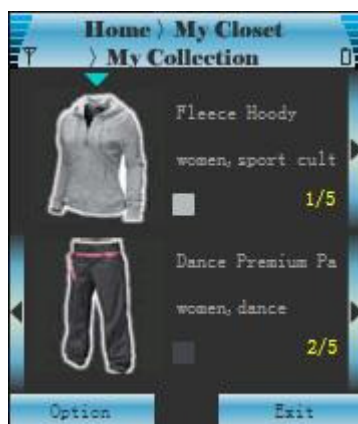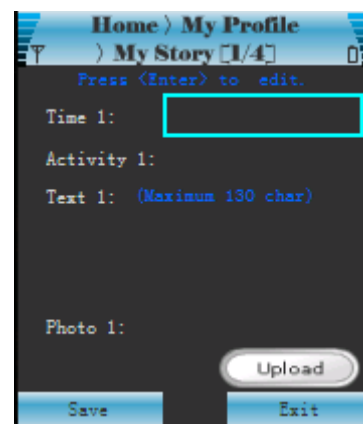

Figure 18　My Closet - tryout page

Figure 19　My Story - editing page

Design guideline 5: Stepwise navigation and information

Due to the small displays and interruptibility of mobile users, the information being shown to users needs to be simple, to-the-point, and offered in small pieces [7]. At the product overview page (as Figure 20-a), only the basic information like product name, type, and colors is available. If users favor a certain item, the detail page (as Figure 20-b) then displays more useful information such as price, functionality overview, fabric description, as well as the closer pictures. The layout of the information gives respect to the high priority of what the user needs. As one user said,

F2: "…The information I want the most is the title of the product, and its price. I don't care so much about the fabric detail when I go into the page first; therefore I don't want to scroll all the way down to see the price at the bottom…"(*Iterative design 2-1 in* Table 5)

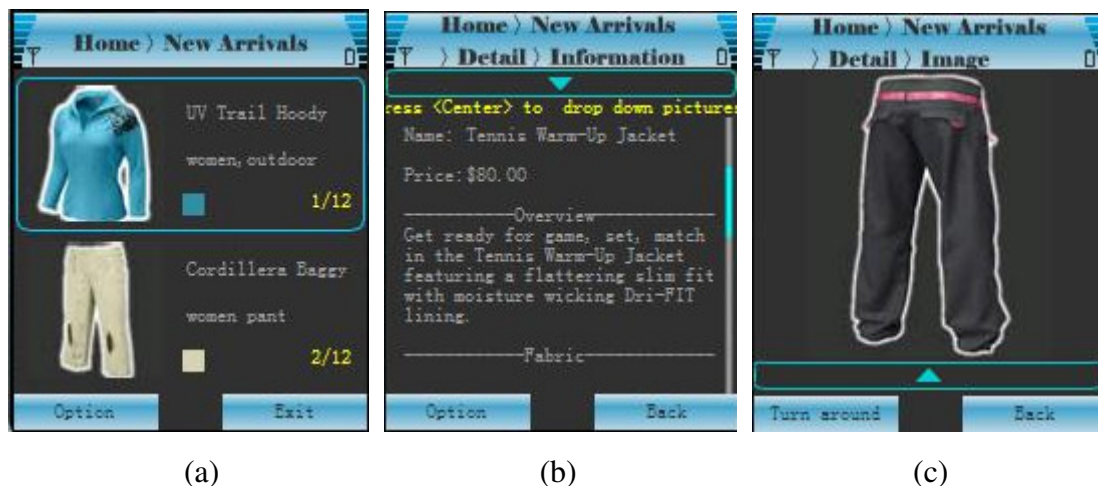| (a) | (b) | (c) |

Figure 20   New arrival pages

In the story editing page Figure 18   My Closet - tryout page   Figure 19   My Story - editing page, the whole writing process is split into 4 separate steps and the content of each part is structured. There is a step number shown in the navigation bar to indicate the current step and how many steps to go.

Design guideline 6: Simplify the user input [7]

Mobile devices has limited displays and input capabilities. The less the user needs to input, the better of the customer experience. For sending messages to friends, the SMS application will be launched with basic product information prewritten as the content. The user can insert additional information thereafter, and sends it by simply choosing friend's number from the "Contacts".

Design guideline 7: Using graphics

As mentioned earlier, it is tempting to involve graphics in the applications, especially this graphic-based project. Originated from the initial user interview and first round user test, the images of the clothes are expected to be elaborate, separated from the background, and in addition, must be processed in proportion between tops and bottoms so that it creates a real sense of trying.

F3: "*…I won't care about the money spent on browsing pictures, but I do care about the quality of the pictures. If I want to see my friend's closet, I don't even need any text information at the first glance, I can click into a specific interested item as long as I take interests in the thumbnail image…*"(*Iterative design 1-2* in Table 3)

At the same time, some other users during the test do care about the fees on picture downloading. At one hand, images are kept at a high performance-cost ratio. Each image is stored in JPEG format at the size of 1~3 KB, ensuring the satisfied quality. At the other hand, in the image detail information page (as shown in Figure 20-b), the text information displays first with a breadcrumb hanging at the top. It is the user's choice whether to drop it down for detailed pictures or not. The idea is designed at the very first phase. During the user test, some user mentioned about the layout of the item information:

F2: "*…when I go into a detail page, I preferred to see the name, price, and the pictures of the product …*"

However, after I asked her "Have you thought about the fees you have to pay for the pictures? And in this way, you may have a choice to open the picture or not. Then which do you prefer?", she would then perceive the original design more reasonable. Therefore it confirms our original idea is user-friendly.

7 Implementation

This chapter demonstrates how to implement the system at both the client and the server sides. With specialty on Flash Lite development on mobile phones, it gives a quick illustration on producing the animations in the project. After that the performance optimization will be introduced. Finally it discusses a possible solution for the content distribution.

7.1 Application development process

The complete development is degraded into 3 phases: the client-side interface and interaction ActionScript, the server-side scripts, and the client-server communication scripts. At the client side, the four function branches were developed independently first, and then integrated together into the same root timeline. At this time, the data in relation to user profile are stored locally on the mobile phone, and the external images are saved at the same file folder as the SWF file for loading. When it comes to the second phase, a classic architecture of web design is built up involving the Apache server and MySQL database. In the server's document directory file folder, PHP files are written out there for querying database and returning dynamic content. Given the predefined variables, each file was tested locally first. The final step is to enable the communication between the client and the server: the client is able to deliver data to

the server, while the server can insert the received data into the database, and return data back to the client. After the completion of the functional implementation, it is followed by the iterative design for the performance optimization on the ActionScript and interface components.

During this implementation, simplification should be applied due to the limited time concerns. The high-fidelity prototype is developed to realize the preliminary outlook of the service. Therefore, we decided to leave out some repetitive programming work and aim to focus more on the broader availability of possible functions. For instance, in the mobile online community, the tab bar contains only "friends" and "sports" at the current stage. There is no doubt that more tabs could be incorporated here, but we deem it as an easier programming task compared to implementation of other important functions defined in the specification. In the "My Closet" part, the application directly goes to "tryout" page for matching the outfits because right now there are only tops and bottoms in the closet. In the future, more items such as shoes and accessories can be added to the user's personal closet. In the "My Profile" section, users can only input the personal information manually, which can be replaced by dropdown menus in the further development for them to select. To give users personal recommendations based on the user profile, simple mappings are applied to relating the product profile with the user profile. Details about the extensibility of the project will be examined at a closer look in chapter 9.

As can be seen from Figure 11, functions in the system specification are classified into primary and optional levels. Finally in this project, the primary functions have been implemented (except "Add to cart"), while not all of the optional functions are implemented. We have left the detailed buying process out of implementation in that the page layout can be carefully designed in the similar style based on the design guidelines, and moreover, it requires other system (such as the payment system) to function. Due to the time considerations, it can be the future work that incorporates more project resources. In the current stage, users cannot get alerts from the server. We just stop at the point where the server extracts all the users who are expected to be notified, and writes their IDs into a TXT file. This file can be used in the future to send advertising SMS.

It should also be claimed that since the Apache server is configured as a local host, all the functions in the application requiring an interaction with the server is conducted in the local test. For the functions requiring the integration with the phone (such as SMS), the application is run on the test device (Nokia 6630) with capabilities of data communication. The content files are stored on an FTP site where they can be downloaded to the client, however, there is not any interaction with the server in this case.

7.2 Image format

The image formats that supported by Flash Lite 2.x include JPG, PNG and GIF [6]. During the communication with users, we felt users have a high expectation of the product images. It is evident that elaborate images provide rich information, which is significant to the limited mobile screen displays. On the other hand, the image file size should be kept as small as possible for saving the time and money during content loading. Therefore, the quality of images and the file size are a trade-off.

The original images are saved in PNG formats in that it is a lossless-based compression and therefore can preserve the original information on the picture. GIF is not well suitable for taking this step because of the versatile colors and gradients in the clothes images. Neither is JPG the best choice at this stage due to the fact that it is loss-based compression, leading to the result that the image quality gets worse every time after processing and saving it [39].

Once the image is ready for the application, it should be converted to JPG format. This is the optimization of the image file size. There exists a significant difference in the file size in JPG and PNG formats. For example, a typical thumbnail product image is usually around 1~2 KB in JPG, with the comparison of PNG file at the size of 35~40 KB; the typical detailed product image is around 2~3 KB in JPG, compared to 70KB on average in PNG format. The most important is they can provide the same image quality on the mobile screen.

We have used Adobe Fireworks to process the images, which is in accordance with the Flash Lite design style. The content created by Fireworks can be ported into Flash Lite seamlessly. The process work ranges from collecting the original image, separating the body of the product from the background, and saving the pictures for different usage.

All the image files are stored in the server directory folder for users to download. They can be retrieved by the unique product ID. They are not kept in the database for the purpose of a quicker response.

7.3 Self-defined functions description

The following table lists out all the key self-defined functions in the FLA file.

Function Name	Parameters	Description
setSoftKeys	*left:String*, text to be displayed on the left softkey. *right:String*, text to be displayed on the right softkey.	Remap the soft keys on the device to *left* and *right*.
displayItemInfo	*i:Number*, product item ID	Load the detailed product information identified by *i*
displayColor	*mc:MovieClip*, the target product movie clip lv:LoadVars, the loader for passing variables from server	Display the available colors indicated in *lv* to the target *mc*
updateUserProfile	*target:String*, the target name to be updated in the database, it can be either "top", "bottom", or "friend" *id:Number*, the user ID *list:String*, the list to be set into the database, it can be either a top list, a bottom list, or a friend list	Send the client-side updated *list* from a specified user *id* to the server for updating the database
pageDisplay	*i:Number*, the index of new arrivals	Display product items on the page started with newArrival[*i*]
displayItem	*i:Number*, the index of new arrivals	Load and display one item newArrival[*i*] information
addToMyCloset	*i:Number*, the product ID *myTop:Array*, the user's top array *myBottom:Array*, the user's bottom array	Add the product *i* into the personal closet, and send the updated top or bottom information to server
displayTop	*i:Number*, the index of tops in the closet	Display a top item myTop[*i*] in the movie clip
displayBtm	*i:Number*, the index of bottoms in the closet	Display a bottom item myBottom[*i*] in the movie clip
displayFriend	*i:Number*, the index of friends	Load the detailed friend information identified by myFriend[*i*]
friendPageDisplay	*i:Number*, the index of friends	Display friends on the page started with myFriend[*i*]

Figure 21   Self-defined functions

7.4 Main function module

Flash Lite 2 allows two main options to build an application: the time-line based approach and the pure code approach. The first method mainly uses the labeled keyframes to define the states of the application. Codes are written in the frames on the time line. The transition between states is driven by events either from the system or the user input. In reaction to that, the corresponding service logic is then employed to the next stable state through controlling the playhead, the variables and the objects in the system. The pure code method uses the ActionScript classes to structure the service logic, flow, and entry point. The SWF file more often probably contains only a single code line in the FLA file but nothing on the stage. All the codes are saved in the AS file that is to be imported to the FLA. As compared in the book [16], the reasons why this project takes advantage of the time-line based method lie in that we need to rapidly prototype content within limited timeframes.

