A comparative study of Java Micro Edition and Flash Lite for mobile data services

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Abstract

Mobility is one of the most invigorating features, having an enormous impact of how communication is evolving into the future. It is estimated that there are over two billion mobile subscribers worldwide and that this figure is projected to grow close to four billion by 2010, which is 50% of the world's population. As voice becomes less of a deterministic factor in reducing customer churn, mobile operators are now looking to mobile data services to differentiate themselves from their competitors and at the same time, generate substantial revenue in order to maintain or increase their market share. This has led to the advancement of mobile data services ranging from simple text messaging to complex e-commerce services. However, the right development tools are required to ensure the rapid and efficient creation, deployment, and management of these mobile data services.

This thesis offers a feature-by-feature analysis and comparison of the well-established Java Micro Edition (JME) and the emerging Adobe Flash Lite mobile development environments. The results obtained show various strengths and weaknesses of the two environments enabling trade-offs to be made when developing specific mobile data services. JME currently provides more control and functionality over mobile applications through it numerous APIs, whereas Flash Lite allows for the efficient and rapid creation of mobile applications with rich graphical user interfaces.

Table of Contents

Chapter 1 : Introduction 9

1.1. Background 9

1.2. Project Introduction 10

1.2.1. Motivation 10

1.2.2. Project Objective 11

1.2.3. Project Approach 11

1.2.4. Thesis Structure 11

Chapter 2 : Related work 12

2.1. Mobile phone data evolution 12

2.1.1. The dynamics of mobile phone data evolution 12

2.1.2. Widespread adoption of mobile phones 14

2.1.2.1. Culture 15

2.1.2.2. Wireless Technologies 17

2.1.2.3. Independent manipulation of devices 19

2.2. Types of mobile phone data services 19

2.3. Short Message Service 20

2.4. E-commerce services 21

2.4.1. Mobile Gaming 21

2.4.2. Mobile Television 21

2.4.3. Mobile data service Technologies 22

2.4.3.1. First generation communication 23

2.4.3.2. Second generation communication 23

2.4.3.3. 2.5 generation communications 24

2.4.3.4. Third generation communications 25

2.4.3.5. Higher bandwidth capabilities 25

2.5. Mobile Data Services in South Africa 26

2.6. Wireless Technologies in South Africa 26
2.7. Mobile Operators in South Africa 26
2.8. Data services in South Africa 27
2.9. Future of Mobile phone data services 27
2.9.1. Mobile phone innovation 27
2.9.2. Upcoming Mobile data services 28
2.10. Development Environments/Platforms 29
Symbian 30
Palm OS 30
Windows CE 30
Java Micro Edition 30
Adobe Flash Lite 31
2.11. Chapter Review 32
Chapter 3 Design and Implementation 33
3.1. The Mobile Movie Booking System 33
3.2. Hardware, Software and Network Environment 34
3.3. Developing the Middle tier Web Component 37
3.3.1. Java Servlet technology 37
3.3.1.1. Servlets 37
3.3.1.2. Servlet tasks 38
3.3.2. Developing servlets for the Mobile Movie Booking System 39
3.3.2.1. The movieDetails Servlet 39
3.3.2.2. The bookedSeats Servlet 41
3.3.2.3. The clientDetails Servlet 43
3.3.3. Middle tier web component classes overview 45
3.3.4. Packaging the servlets 46
3.4. Designing the backend data component 47

3.4.1. The movies database 47
3.5. Chapter Review 48
Chapter 4 Development of the JME and Flash Lite front tier 49
4.1. JME overview 51
4.2. Adobe Flash Lite overview 51
4.3. Developing the Mobile Movie Booking System front tier 52
4.3.1. Design and implementation 52
4.3.1.1. Creating graphical user interfaces 56
4.3.1.2. Network connection 58
4.3.1.3. Handling Dynamic XML in JME 59
4.3.1.4. Multimedia content handling 59
4.3.1.5. Persistent Storage 61
4.4. Chapter Review 62
Chapter 5 Benchmarking Flash Lite against JME 63
5.1. General Comparisons 63
5.1.1. Foundation Language 63
5.1.2. Mobile device diversity (fragmentation) 63
5.2. Mobile device comparison 64
5.2.1. Runtime environment 64
5.2.2. Persistent Storage 65
5.2.3. Dynamic XML handling 65