In the following sections, function modules will be explained with detailed classes and methods that have been utilized in the development. The sources of all the references come from the Flash Lite help documents [18][19][20] and the related book [16].

7.4.1 The client side

Manage the highlight on the screen
The *Selection* class is used to set and return the focus status on the screen. The method "*setFocus( )*" of the *Selection* class gives focus to the input text field or the button which is specified in the parameter field. Another method "*getfocus( )*" returns the absolute path of the currently focused object.

Handling key and button events
Due to the limited number of keys of mobile phones, and lacking of a clicking mouse for an alternative user input method, keys are therefore even more important in terms of user input.

Keys that have been used in this application involve the 5-way keypad and the left/right soft keys. They are defined as properties respectively from the *Key* class and the *ExtendedKey* class, either in constants or strings. The *Key* class provides methods to capture the information about the keyboard itself and the key presses input. The method "*getCode( )*" returns a string or a number indicating the last pressed key. In Flash Lite 2.x, a key listener is created for the global Key object, listening for the keyboard event. In this project the event is referred to "*onKeyDown*", notified when a key is pressed. The method "*addListener( )*" registers the key listener object to receive the event notifications. [18][19]

Loading external images

A *MovieClip* instance of the *MovieClip* class is created for content loading. The "*loadMovie( )*" method of the *MovieClip* object is used to load the supportive external images into the application. The method passes the parameter "*url*" to the application, which is the absolute or relative path of the JPEG file to be loaded. It should be addressed that Flash Lite limits the number of *loadMovie( )* operations up to five in a given frame, and total operations up to ten at any one time. The excessive loading operations will not be performed due to the limitation. In that case, the loading must be split over multiple frames so that each frame contains less than five *loadMovie( )* calls. [20] Later on, the method "*unloadMovie( )*" can be used to remove the content that has loaded previously by *loadMovie( ).*

Local storage

In the early development, local storage is largely used to store user data on the phone. Some data can also be stored locally in the later phase. For example, if the user has selected "Remember Me", his/her username can be retrieved from the phone's local storage.

Mobile shared objects (MSOs) are introduced to store text, numbers or even complex objects in a persistent local file, and they are ready to be loaded the next time when the application is launched [16]. It requires four steps to follow: add an event listener to the *SharedObject* class; get a handle to a local shared object; inform the user via the listener that the shared object has finished loading; the user can read, write, or clear the shared object's data object.

The *SharedObject* class enables the application content to save data when it is closed and load the data from the phone itself. The method "*flush( )*" is called to write the data to the local file. The method "*getLocal( )*" asks the Flash Lite player to return the shared object available to the current user. The "*addListener( )*" method creates an event listener so that we can find out when the shared object has loaded data from the device. Its arguments include the name of the shared object, and the name of the function which is called to notify the application that the data is finished loading. This function starts with checking the shared object size. If it is 0, we know it doesn't exist out there. If it isn't 0, that indicates the application has been run before and the saved data is then loaded from the shared object data object to the variables on the stage.

Load from remote server

The *LoadVars* class enables the client to load variables from a specified URL. It works much as the XML class in that it passes a number of variables together through one object, but is different from the XML class due to the fact that it transfers the ActionScript name and value pair instead of the XML DOM tree. The "*load( )*" method downloads all the data returned from the server, placing the parsed variables into a *LoadVars* object. And then it can be passed to the client-side variables. The

"*onLoad*" event handler is invoked when the *load( )* has ended operation. The variables are available if it is ended with success.

Interacting with server-side scripts

Two objects of the *LoadVars* class are defined: one is for sending variables and the other is for loading. The method "*sendAndLoad( )*" posts the specified variables in a *LoadVars* object to the target URL, and performs the loading just in the same manner as the *load( )* method.

Integrating with the phone

Extra values can be added to the application if the phone's native functionality is accessible, such as messaging service and battery-level indicators. Figure 22 demonstrates the overall picture of the service and the phone.
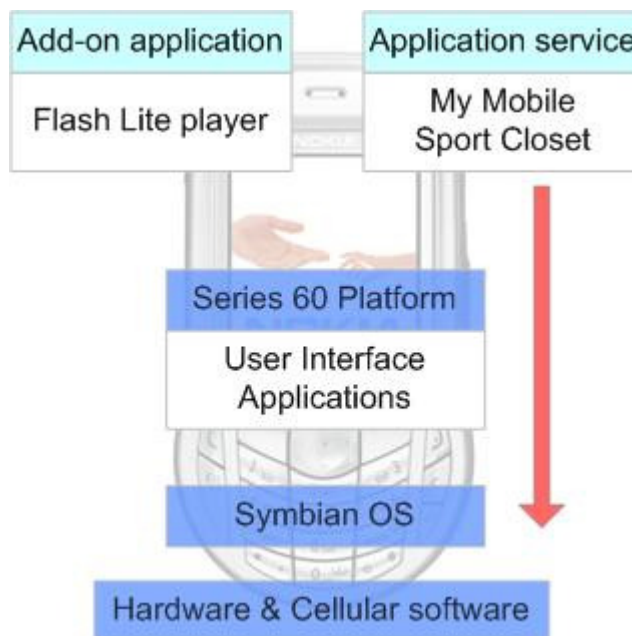

Figure 22   Integrating with the phone (Inspired by [8])

The global function "*getURL( )*" instructs the Flash Lite application to pass arguments to the Symbian OS to deal with. Protocols like "*sms:*" and "*http:*" in the *getURL( )* enable the seamless integration with the phone's built-in SMS and web browsing capabilities. For the optional functions, "*mailto:*" and "*mms:*" protocols are used to open the phone's e-mail composition and MMS editor. As described in the design guidelines, optional parameters have been filled into the subject and message body in advance.

Another global function *fscommand2* provides the device information and exposes native functions to the SWF file. A couple of functions have been introduced to make the application blend in a better way with the phone's normal operation. We can change the color of the focus rectangle by using the *SetFocusRectColor* command;

specify the type of text input by using *SetInputTextType* command; remap the soft keys by using *SetSoftKeys* command; terminate the Flash Lite player by using *Quit* command, and so on.

7.4.2 The server side

Database tables and their relationship

The database contains two tables: one is for the product profile, while the other one is for the user profile (as can be see from Figure 23). The product profile table includes information on the product ID (*id*), product name (*name*), the flag of tops or bottoms (*top*), product tags (*type*), product fabric description (*fabric*), price (*price*), product released date (*date*), available colors (*color*), and finally the product overview description (*overview*). The user profile table contains user ID (*id*), user name (*name*), password (*pswd*), living country (*country*), gender (*gender*), favorite sports (sport), contact email (*email*), preferred fabric (*fabric*), preferred colors (*color*), user story

part x (1 ≤x ≤ 4) (*time*x-*activity*x-*text*x), the number of votes for the story (*vote*),

user friend list (*friendList*), top collection list (*topList*), and bottom collection list (*btmList*).
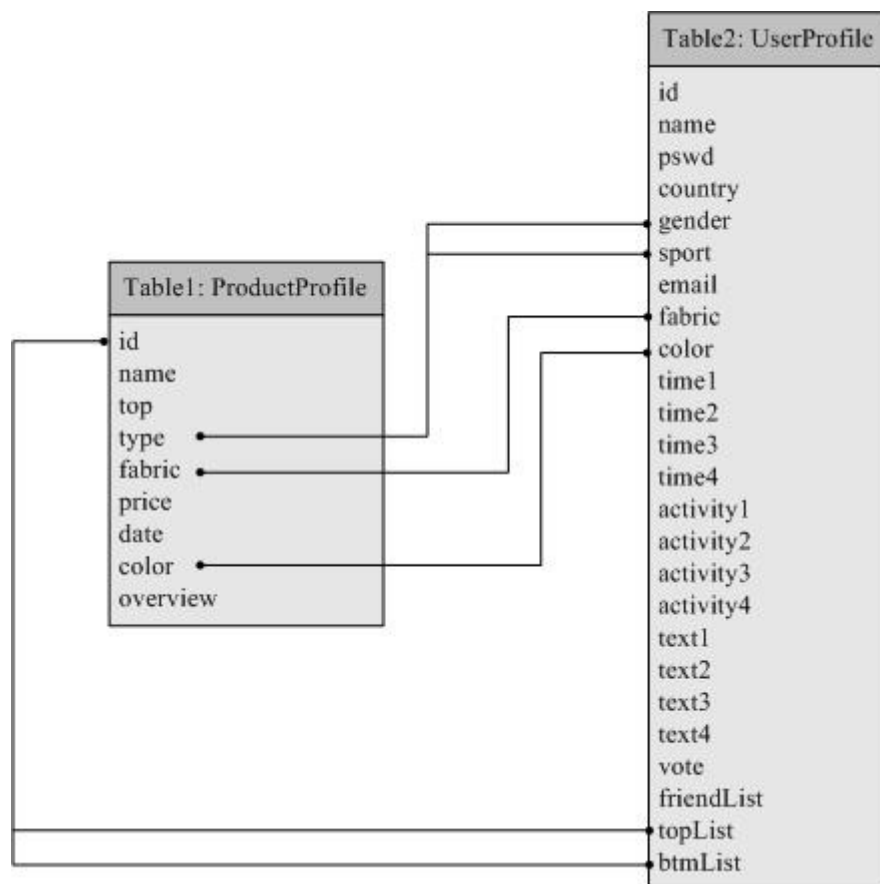

Figure 23   Tables in the database

The projection relations between two tables are employed. For example, the top/bottom list consists of a series of product IDs. The product tags (*type*) may involve the *gender* and *sport* rows in the user profile. It will associate the user preference with the product description. Similarly, the *fabric* and *color* in the product profile can be related to the same context predefined by users. Such a relationship provides the simple matching in order to deliver the relevant information to the right customers. For instance, if a user has a special favor of *blue* color clothes in the fabric of *polyester*, then the server will query the database with a combination of the conditions and derives a list of products meeting the requirements. It is then filled in the recommendation SMS and sent to the user. Such a customized advertising SMS help improve the level of service personalization. It requires a lot of further research in terms of designing a fully functioned context-awareness system. It is not included in this project.

Communication between the server and the database
As mentioned in 5.3, PHP script is introduced to enable the communication between the Apache server and the database. When the client initiates an request to the server, the method *mysql_connect( )* is used for opening the connection to the server and then the current active database can be set through *mysql_select_db( )*. The server sends the query to the database using *mysql_query( )*, the returned result resource is then passed to mysql_fetch_array( ) for fetching a specific property row in the result table. The SQL query string specified in *mysql_query( )* indicates what the server wants to extract from the database. With the query result, the server further returns the variables to Flash Lite by use of *echo* function. If the server needs to write the result to a TXT file (It is useful to update the product list in a TXT file at the server side regularly for users to download), *fopen( )* can be used to open the file (create one if not existed), after which *fwrite( )* is used to write the contents to the file [45].

7.5 Animations in the project

7.5.1 Story-photo cycles

Figure 24 illustrates the process of creating the photo animation in "MS_Reading" page (can be referred to Figure 15). We prebuilt a movie clip that contains images of all the personas photos vertically. A masking layer object, which is required to be completely opaque, is then created to define the visible area. Therefore other photos in the animation layer just below the masking layer cannot be seen by users. After that, a series of tweens should be created to enable the movie clip to move upwards. At the end of this movie clip lies the duplicate image the same as the first one. For users,

when they continue to browse the next photo after the last one (the fourth image), the duplicate image shows up, and then the movie clip goes back to the initial state, where the first image was under the mask again. In this way, the animation sequence will be perceived in a fluid manner. Later, navigation and ActionScript can be added in the timeline to associate the user input with actions on the screen.
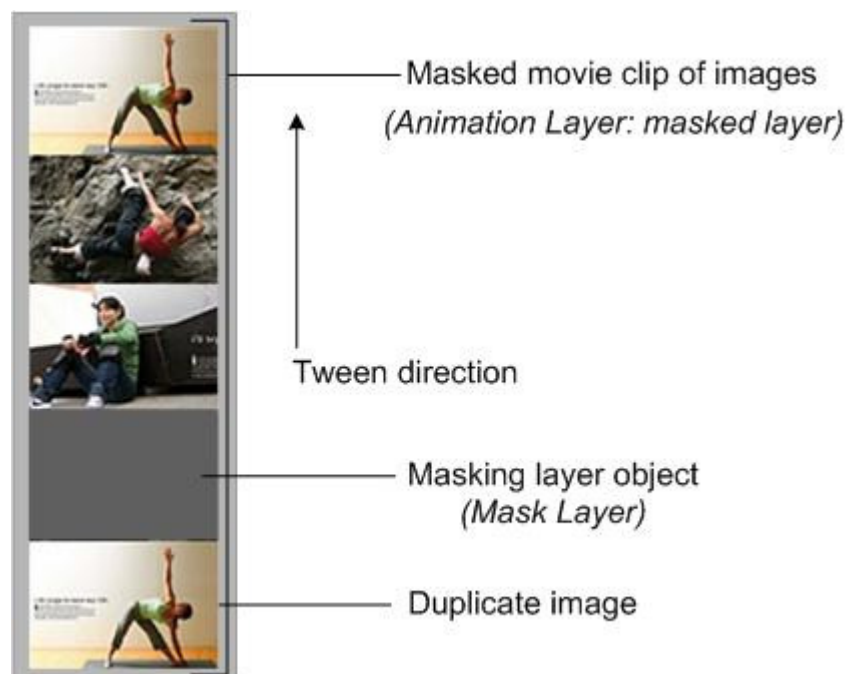

Figure 24   Creating the animation in "My Story"

7.5.2 Matching outfits

The creating process of the animation in "MC_Collection" page (can be referred to Figure 15) is illustrated in the above Figure 25. We try to use only one movie clip to create the effect of pushing the current item to the left with the next item showing up. The animation for retrieving the previous item is in a similar way but merely in the opposite tween direction. In the figure, layer 1 is the mask layer and layer 2 is the animation layer, the content of which is shown through the filled area on the mask. As the figure shown, the current existing movie clip moves to the left first by use of the tween, and then it is removed. A new movie clip of the same type is created ultimately for displaying the next item. Combined with the mask layer, the users will see the current item diminishing from the left side, and the next item displays in place.
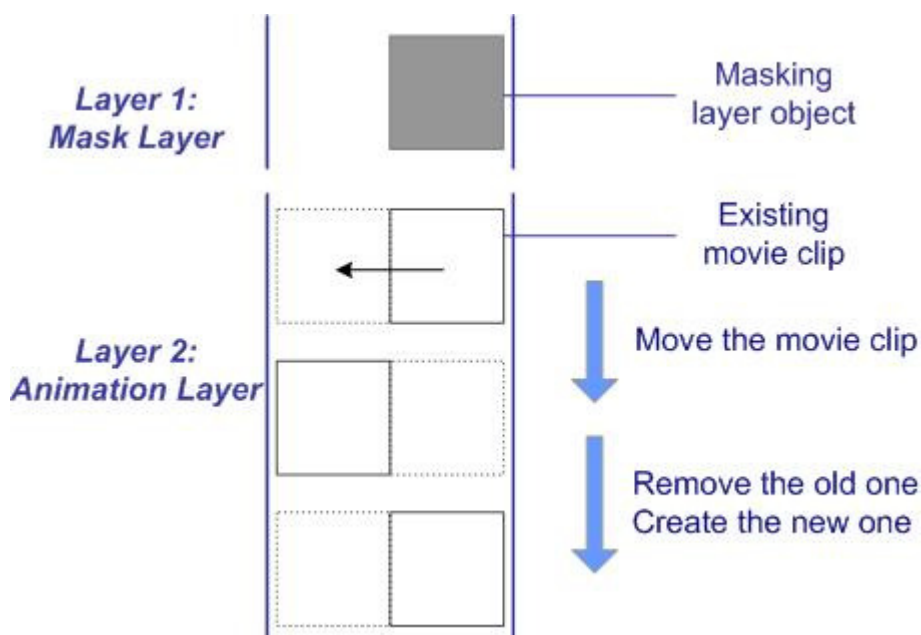
Figure 25   Creating the animation in "My Closet"

7.6 Performance optimization

Since mobile phones has many constraints due to their limited memory and processing power, the application content must be optimized for a better performance as well as a smaller file size on the device. It is important to consider the application performance and optimization at the early start of the project and bear it in mind during the ActionScript development. Issues that should be taken into consideration include:

- **Reuse the symbols in the library**. Symbols are reusable units in Flash Lite. Each time the symbol is reused, Flash Lite creates an instance of it. That means it is merely a point directing to the original element, instead of creating a copy of the symbol in the library. Therefore, the symbol is stored only once in the library [46]. It is proved to be an effective way to keep the file size to a minimum. In the early content creation, one file size was over 200KB, which was drastically reduced to 20KB on average by using this tip.

- **Optimize graphics**. In addition to choosing the best image format and compression rate in the previous discussion (section 7.2), the image file size can be reduced by color tinting instead of importing separate images [9]. In the application, the color blocks showing the available product colors are actually reused elements but only filled with different colors. An additional consideration

for using graphics is to import the graphics at the size of actual usage instead of have to be scaled down in Flash [20].

- **Use device fonts**. It is another effective way to reduce SWF file size and more often, the device fonts tend to be more legible on the screen. In this project, only a small portion of text, the title shown in the navigation bar, uses the embedded fonts. The main part of the page content just uses the device font. Usually the embedded fonts should be added with the Alias Font feature to obtain crisper text [9].

- **Keep animations as simple as possible**. It is avoided to create multiple simultaneous tweens. As the Figure 17-b, only the animation of the photo cycle will be performed. The scrolling bar begins to move when the photo cycle stops at a keyframe. Meanwhile alpha effects should be sparingly used and the animation constrained to relevant areas of the screen [20].

- **Avoid using the user interface components for the desktop Flash**. Since most of the components are designed for desktop Flash, it is not optimized for the mobile phone memory and processing power. In this project, not any components are used directly from the Flash component library.

As mentioned earlier, in the preliminary Flash Lite design, the SWF file for only one (four in total, can be referred to Figure 11) function branch has already come to the size of over 200KB. However, after introducing the tips and techniques discussed above, the complete set of functions (besides the four function branches, we also add other functionalities such as log in and sign up) result in the SWF file at the size of only about 100KB. It is evident for effectively cutting down the file size, and that means the application takes up less memory and improves run time significantly.

7.7 Content distribution

Once the application has been made, it has to be distributed to the client devices. As far as this service considered, a more user-friendly way – using an installer that guides the installing process should be provided for content distribution in a wider scale.

The reasons why to make use of SIS packages on mobile phones lie in the fact that end users can get a SIS package through PC connectivity or from other connections (such as infrared, Bluetooth, MMC etc.), and SIS packages can be upgraded with versioning mechanisms [16]. All the files for the application can be packaged together, and sent to

1. The portal Internet website
2. The sport apparel manufacturer Internet website

3. The portal mobile website

After that, the users can download the installing file (may involve transferring it into the phone if in case 1 or 2). The users will then open the file and start installing. The file is recognized automatically according to the file extension ".sis", and the operating system executes its installer software to start the installation process using the content stored within the SIS file.

In the current market, a number of software tools have been developed as the wizards for the Symbian SDK, for example, SWF2SIS and KVT Symbian Installer [47][48]. Such software tools make it easy to create installers and allow for adding icons to the phone menus. Following the creation steps, the SWF file and additional text files can be selected, together with the icon graphic to be shown in the menu. After the SIS file is created, it is ready for the distribution.

This is only one of the possible ways to distribute the application, and it is the most developer-friendly way.

8 Testing

During the design and implementation period, we have introduced both user tests and the functional test, which will be elaborated in this chapter.

8.1 User test

During the project development, we felt that it is never too over addressed to underline the user centricity. The fact is that, after each phase of design work, more detailed questions will be raised and we are inclined to wonder whether it conveys our ideas to the users, and if the user can satisfy with the work, both from the interface and the functionality aspects. It also motivated us to be more considerate for the final prototype, and meanwhile get a sense of accomplishment after each iterative design. As a matter of fact, quite often the designers will encounter some "stupid" mistakes when it comes to real use. As a rule of thumb, the testing is the process to go, but the result should be aimed at the closer distance to meet end users' expectations. Therefore, it is an urge to communicate with the end users for testing.

8.1.1 Compromise for prototypes

When it comes to practice, one big problem will be how to compromise the prototypes. By their very nature, prototypes are intended to produce something quickly to test an aspect of the product. Therefore it is more often designed and built with the key issues in mind, instead of a perfect operational system. It is proved that two common compromises that are often traded against each other are breadth of functionality provided versus depth.

In this project, the prototypes go through two phases: a low-fidelity prototype produced by Microsoft PowerPoint, and a high-fidelity prototype produced by Adobe Macromedia Flash Lite. The first prototype is more of a horizontal prototyping which provides a series of key functions but with limited content details. Other compromises regard, for example, the internal structure of the system has not been carefully designed, the lack of capability to communicate with the server, and so on. However, it is used for the purpose to give users the visual overview of the system and let them know fundamentally how the system will work. It is the practical result in response to the previous envisions we have described to users about our service, since most of our users have not experienced any mobile shopping. From this prototype we can test for the users' intuition to our interface design, the degree of satisfactory to our key function design. It allows the end users to perform some simple tasks during their interaction with the system. This prototype is built with the intention of throwing it away after it has fulfilled its immediate purpose [13].

The second prototype provides more concrete and comprehensive functions. It is the de facto combination of both horizontal prototyping and vertical prototyping. Nevertheless, compromises also have to be applied here. Originally the high-fidelity prototype is built on real devices, but due to the budget concern, after ensuring the correct and consistent display on devices, it will mainly run on the NOKIA 6630 simulator from Flash Lite. And at the start of the testing phase, not all the functions can be available. Some functions can not be fully realized such as user log in and sending SMS. One obstacle is that Flash Lite still limits some of its classes, components, and built-in API functions within the desktop Flash applications due to the CPU and RAM capability of mobile devices, for instance, the menu items classes, the drag-down list component, the function of uploading files to the remote server, etc. They can only be realized on desktop Flash applications. Some of these obstacles can be overcome by self-producing development work, while others have to be left out as unnecessary details in order to keep focus on the main functions. All of these require extra amounts of time for implementation.

8.1.2 Conduct the test

As illustrated in Figure 10, two rounds of user test were conducted. Due to the time and scale considerations, qualitative tests are more practical to carry out. Along with the test, a number of evaluation techniques are used to facilitate process.

For each round of test, the prototype is tested by one user first. Normally it will result in some obvious problems that need to be configured before carrying out the next test. We are not aimed to concentrate on the large quantity of the users, but with careful focus on the subjective opinions derived from each user.

To obtain a successful user testing, we normally start from a short introduction of the project (it happens at the beginning that we are so familiar with the project that will forget introducing the overall project, and that does confuse the users), and tell the user that their natural behavior is expected. It is anticipated that most people react negatively to being observed. They will lose confidence and become self-conscious when being observed by others. [14] We exert our effort to make them in a happy mood and alleviate their worries through multiple ways. After all, that also benefits a lot in our final derivatives from the users' feedback. We noticed that for inexperienced users (refer to those who have not taken this kind of user test before or not familiar with the user test process), they tend to have a sense of right or wrong judgment (users unconsciously try to produce the result they believe the experimenters are looking for [14]). It is then necessary for us to tell the user that it is the system we are testing but not their performance; any kind of reaction is reasonable so that they don't have to concern too much on their behavior. It is effective to make users easier and more creative by doing so. Another way to put them at ease is to state that they are welcome to ask any questions at any time. It is inevitable for users to doubt a term on the screen or options in the questionnaire, etc. It should be made abundantly clear that it is also part of the iterative design for the testing techniques and contents; their questions will help us provide a more precise and efficient survey for evaluation. All through the evaluation process, one principle to keep in mind for the testers is to hide personal feelings and make sure that we present the evaluation in such a way as to give no clue about what is expected of the users.

8.1.3 The 1st round user test

In this project, we take use of DECIDE framework to guide our evaluations. [13] It helps us set clear goals and ask the right questions during the test. It involves 6 steps to go, among which the first three steps are especially important for planning the test, and the last step for iterative design work:

- *Determine the overall goals for the evaluation*

- *Explore the questions*
- *Choose the evaluation paradigm and techniques*
- *Identify the practical issues*
- *Decide how to cope with the ethical issues*
- *Evaluate and interpret the collected data*

Determine the goals: The 1st round user test is to evaluate the low-fidelity prototype, in the aim to:

1. Check if the functionalities satisfy the users
2. Check if the primary interface is accepted by users
3. Identify how the interface could be engineered to improve its usability

Explore the questions: The goals can be explored with the following detailed questions.

1.1 Do you find the functionalities sufficient?

1.2 Do you want to design your own products through the mobile phone?

1.3 What are the primary concerns in this service (mobile screen size/ mobile payment/ privacy issues/ mobile color display/ mobile input)?

1.4 Comments on the available service development and any suggestions of other possible functionalities?

2.1 Do you understand the icons?

2.2 Is it easy to remind you of where you are? Can you associate the icons in the main menu to the icons in the navigation titles?

2.3 Are you clear of where you are and where you are heading for by virtue of navigation titles?

2.4 Do you find it easy to know which key to press after entering a new page?

2.5 Do you feel enough about the display information? If no, what else more do you want?

2.6 When you press a key, can it function as you want?

3.1 Have you noticed the picture display (you don't have to open it if not wanted), do you preferred this way of displaying in terms of charging GPRS fee?

3.2 Do you prefer the picture display rather than plain text information in the cost of loading time and fee?

3.3 Would you like to share your own stories with other sport friends?

3.4 If possible, would you like to be contacted by revealing necessary contact information to other sport fans within the mobile service community?

3.5 Do you need any HELP information during the using process?

3.6 I am worried about the consistence of the pictures on the mobile phone and the real clothes.

3.7 Have you had any bad experience in the online shopping?

<u>C</u>**hoosing the evaluation paradigms and techniques:** In this user test, the evaluation methods mainly include direct observations, think-aloud, semi-automatic interaction. The first two are easy to understand, the last one is actually the compromise we have to make. The users will perform simple interactions on the prototype, and sometimes it is our responsibility to give instructions when necessary to facilitate the evaluation process. After the test, we will debrief the participants for more personal opinions.

Table 2 specifies the detailed issues in planning the 1st round user test.

Title	Content
Which users: Domain knowledge: IT knowledge: Finding test users:	One + revision. Then 2 more. (F1, M1, M2) None. Know how to use mobile phones. Actual users
Test site:	Indoor office (on Microsoft Powerpoint)
Facilitator: "Computer": Log keeper:	Main contact with user. Semi-automatic for system operations. Notes down – particularly the problem.
Test tasks: Presenting tasks: Start-up state: User instruction: Test method: Data collection:	1. Find a specific item's detailed information. 2. Add one item into your closet. 3. Match an outfit in your closet. 4. Read a sport story. Oral instruction, acting, explaining. Don't give hints! Have registered as a member. A short introduction; As in real life. Observe one user at a time; Think aloud during operation; Semi-automatic interaction. Written notes (primary) Questionnaire (secondary)
Debriefing:	The questions explored using DECIDE.
Planning the time:	Welcome and intro: 5 min Test tasks: 10 min Debriefing: 20 min Total, one user: 35 min

Table 2   The 1st round user test plan

<u>E</u>valuate and Interpret the collected data:
Due to tight time schedule for the preparation work before user tests, only a small test is conducted. Nevertheless, we have obtained valuable qualitative suggestions and use them in the iterative design. Most of the feedback has been accepted provided it is

practical and out of our consideration in the original design, while some of them have to be abandoned from the developer's perspective. The detailed test result can be seen from Appendix B – The 1st round user test result.

Having a look at the determined goals in retrospect, from the answers to the question 1.1 and 1.2, we feel relieved that users are satisfied with the existing functional designs and find it interesting to carry on. Originally the personalized product design on the mobile phone is considered to be an optional function, but it seems that they are reluctant to use the limited screen for designing the personalized products. Both of the users (F1, M1) explained "*if the existing functions can be fully exploited, it is enough*". The result of question 1.3 stresses that the importance of privacy protection and payment security are of primary concerns before the application interface is considered. Answers to the subsequent questions have given us clues for the prototype refinement.

Key iterative designs after the 1st round user test are listed in
Table 3.

No.	Feedback	Inspiration from [user, (answer)]
1	Establish the online community.	[F1, (3) (4)]
2	Separate the clothes from the backgrounds.	[M1, (3); M2, (5-8)]
3	Provide system feedback and help information.	[M1, (9) M2, (5-28)]
4	Provide more detailed product introduction.	[M1, (11) M2, (5-14)]
5	Bugs during the operation.	[M2, (5-15)]
6	Smaller font size in "My Story" and shorter story text.	[M1, (6)]

Table 3   Key iterative designs after the 1st round user test

8.1.4 The 2nd round user test

Determine the goals: The 2nd round user test is to evaluate the high-fidelity prototype, in the aim to:

1. Check if the system functions as expected.
2. Check if the detailed functions sufficient to cover the service.
3. Check if the interface on this prototype is acceptable by users.
4. Identify how the interface could be engineered to offer an optimal user experience.

Explore the questions: The detailed questions are listed in a questionnaire (See Appendix C – Questionnaires for the 2nd round user test).

Choosing the evaluation paradigms and techniques: In this user test, the evaluation methods mainly include direct observations, think-aloud, automatic interaction, and questionnaires. The user first fills out the background information in the questionnaire (Part 1 ~ Part 4), and then works on the prototype on Flash Lite emulator. When they finish all the tasks, they will complete the evaluation part (Part 5 ~ Part 6) in the questionnaire. After the test, we will debrief the participants for the questions to which they have given a low mark.

Table 4 specifies the detailed issues in planning the 2nd round user test.

Title	Content
Which users: Domain knowledge: IT knowledge: Finding test users:	One + revision. Then 2 more. (F2, F3, M3) None. Know how to use mobile phones. Actual users
Test site:	Indoor office (on Flash Lite emulator)
Facilitator: "Computer": Log keeper:	Main contact with user. Automatic for system operations. Notes down – particularly the problem.
Test tasks: Presenting tasks: Start-up state: User instruction: Test method: Data collection:	1. Sign up the system. 2. Log in the system and find a specific item's detailed information. 2. Add tops and bottoms into the closet. 3. Match an outfit in the closet. 4. Read a sport story. 5. Find the help information. Oral instruction, explaining. Don't give hints! A new user. A short introduction and the background information from the questionnaire. As in real life. Observe one user at a time; Think aloud during operation; Automatic interaction. Questionnaires (primary) Written notes (secondary)
Debriefing:	The questions with a low mark in the questionnaires. The open questions at the end of the

	questionnaires.	
Planning the time:	Welcome and intro:	5 min
	Test tasks:	20 min
	Debriefing:	15 min
	Total, one user:	40 min

Table 4   The 2nd round user test plan

Evaluate and Interpret the collected data

From the test result, we are glad to see most users are fond of the application user interface. We have also found out some program bugs for the center and the left softkey. From part 2 and part 4 in the questionnaire, it can be predicted that the higher the users' sports enthusiasm is, the more they will concern about the product functionality. Therefore, the product overview on the functionality is necessary to sport fans. Part 4 also reveals that users will prefer the month fee payment to this service.

The detailed test result can be referred to Appendix D – The 2nd round user test result. Key iterative designs after the 2nd round user test are listed in Table **5**.

No.	Feedback	Inspiration from [user, (answer)]
1	Arrange the information more logically.	[F2, (6-1)]
2	Enhance the text display	[M3, (6-1)]
3	Provide a search engine.	[M3, (6-1)]
4	Change the item colors.	[F3, (6-1)]

Table 5   Key iterative designs after the 2nd round user test

Due to the time considerations, we have just refined the first two feedback suggestions from the users. The others can be put into the future work.

8.2 Functional test

In this project, the functional test is carried out to check if it has fulfilled the system requirements. It focuses on the behavior of the application, and is conducted in the following procedure:

1. List the system input sets to cover the typical input events based on Figure 11 and Figure 15.

2. Fill the test table with the corresponding expected system output.
3. Run the application and compare the outcome to the expected output.
4. If it cannot meet the expected output, fix the bugs and test it again.

The test is carried out mainly in the Flash Lite emulator with the template of Nokia 6630, except the circumstances when the function needs to involve the phone built-in capability such as sending an SMS to friends. In that case, we test the function on the physical mobile phone instead. The detailed test results can be found in the appendix. The system has been verified to perform all the available functions listed in Figure 11 as expected.

9 Future work

This chapter provides the discussion on the future work that extends the current system. It is divided into different levels in terms of the complicity for practical implementation.

This project should be perceived as an initial effort for realizing the proposed mobile shopping process. As is clear in Figure 5, this project corresponds to the *Pre* phase. The user experience is extremely important in this phase other than in the *During* phase in that it is where users decide whether to take the service or not. Due to the fresh hand with Flash Lite and limited time for developing the high-fidelity prototype, we can extend our present work to a future prospect. During the application development, we have found Flash Lite is very efficient and developer-friendly to create graphic-heavy and visually appealing user interface, therefore we feel quite motivated to enrich our service with additional possible functionalities. Here, we list some of them for inspiration.

First, some refinement work can be carried out to improve the present user interface.

- Use drag-down menu options to provide selections for users to choose instead of typing input. It helps relieve the mobile user input to a great extent. Since Flash Lite cannot user the drag-down component, the content can be created based on the Flash Lite 1.1 SDK or created using nested movie clips by ourselves.

- Provide more category tabs on both products and friends. Tabs on products can be enriched with footwear, accessories etc. It can also contain other types of classification like men and women products, or types of various sports. The friends can be further grouped into different genders, countries. However, an increasing number of tabs will introduce conflicts with the limited mobile screen. Therefore, the tabs can be scaled into different layers and meanwhile, more icons can be used instead of long text-based labels to save the screen space.

- Provide a search engine for products and friends. The present version can only enable users to share products through SMS. As a result, when a user gets a recommendation SMS from his friend, he needs to look for the product information and images through such a search function. Therefore, a "Search" page should be created where users can input a combination of search conditions. The template for displaying the "Search Result" can be produced with minimal changes from the current product overview page.

Second, some future functions may require a wider scale of resources to be integrated.

- Cache the personal collection pictures to the device local storage. The MSO in Flash Lite can only store variables at the current stage. In the future, if we have found a way to cache the user's personal collection information in the device, it not only reduces the time for displaying the content on the screen, but also benefits in deploying MMS to share visual products among friends. Although Flash Lite has integrated with the phone's MMS capability, it only activates the MMS editor in the phone. Users cannot share the product through MMS if there are no pictures stored in the phone. As the development of increasing memory capability, it is expected to cache the content locally, especially for graphics storage.

- Step into the *During* process with employing one-click payment. One-click payment requires minimal attention from the mobile users. Nowadays, the payment service providers offer this kind of service between the mobile content pages and the end users. Therefore the secure payment issues can be left to the payment partner who works with a broad range of billers and offers multiple payment options. One-click payment provides the same experience that users are familiar with as PC Internet shopping. Our responsibility is just to design the UI for collecting the ordering information and stop at providing the connection channel to the payment agents.

- Along with the condensing process of purchasing, the user profile database needs to be extended beyond the existing data tables. New tables of "orders", "order details" will be added into the system and the existing user profile and product profile tables should also be enriched more detailed information.

Finally, other improvements that can be considered for inspirations include:

- Change the product color within available ones by using color tinting on product templates.
- Integrate Instant Messaging service in the online community.
- Take advantage of Flash movie to introduce video sport stories.
- Advertising through video mails besides the current SMS.
- Advertising based on context awareness associated with time and weather changes.

10 Conclusion

This thesis actually originates from a simple click on an online advertisement. Attracted by the rich user experience with the Internet shopping experience, the author began to consider porting the same kind of application to the mobile world. Therefore, assumption was made that a sport apparel manufacturer is in need of exploring new sales channels within M-commerce realm apart from their current e-business strategies. And we are supposed to provide a personalized mobile service to the virtual sport apparel manufacturer: My Mobile Sports Closet.

During the past six months working on this project, there have been great challenges from a personal perspective. Since the proposed application is graphic-heavy, and the user experience is expected to be put forefront, we have chosen Flash Lite as the client side development technology. Then the biggest challenge to come up with is the green hand to Flash Lite. Although the early phase in this project does not involve any Flash Lite development work, it is required to pour time for learning the ActionScript and producing the animations in Flash. In addition, it is not recommended to use the components that are especially designed for desktop Flash, as a result, we have developed our own equivalent components for mobile phones.

The second challenge is the fresh hand to the user experience design. The whole design process is quite different from the traditional technology-centric development. Inspired from the existing methodology framework, we have followed the typical user experience design process throughout the project.

The next obstacle is the collection of the raw information. Since the project is a virtual one, there is not any existing database ready to use. However, we have managed to collect all the images and text-based information from the Internet and furthermore to process and format it ready for this project.

Besides the challenges stated above, it is also high demanding to play multiple roles in this project, spanning from a technical developer to a user experience designer, from a content provider to a little bit viral to the service provider. Accordingly, we have been keeping our main position as the content provider and balance ourselves between the technical developer and the user experience designer roles.

The last challenge that has been brought about is the interface design constrained by the mobile phone physical limitations: the small display screen and the limited user input. We have been trying to use the design guidelines together with the feedback from the users to optimize the interface and interaction design.

The end results of this thesis include:

- A high-fidelity prototype has been developed with a clear focus on user experience, encompassing personalization and community-based interaction. It enables users to register at the system, browse the new releases, manage the personal closet, and share sport stories within personal circle of friends, It runs in a different manner from the mobile internet shopping in that the dynamic updating content has been separated from the UI framework, it eliminates the unnecessary loading of the UI elements during information browsing.

- Positioning the service target end users: youth and young generation, and potentially the elders who have a craze for sport.

- Depicting the service value system to give a clear overview of the market players with regards to this service. The "content provider centric business model" is expected to be introduced for this service.

- Meeting the end users' expectations by following the user experience design process. It started out with user requirement analysis, followed by system specification, user interface and interaction design, and finally the visual design. The user needs have been addressed at the forefront in order to improve the user satisfaction and brand-loyalty.

- Providing a most probable way for a wider scale of content distribution. By creating the SIS package file, users can easily transfer the installation file into their mobile phone and complete the installing process.

- Identifying the issues for optimizing Flash Lite application performance. It is evident that "reuse the symbols in the library", "optimize graphics", and "use device fonts" have reduced the SWF file size significantly.

- Making compromises in the earlier user tests. From the experience in user tests, it is proved that scenario description and semi-automatic test lead to a more practical and realistic way to achieve a better and more effective communication with users.

This report presents an initial effort in developing a mobile shopping service on sport clothes, corresponding to the *Pre* phase in Figure 5. The subsequent detailed purchasing process is not included in the current project. It requires amounts of extra efforts and time and to integrate more resources into the system. Moreover, the privacy and security issues for this service should be extended in the future work.

Anyway, developing "My mobile sport closet" has been fun by using Flash Lite. It contains diversified drawing APIs and provides an efficient way to visualize the content creation. In that way, we are able to focus the attention where it should be – the user experience.

There have been rapid changes during the past half a year in Flash Lite. The enhanced version with more powerful features gives rise to more service possibilities, and it will absolutely excite the users for meeting their expectations of a good user experience. On the other hand, we should notice that since the immaturity of Flash Lite technology, some functions are still limited to be realized. At the current stage, a combination of development technologies is recommended to enrich the function sets as well as impose on the user experience. For example, Flash Lite can work with J2ME on network activity and with Python for S60 on hard-ware level integrations.

From the author's personal opinion, Flash Lite wins its unique advantages for developing mobile application services. However, it should better cooperate with other technologies to extend its potential to a great extent.

References

Articles

[1] Randy Giusto. (2007) "*Creating a More Engaging Mobile Experience*", USA.

[2] PauSisler, Catherine. Titta. (2001) "User Experience Design for Working Web Sites and Applications", STC Proceedings.

[3] Giovanni Camponovo, Yves Pigneur. (2003) "*Business Model Analysis Applied To Mobile Business*". The university of Lausanne.

[4] Spiridoula Koukia, Maria Rigou etc. (2006) "*The Role of Context in m-Commerce and the Personalization Dimension*", IEEE.

[5] Jeffrey L. Funk. (2006) "*The future of mobile shopping: The interaction between lead users and technological trajectories in the Japanese market*", Tokyo, Japan.

[6] Adobe Systems Incorporated, "*Feature comparion: Adobe Flash Lite, Flash Player and Flash SDK at a Glance*". 2007.

[7] NOKIA. "*Flash Lite: Visual Guide*", Forum NOKIA, Version 1.1; 6 July, 2006

[8] Pertti Korhonen. "*Mobile Minds: Life goes mobile*", Nokia Mobile Internet Conference 2003 – Press Day.

[9] Nokia. "*Flash Lite for s60 – an emerging global ecosystem*", May 2006.

[10] Bill Perry. (version 1.8) "*Devices-with-FL-pr-installed*", 7 November 2007.

[11] UMTS Forum. (2002) "Charging, Billing and Payment Views on 3G Business Models", London UK.

Books

[12] Ben Shneiderman. (2002) "*Leonardo's Laptop – Human Needs and the New Computing Technologies*". p.2.

[13] Jennifer Preece, Yvonne Rogers, HellenSharp. (2002) "*Interaction design: beyond human-computer interaction*", John Wiley and Sons, NY.

[14] Matt Jones, Gary Marsden. (2006) "Mobile Interaction Design", John Wiley and Sons, UK.

[15] Barbara Ballard. (2007) "*Designing the Mobile User Experience*", John Wiley & Sons, Ltd, England.

[16] Richard Leggett, Weyert de Boer, Scott Janousek. (2006) "*Foundation Flash Applications for Mobile Devices*", New York.

[17] Jesse James Garrett. (2003) "*The Elements of User Experience: User-Centered Design for the Web*", New Riders Press, New York.

Tutorials

[18] Macromedia Flash. (2006) "*Introduction to Flash Lite 2.x ActionScript*", San Francisco.

[19] Macromedia Flash. (2006) "*Flash Lite 2.x ActionScript Language Reference*", San Francisco.

[20] Macromedia Flash. (2006) "*Developing Flash Lite 2.x Applications*", San Francisco.

[21] Adobe. (2007) "*Getting Started with Flash® Lite ™ 1.x*", California, USA.

Internet resources

[22] Available from the Internet:
Nike.com Web Page
http://www.nike.com/index.jhtml#l=nikehome&re=US&co=US&la=EN
[cited 11 November 2007; 14:50]

[23] Available from the Internet:
Welcome to adidas Web Page
http://www.adidas.com/dk/shared/home.asp [cited 11 November 2007; 14:53]

[24] Available from the Internet:
Shneiderman's Eight Golden Roles of Interface Design Web Page
http://www.artificialmemory.net/(S(5dbbrqiznswbin55ac1bmw55))/doc/2003.03.
12_EightGoldenRulesofInterfaceDesign.htm [cited 23 August 2007; 12:56]

[25] Available from the Internet:
PHP- Wikipedia, the free encyclopidia Web Page
http://en.wikipedia.org/wiki/PHP#Server-side_scripting [cited 1 November 2007;
13:53]

[26] Available from the Internet:
*Macromedia – Press Room: Use of Mobile Data Services Hampered by Poor
User Experiences* Web Page
http://www.adobe.com/macromedia/proom/pr/2005/mobile_survey.html
[cited 9 November 2007; 13:53]

[27] Available from the Internet:
RBK.com Web Page
http://www.rbk.com/rbklaunch.aspx?country=se [cited 11 November 2007;
14:56]

[28] Available from the Internet:
Compete on Usability: What's user experience? Web Page
http://joshualedwell.typepad.com/usability_blog/2007/07/whats-user-expe.html
[cited 12 November 2007; 11:56]

[29] Available from the Internet:

How To Quantify The User Experience? Web Page
http://snowwon.tistory.com/tag/brand [cited 12 November 2007; 13:14]

[30] Available from the Internet:
Intelligent Experience Design-Articles-What is User Experience Design Web Page
http://www.paradymesolutions.com/articles/what-is-user-experience-design/
[cited 18 November 2007; 13:50]

[31] Available from the Internet:
User Experience Design Web Page
http://www.semanticstudios.com/publications/semantics/000029.php
[cited 18 November 2007; 14:20]

[32] Available from the Internet:
Macromedia-Flash Lite 1.1: Features Web Page
http://www.adobe.com/products/flashlite/productinfo/features/flashlite_1_1.html
[cited 7 November 2007; 10:50]

[33] Available from the Internet:
Macromedia-Flash Lite: features Web Page
http://www.adobe.com/products/flashlite/productinfo/features/
[cited 7 November 2007; 12:20]

[34] Available from the Internet:
Adobe-Mobile & devices: Supported Devices: Handset Manufacturers Web Page
http://www.adobe.com/mobile/supported_devices/handsets.html
[cited 19 November 2007; 21:20]

[35] Available from the Internet:
Mobile development – Wikipedia, the free encyclopedia Web Page
http://en.wikipedia.org/wiki/Mobile_development
[cited 20 November 2007; 17:33]

[36] Available from the Internet:
design-nation.blog/en: FlashLite or J2ME? Web Page
http://www.design-nation.net/en/archives/000453.php [cited 20 November 2007; 20:23]

[37] Available from the Internet:
So You're Thinking About Using Flash Instead of J2ME? Web Page
http://www.adobe.com/devnet/devices/articles/flashlite_j2me_04.html
[cited 20 November 2007; 17:50]

[38] Available from the Internet:
Porting J2ME games to Flash Lite Web Page
http://www.adobe.com/devnet/devices/articles/porting_j2me_flashlite.html
[cited 20 November 2007; 17:55]

[39] Available from the Internet:
Image file formats – TIF, JPG, PNG, GIF Web Page
http://www.scantips.com/basics09.html [cited 20 November 2007; 22:53]

[40] Available from the Internet:
Adobe Press Room: For immediate release Web Page
http://www.adobe.com/aboutadobe/pressroom/pressreleases/200709/100107Flash
Lite3.html [cited 21 November 2007; 11:50]

[41] Available from the Internet:
UsabilityNet: International Standards Web Page
http://www.usabilitynet.org/tools/r_international.htm [cited 21 November 2007;
21:45]

[42] Available from the Internet:
Flash Lite 3: Features Web Page
http://www.adobe.com/products/flashlite/features/ [cited 21 November 2007;
11:57]

[43] Available from the Internet:
Flash Lite: FAQ Web Page
http://www.adobe.com/products/flashlite/faq/ [cited 21 November 2007; 12:51]

[44] Available from the Internet:
Flash Lite-Developer Edition Web Page
http://www.adobe.com/products/flashlite/developer_edition/
[cited 21 November 2007; 15:53]

[45] Available from the Internet:
PHP: Function Reference – Manual Web Page
http://dk2.php.net/manual/en/ref.mysql.php [cited 28 November 2007; 10:50]

[46] Available from the Internet:
Introduction to Flash Symbols Web Page
http://www.bellaonline.com/articles/art34608.asp
[cited 28 November 2007; 11:15]

[47] Available from the Internet:
SWF2SIS from BlueskyNorth Web Page

http://www.blueskynorth.com/swf2sis/ [cited 29 November 2007; 9:15]

[48] Available from the Internet:
   Kheng Vantha Welcome to My home Page Web Page
   http://www.kvtsoft.net/ [cited 29 November 2007; 9:18]

[49] Available from the Internet:
   http://www.adobe.com/cn/devnet/devices/articles/tmobile_launch_04.html [Cited 30 April 2007; 23:42]

[50] Available from the Internet:
   M-Commerce Web Page.
   http://www.mobileinfo.com/Mcommerce/index.htm [Cited 2 November 2007; 14:42]

[51] Available from the Internet:
   Mobile e-commerce? It's on the move Web Page.
   http://www.allbusiness.com/management/3592752-1.html
   [Cited 2 November 2007; 14:50]

[52] Available from the Internet:
   Products, Services & Applications Suited for M-Commerce Web Page.
   http://www.mobileinfo.com/Mcommerce/prod_serv_appl.htm
   [Cited 2 November 2007; 15:20]

[53] Available from the Internet:
   Mobile Shopping in Japan – Next Great Thing Web Page.
   http://www.nextgreatthing.com/2007/11/12/mobile-shopping-in-japan/
   [Cited 2 November 2007; 15:20]

[54] Available from the Internet:
   Adobe-Developer Center: iShop Web Page.
   http://www.adobe.com/devnet/devices/articles/ishop_03.html
   [Cited 2 November 2007; 15:56]

[55] Available from the Internet:
   S60 Phones Web Page.
   http://www.s60.com/life/s60phones/displayDeviceOverview.do?deviceId=1
   [Cited 28 November 2007; 10:52]

Lecture slides and reports

[56] Jakob Nybo. "IBM's e-business class at DTU, Module 2: e-Business Strategy", June 2006.

[57] Henning Olesen. "*Enrichment of services: Personalization, context awareness and identity management*", 23 October, 2007.

[58] Report:
Emir Mehmedalic, Ricardas Brazinskas, etc. "Towards the good user experience", December 2006.

Pictures

Courtesy of the Nike website

All the images involved in this project are not for any commercial purpose.

Appendices

Appendix A –Features of different Flash Lite versions

A.1 Flash Lite 1.x

Flash Lite 1.x features are listed as follows [32], the detailed architecture of S60 implementation of Flash Lite 1.1 will be placed in the appendix:

- **ActionScript Extensions**: new extensions allow the application to access the phone-specific capabilities directly from ActionScript.
- **Network Access and Connectivity**: the *getURL( )* function can be used to load contents from a web server over HTTP(*http:*) or Secure Sockets Layer HTTP (*https:*), to send e-mail (*mailto:*), or to dial a phone call (*tel:*). It is also possible to load new data using *loadVariables( )*, and *loadVariablesNum( )* functions, and to load SWF files through *loadMovie( )*, *loadMovieNum( )* functions.
- **Additional Audio Support**: Flash Lite 1.1 adds additional support for MP3, PCM, ADPCM and SMAF audio formats besides the device-dependent MIDI support.
- **SVG-T Playback**: Operators and OEMs now can license a single solution

supporting Flash and the animations created using SVG-T, instead of integrating a number of solutions together into one project. Many applications are capable of supporting Flash and SVG-T playback using Flash Lite 1.1.

▪ **Scaleable Rendering Engine**: The core rendering engine has a small and compact footprint, and is deployable across a number of handsets and platforms. It is the standard based on which rich interactive content is supported.

▪ **Static, Dynamic Text and User Input**: static text and dynamic text fields are supported in Flash Lite 1.1. It also supports input text for runtime data entry by the user. The native text entry mechanism, for example T9, is also supported.

▪ **Navigation and Key Events**: Three keys are used for navigation within the interactive Flash movie: Up, Down, and Select. Other keys available to attach ActionScript involve 0,1,2,3,4,5,6,7,8,9,*, and #.

▪ **Fonts and Text**: Flash Lite 1.1 supports for both device fonts and embedded fonts. The embedded fonts enable the developers more control over the information design, however, it may increase the final SWF file size explicitly.

▪ **Event and Streaming Sound**: It includes support for MIDI, MFi, SMAF, uncompressed PCM (or WAV), compressed ADPCM, and compressed MP3 audio formats for event sound; PCM (or WAV), ADPCM, and MP3 audio formats for local and streamed playback; and SMAF for local audio playback in handsets using Yamaha audio chips.

Flash Lite 1.1 is supported in devices starting from S60 2nd Edition, Feature Pack 3 [9]. From a global perspective, devices supporting Flash Lite 1.1 include the Symbian S60-based devices from Nokia, Sendo, and Siemens, and the Symbian UIQ-based devices from Sony-Ericcson. As of this writing, some devices come with Flash Lite 1.0/1.1 preinstalled from the device manufacturer while others still need to have it installed manually after purchasing. From a regional perspective, devices in Japan usually come with the pre-installed Flash Lite and support several content types [21].

A.2   Flash Lite 2.x

Flash Lite 2.x features are listed as follows [33], the detailed architecture of S60 implementation of Flash Lite 1.1 will be placed in the appendix:

▪ **Flash Player 7 support**: It is based on Flash 7, and consequently all the contents developed in the latest Flash environment can be re-purposed for mobile devices.

▪ **Multi-Platform support**: Flash Lite 2.1 provides support for a number of key open platforms in the market, involving Symbian S60 v2/v3, Qualcomm BREW 2.x/3.x and Microsoft Windows Mobile 5.

▪ **Dynamic XML data**: It supports for loading and parsing external XML data by using the same XML handling methods as Flash Player 7.

▪ **Persistent data**: It is now capable of storing data locally in a file on the device.

Such application-specific information can be retrieved in the next time when it launches. This provides a more robust development environment.

- **Powerful and dynamic media**: It includes support for dynamic loading of multimedia content based on the supportive codecs available on the device, for instance, loading and handling XML data and SWF content. It also supports in place video and loading external multimedia such as gif/jpeg/png images and audio.

- **Text enhancement**: Users are enabled to modify text color, size, and other properties at run time. Vector fonts can be embedded into the applications for text rendering.

- **Shape drawing ActionScript API**: ActionScript 2.0 can be used for easy creation of sophisticated vector graphics and animated shapes at run time.

- **Action Script 2.0 support**: Flash Lite 2.x is based on the ECMA 262 standard, and enables the content developer with a modern event model, tab index control, shape drawing API, and better SWF compression.

- **Synchronized device sound**: The animation can be synchronized with the sound data in device specific sound formats.

- **Compressed SWFs**: SWF files which have been compressed using the Flash authoring tool are renderable in Flash Lite 2.x, for it will decompress the file before it starts.

- **Tighter device integration**: Flash Lite 2.x includes device fonts, dynamic multimedia, inline video, and pass-through to local codecs.

As of this writing, a large number of devices from Nokia, LG, Motorola, and Samsung are available either with Flash Lite 2.x pre-installed [10] or via over-the-air download [34]. Detailed information about Flash Lite on each device can be referred to [34][10].

A.3   Flash Lite 3

Flash Lite 3 is based on Flash 8 equipped with typical feature enhancements on Flash compatible video and dynamic web content [40], which provide even richer and more engaging experiences to users. The detailed new capabilities in Flash Lite 3 are listed as follows:

- **FLV support**: Flash Lite 3 supports FLV video format, as is the most popular one on the internet. Users can transport their web video experience from the desktop to the mobile phone. Video codecs of On2 VP6 and Sorenson are supported.

- **Improved web browsability**: With support for most Flash 8 content, users now can view their favorite web videos and popular new and entertainment sites created by recent Flash authoring tools.

- **Faster performance**: Flash Lite 3 has improved rendering, scripting speed, and code optimization.

- **MMI extensions for UI design**: MMI extensions enable the same source assets to

be used across multiple handset design, and enable more customized UIs.

- **Integrated authoring environment**: A new component, Adobe Device Central CS3, has explored new avenues for content preview and test. Developers are able to update device profiles regularly in consistent with new device releases. At the other hand, manufacturers use web-based Adobe Device Intelligence Portal for publishing their latest device information to Adobe authoring tools.
- **Multiplatform support**: The reference platforms available for Flash Lite 3 are Symbian OS v3 and Microsoft® Windows® XP.

Flash Lite 3 Developer Edition is optimized for Symbian version 3 handsets and has been certified on Nokia N95 by Adobe. The Flash Lite 3 Developer Edition will be available for noncommercial distribution in the Mobile and Devices Developer Center in November 2007. [43] Flash Lite 3 will be shipped with device at late 2007. Nokia has announced the first mobile phones that will start shipping with Flash Lite 3 pre-installed will be in Q1 2008 [44]. Some other OEMs plan to start shipping in the upcoming 2008 as well.

Appendix B – The 1ˢᵗ round user test result

User 1 (F1, *24, female, project planner, sports enthusiasm: high, favorite sports: dancing, roller skating, cycling, badminton*)

Question	Answer
1.1	Sufficient and interesting
1.2	Not necessary.
1.3	payment > privacy > color display > information > screen size > input
1.4	(1) Prefer to browse the products rather than buying.
	(2) Feel more of an experience to have fun.
	(3) In My Story, sport fans in online community can be classified, for example, by gender, types, friend list.
	(4) If I can keep an eye on my friends' collection, that would be great.
	(5) Prefer the third-party payment, ensuring the after-sale refund.
	(6) Worried about the B2C credibility. Trust in the notable brand manufacturer.
	(7) Would like to make new friends through the mobile service.
	(8) Care about the personal information revealed to others, but it is OK if using a virtual ID.
2.1	Yes. It is easy to understand.
2.2	Yes. The navigation bar is clear.
2.3	Yes.
2.4	Yes.
2.5	Yes.
2.6	Yes.
3.1	This is good.
3.2	Yes, I preferred the picture information better.
3.3	Yes.
3.4	Yes, but with a virtual ID.
3.5	Yes.
3.6	Yes.
3.7	Yes. I had a bad experience one time when buying the shoes, because it is inconsistent with what I've seen on the picture. But thanks to the third-party payment, it's been settled out very easily.

Table 6   The 1st round user test result -- user 1 (F1)

User 2 (M1, *25, male, environmental engineering student, sports enthusiasm: low, favorite sports: jogging, swimming*)

Question	Answer
1.1	Sufficient, attractive.
1.2	Not necessary.
1.3	payment > privacy > information > input > color display > screen size
1.4	(1) In the main menu, more space should be left between lines. (2) I would like to browse more pictures. (3) The product pictures are clear, but it is better to separate clothes from background. It will create a real feeling of trying. (4) The "Turn around" is good. (5) The discount comparison information would be tempting. (6) The story text font can be smaller. And the story is not necessarily to be too long. (7) Personal information such as email can be public, but too private information such as mobile number should be invisible to others. (8) Trust in the service authorized by the well-known brand. (9) I want more help information, or probably a simple hot-line service. (10) Products should be classified into types. (11) Improve more detailed product introduction. (12) Terms in the main menu and the navigation bar should be the same. (13) I prefer to use the application in micro-breaks, when I'm alone.
2.1	Yes.
2.2	Yes. Pay attention to the consistent terms.
2.3	Yes.
2.4	Yes.
2.5	Yes. More detailed information such as the fabric and function is required.
2.6	Yes.
3.1	It is considerate. But if I use the service, I won't care too much about the cost of pictures, as long as it is elaborate images.
3.2	Yes, very much.
3.3	Yes, it's fine.
3.4	Yes. (Please refer to (7)).
3.5	Yes.
3.6	Yes.
3.7	No. All the experience is quite good.

Table 7   The 1st round user test result -- user 2 (M1)

The test result from user 3 (M2, *26, male, environmental engineering student, sports enthusiasm: high, favorite sports: football, golf, cycling, skiing*) is presented in Table 8.

Appendix C – Questionnaires for the 2nd round user test

Welcome !
First, we have a few background questions before we start with the questionnaire.

Part 1. Basic information

Please answer the following questions about yourself-

Enter your age here:

Gender: ☐ Female ☐ Male

Part 2. Technical Experience

Of the following mobile devices, software, and systems, please check those that you have personally used and are familiar with:

☐ mobile phone	☐ mobile E-mail
☐ PDA	☐ download image
☐ keypad	☐ ring tone
☐ touch screen	☐ browsing news
☐ hand input	☐ ring back tone
☐ MMS	☐ music
☐ WAP	☐ game
☐ GPRS	☐ video
☐ SMS	☐ mobile TV

☐ MMS   ☐ online community

Part 3. Enthusiasm on sport

1. Of the following types of sports, check those that you have personally interested in and are familiar with:

    ☐ football   ☐ yoga

    ☐ basketball   ☐ pilates

    ☐ volleyball   ☐ body bike

    ☐ rugby   ☐ steps

    ☐ badminton   ☐ bodytoning

    ☐ rugby   ☐ fighterfit

    ☐ tennis   ☐ jogging

    ☐ golf   ☐ skiing

    ☐ cycling   ☐ others:

2. Please list out the sports you've participated during the past week/month (if any).

    _____ _____ _____ _____

Part 4. Shopping Behavior

1. Imagine you are about to make a decision about whether to buy the product. Please prioritize your concerns in terms of mobile shopping. You can mark "1" to "4" representing the primary concern to the least concern.

☐ product style   ☐ color   ☐ fabric   ☐ sport functionality

Please mark the degree of your intuition by inserting "|".

2. I'm loyal to my favorite brands.

    Not at all - - - - - - very much

3. I would like to share with my friends about the product if I find it attractive.

    Not at all - - - - - - very much

4. I'm quite interested in mobile shopping and want to have a try.

    Not at all - - - - - - very much

5. I usually buy new clothes once a :

    ☐ week   ☐ month   ☐ season   ☐ half year   ☐ year

6. I prefer to pay for the service by

    ☐ month fee   ☐ per MB

Part 5. Evaluation on the application

OVERALL REACTION TO THE SOFTWARE		-3	-2	-1	0	1	2	3		N/A
1.	terrible	☐	☐	☐	☐	☐	☐	☐	wonderful	☐
2.	difficult	☐	☐	☐	☐	☐	☐	☐	easy	☐
3.	frustrating	☐	☐	☐	☐	☐	☐	☐	satisfying	☐
4.	inadequate functions	☐	☐	☐	☐	☐	☐	☐	adequate functions	☐
5.	dull	☐	☐	☐	☐	☐	☐	☐	stimulating	☐

		-3	-2	-1	0	1	2	3		N/A
6.	rigid	☐	☐	☐	☐	☐	☐	☐	flexible	☐

SCREEN		**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**		**N/A**
7. Colors used are	unnatural	☐	☐	☐	☐	☐	☐	☐	natural	☐
8. Pictures brightness	bad	☐	☐	☐	☐	☐	☐	☐	good	☐
9. Character shapes (fonts)	barely legible	☐	☐	☐	☐	☐	☐	☐	very legible	☐
10. Understanding the icons	confusing	☐	☐	☐	☐	☐	☐	☐	very clear	☐
11. Quality of the images	bad	☐	☐	☐	☐	☐	☐	☐	good	☐
12. Highlighting on the screen	confusing	☐	☐	☐	☐	☐	☐	☐	very clear	☐
13. Arrangement of information on screen	illogical	☐	☐	☐	☐	☐	☐	☐	logical	☐
14. Amount of information displayed on screen	inadequate	☐	☐	☐	☐	☐	☐	☐	adequate	☐
15. Going back to the upper-level screen	impossible	☐	☐	☐	☐	☐	☐	☐	easy	☐
16. Sequence of screens design	confusing	☐	☐	☐	☐	☐	☐	☐	very clear	☐

TERMINOLOGY AND SYSTEM INFORMATION		**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**		**N/A**
17. Use of terms throughout system	inconsistent	☐	☐	☐	☐	☐	☐	☐	consistent	☐
18. Terminology relates well to the work you are doing	never	☐	☐	☐	☐	☐	☐	☐	always	☐
19. Mobile keeps you informed about where you are	never	☐	☐	☐	☐	☐	☐	☐	always	☐
20. Performing an operation leads to a predictable result	never	☐	☐	☐	☐	☐	☐	☐	always	☐

LEARNING		**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**		**N/A**
21. Getting started	difficult	☐	☐	☐	☐	☐	☐	☐	easy	☐

22. Learning the service   difficult ☐ ☐ ☐ ☐ ☐ ☐ ☐   easy   ☐

23. Exploring of features   discouraging ☐ ☐ ☐ ☐ ☐ ☐ ☐   encouraging   ☐

24. Number of steps per task   too many ☐ ☐ ☐ ☐ ☐ ☐ ☐   just right   ☐

25. Steps to complete a task   illogical ☐ ☐ ☐ ☐ ☐ ☐ ☐   logical   ☐

26. Feedback on the completion of the steps   unclear ☐ ☐ ☐ ☐ ☐ ☐ ☐   clear   ☐

27. Performing tasks is straightforward   never ☐ ☐ ☐ ☐ ☐ ☐ ☐   always   ☐

28. Help messages are expected   not at all ☐ ☐ ☐ ☐ ☐ ☐ ☐   very much   ☐

Part 6. Open questions

The advices you are writing here are highly appreciated.

Please list the most **negative** aspect(s):

1. _____

2. _____

3. _____

Please list the most **positive** aspect(s):

1. _____

2. _____

3. _____

The evaluation is finished now, Thanks for your time.

Appendix D – The 2nd round user test result

		User 3 (M2)	User 4 (F2)	User 5 (F3)	User 6 (M3)
Part 1					
1	**Age**	26	24	25	25
2	**Gender**	M	F	F	M
Part 2					
1	**Technology acquaintance**	high	medium	high	high
Part 3					
1	**Favorite sports**	football, golf, cycling, skiing	football, swimming	tennis, badminton, cycling, swimming, bodytoning, jogging, dance	volleyball, bodybike, badminton, jogging, cycling
2	**Recent sport activities**	none (busy with report)	fitness	badminton, swimming, jogging	fitness
Part 4					
1	**Required Information**	1. Functionality 2. Product style 3. Color 4. Fabric	1. Product style 2. Fabric 3. Color 4. Functionality	1. Functionality 2. Product style 3. Fabric 4. Color	1. Functionality 2. Product style 3. Fabric 4. Color
2	**Brand loyalty**	6	5	4	4
3	**Share with friends**	4	4	4	5
4	**Interests in mobile shopping**	medium	medium	high	very much
5	**Shopping frequency**	per month	per season	per month	per season
6	**Pay the service**	month fee	month fee	month fee	month fee
Part 5					
OVERAL REACTION TO THE APPLICATION					
1	**Wonderful**	2	2	3	2
2	**Easy**	3	3	3	3
3	**Satisfying**	2	2	3	2
4	**Adequate functions**	2	2	3	2
5	**Stimulating**	3	2	3	1

#					
6	Flexibility	1	2	3	2
SCREEN					
7	Colors used are	2	3	3	1
8	Pictures brightness	0	3	3	3
9	Fonts	2	2	2	2
10	Understanding the icons	2	3	2	3
11	Quality of images	3	3	3	2
12	Hightlighting	3	3	2	2
13	Information arrangement	2	1	3	1
14	Amount of displayed information	1	2	3	2
15	Going back to the upper-level screen	1	1	3	3
16	Sequence of screens design	2	2	3	2
TERMINOLOGY AND SYSTEM INFORMATION					
17	Use of Terms throughout system	3	1	3	3
18	Terminology relates well to the work you are doing	1	2	3	2
19	Mobile keeps you informed about where you are	2	0	3	2
20	Performing an operation leads to a predictable result	2	1	2	3
LEARNING					
21	Getting started	3	2	3	2
22	Learning the service	2	3	3	3
23	Exploring of features	3	2	3	2
24	Number of steps per task	2	2	3	3

25	Steps to complete a task	2	2	3	3
26	Feedback on the operation	2	2	3	3
27	Performing tasks is straightforward	2	2	3	3
28	Help information are expected	3	1	2	2
Part 6					
1	**Negative aspects**		Difficult to find price information.	Can be more user friendly; Change the product colors	Increase the font size; Lack of a search engine.
2	**Positive aspects**		Nice user interface; Easy to use.	Good visualization; Good idea; Easy outfit matching, feel good about the "turn around"	Great concept; Easy to navigate generally.

Table 8   The 2nd round user test result

In Table 8, the test result of user 3 is based on the low-fidelity prototype. It should be attributed to the 1st round user test result. It is listed here just for presenting the collected data.

Appendix E – Functional test

Case No.	Input	Expected Output	Output
1.1	Select <SIGN UP> by pressing the <Enter> or left softkey	Display the "MP_UserInfo" page	Passed
1.2	User name; Password; Gender; Country; email; sport; Select <Submit> by pressing the left softkey	Display the "Success" or "Failure" notification on the system board	Passed
1.3	Select <MainMenu>	Display the "Main Menu" page.	Passed
1.4	User name (correct); Password (correct); Select <LOGIN> by pressing the <Enter> or left softkey	Display the "Welcome" message on the system board	Passed
1.5	User name (wrong) or Password (wrong); Select <LOGIN> by pressing the <Enter> or left softkey	Display "Sorry, there is no username with the specified password" on the system board	Passed
1.6	Select <Try again> by pressing the left softkey	Return to "LOGIN" page	Passed
1.7	Check <Remember Me> checkbox	Show the same username in the text field of Username in the next time when the application starts	Passed
1.8	Select <OK> by pressing the left softkey	Display the "Main Menu" page	Passed
1.9	Press <Up> or <Down> key	Change the focus rectangular onto different options	Passed
1.10	Select <Log off> by pressing the right softkey	Display the "LOGIN" page	Passed
2.1	Press <Enter> or left softkey for selecting "New Arrival" option	Display the "NA_Overview" page; Load the product images and information	Passed
2.2	Press <Up> or <Down> key in New Arrivals	Change the focus rectangular onto different product items, in a	Passed

		cycle	
2.3	Press <Enter> key in "NA_Overview"	Display the "NA_Detail" page; Load the text information;	Passed
2.4	Press <Enter> key in "NA_Detail"	Display the "NA_Image" page; Load the front-side large image of the product	Passed
2.5	Select <Turn around> by pressing the left softkey	Display the "NA_Image" page; Load the back-side large image of the product	Passed
2.6	Press <Up> key in "NA_Image"	Display the "NA_Detail" page	Passed
2.7	Select <Option> by pressing the left softkey in New Arrival	The submenu is popped up	Passed
2.8	Select <Open> by pressing the <Enter> or left softkey	Display the "NA_Detail" page; Load the text information;	Passed
2.9	Select <Add to My closet> by pressing the <Enter> or left softkey	Display the current status of your personal closet on the system board	Passed
2.10	Select <MyCloset> by pressing the left softkey	Display the "MC_Collection" page	Passed
2.11	Select <Tell a friend> by pressing the <Enter> or left softkey	Fill the SMS with the content "*You friend xxx has shared the item[x]: xxx with you!*"	Passed
2.12	Select <Help> by pressing the <Enter> or left softkey	Display HELP information on the system board	Passed
2.13	Select <Exit> by pressing the right softkey in "NA_Overview"	Go back to the "Main Menu" page	Passed
2.14	Select <Back> by pressing the right softkey in "NA_Detail"	Go back to the "NA_Overview" page	Passed
2.15	Select <Back> by pressing the right softkey in "NA_Image"	Go back to the "NA_Detail" page	Passed
2.16	Press <Up> or <Down> key in "NA_Detail" or "HELP"	The scrolling bar will move upwards and downwards, along with the scrolling text	Passed
3.1	Press <Enter> or left softkey for selecting "My Closet" option	Display the "MC_Collection" page; Load the product images and information	Passed
3.2	Press <Up> or <Down> key in "MC_Collection"	Change the focus triangle between tops and bottoms	Passed
3.3	Press <Right> or <Left> key in "MC_Collection"	Change the current item with the next or previous item to display	Passed
3.4	Press <Enter> key in	Display the "MC_Detail" page;	Passed

	"MC_Collection"	Load the text information;	
3.5	Press <Enter> key in "MC_Detail"	Display the "MC_Image" page; Load the front-side large image of the product	Passed
3.6	Select <Turn around> by pressing the left softkey	Display the "MC_Image" page; Load the back-side large image of the product	Passed
3.7	Press <Up> key in "MC_Image"	Display the "MC_Detail" page	Passed
3.8	Select <Option> by pressing the left softkey in My Closet	The submenu is popped up	Passed
3.9	Select <Open> by pressing the <Enter> or left softkey	Display the "MC_Detail" page; Load the text information;	Passed
3.10	Select <Delete> by pressing the <Enter> or left softkey	Display the current status of your personal closet on the system board	Passed
3.11	Select <Add to Cart> by pressing the left softkey	Unavailable in the current version	╱
3.12	Select <Tell a friend> by pressing the <Enter> or left softkey	Fill the SMS with the content "*You friend xxx has shared the item[x]: xxx with you!*"	Passed
3.13	Select <Help> by pressing the <Enter> or left softkey	Display HELP information on the system board	Passed
3.14	Select <Exit> by pressing the right softkey in "MC_Collection"	Go back to the "Main Menu" page	Passed
3.15	Select <Back> by pressing the right softkey in "MC_Detail"	Go back to the "MC_Collection" page	Passed
3.16	Select <Back> by pressing the right softkey in "MC_Image"	Go back to the "MC_Detail" page	Passed
3.17	Press <Up> or <Down> key in "MC_Detail" or "HELP"	The scrolling bar will move upwards and downwards, along with the scrolling text	Passed
4.1	Press <Enter> or left softkey for selecting "My Story" option	Display the "MS_Community" page; Load the story persona's images and information	Passed
4.2	Press <Up> or <Down> key in "MS_Community"	Change the focus rectangular onto different stories in a cycle	Passed
4.3	Press <Right> or <Left> key in "MS_Community"	Change the current highlight to different tabs	Passed
4.4	Select a story by pressing <Enter> or the left softkey in	Display the "MS_Reading" page; Load the images and story part1;	Passed

	"MS_Community"		
4.5	Press <Down> key in "MS_Reading"	The animation moves to the next image; Load the next story part; The scrolling bar moves to the next stage	Passed
4.6	Select <Option> by pressing the left softkey in "MS_Reading"	The submenu is popped up	Passed
4.7	Select <Vote> by pressing the <Enter> or left softkey	Display the result of the operation; "# *friends voted for this story*"	Passed
4.8	Select <View his/her closet> by pressing the <Enter> or left softkey	Display friend's collections	Passed
4.9	Select <Edit My story> by pressing the <Enter> or left softkey	Display the "MP_MyStory" page	Passed
4.10	Select <Save> by pressing the left softkey	Display the "Success" or "Failure" feedback on the system board	Passed
4.11	Select <OK> by pressing the left softkey	Display the next story editing page	Passed
4.12	Select <Help> by pressing the <Enter> or left softkey	Display HELP information on the system board	Passed
4.13	Select <Exit> by pressing the <Enter> or left softkey	Go back to the "Main Menu" page	Passed
4.14	Select <Back> by pressing the right softkey in "MS_Reading"	Go back to the "MS_Community" page	Passed
4.15	Select <Exit> by pressing the right softkey in "MS_Community"	Go back to the "Main Menu" page	Passed
4.16	Press <Up> or <Down> key in "HELP"	The scrolling bar will move upwards and downwards, along with the scrolling text	Passed
5.1	Press <Enter> or left softkey for selecting "My Profile" option	Display the "MP_UserInfo" page containing the latest registered information;	Passed
5.2	Select <Exit> by pressing the right softkey in "MP_UserInfo"	Go back to the "Main Menu" page	Passed

Table 9   Functional test result
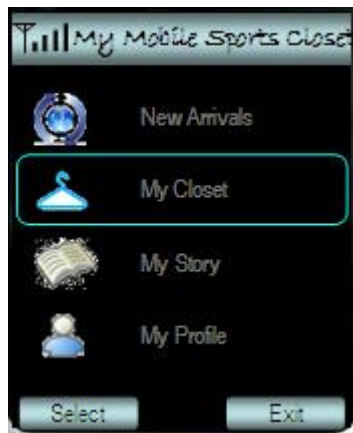
Appendix F – Low-fidelity prototype screenshots

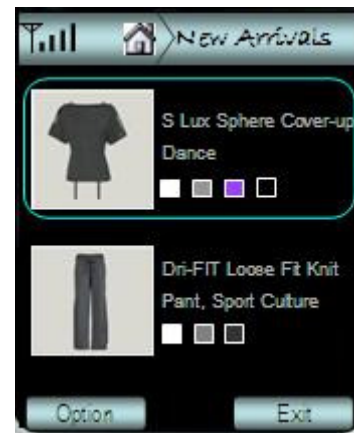**Figure 26   MMSC Prototype 1 - Main Menu page**

Figure 27   MMSC Prototype 1 – New Arrivals page

Figure 28   MMSC Prototype 1 – popup menu page

Figure 29   MMSC Prototype 1 – product detail information page

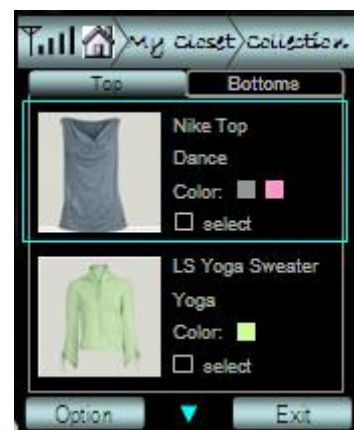

Figure 30   MMSC Prototype 1 – product detail image page
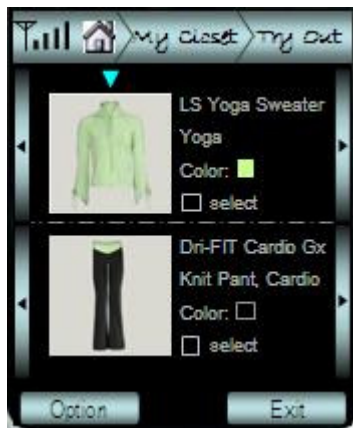

Figure 31   MMSC Prototype 1 – My Closet: Collection page

Figure 32   MMSC Prototype 1 – My Closet:
Try Out page

Figure 33   MMSC Prototype 1 – My Story:
Overview page

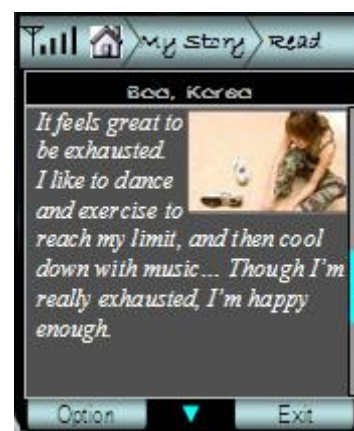**Figure 34   MMSC Prototype 1 – My Story:**
Community page

Figure 35   MMSC Prototype 1 – My Story:
Read page

Appendix G – High-fidelity prototype screenshots
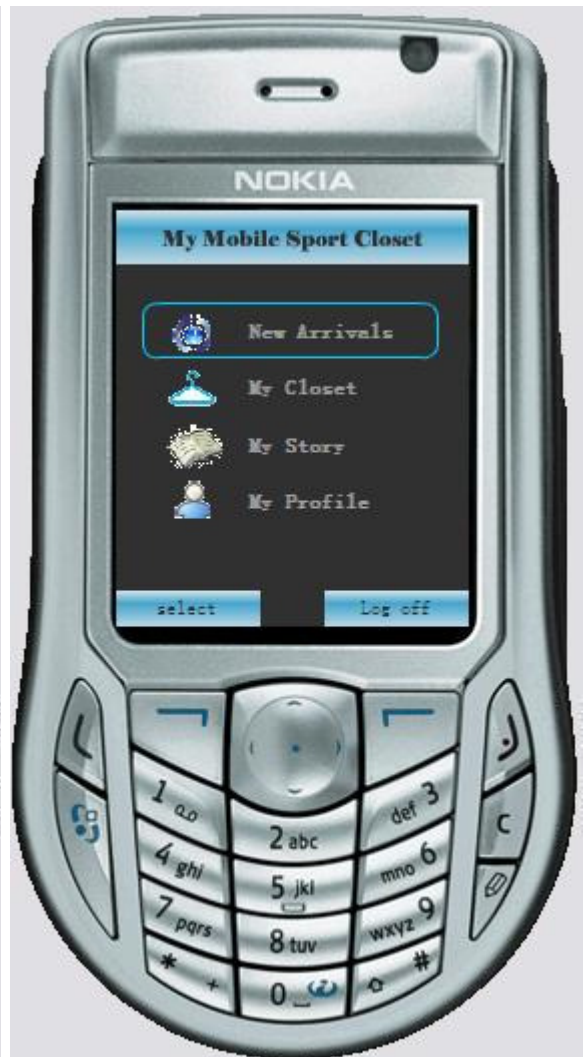

Figure 36   MMSC Prototype 2 – Login page

Figure 37   MMSC Prototype 2 – Main Menu page

**Figure 38   MMSC Prototype 2 –
NA_Overview page**

**Figure 39   MMSC Prototype 2 – NA_Detail
page**

Figure 40   MMSC Prototype 2 – NA_Image page

Figure 41   MMSC Prototype 2 – MC_Collection page

Figure 42　MMSC Prototype 2 –
MS_Community page

Figure 43　MMSC Prototype 2 –
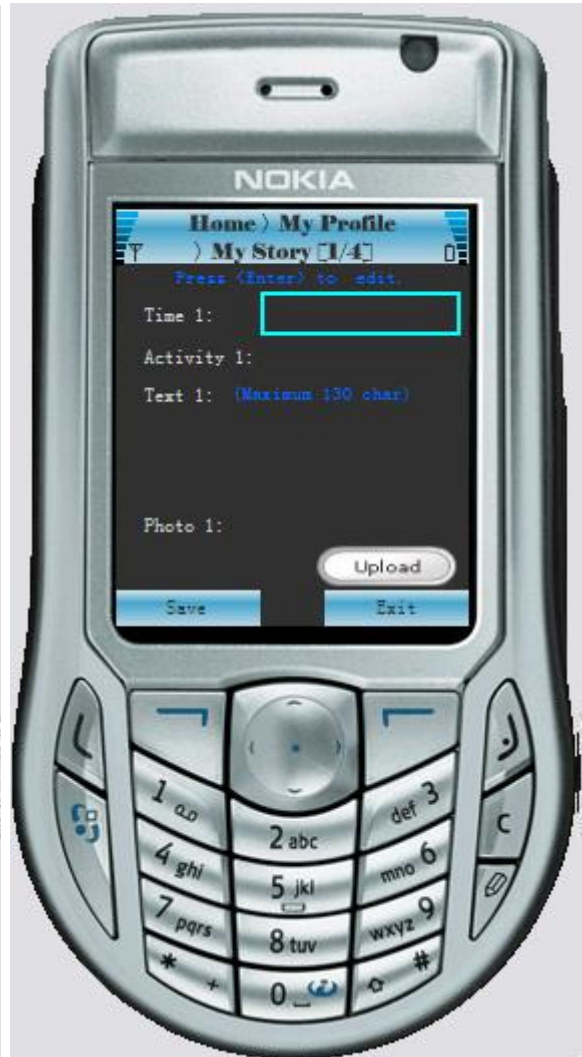**MS_Reading page**

Figure 44   MMSC Prototype 2 –
MP_UserInfo page

Figure 45   MMSC Prototype 2 –
MP_MyStory page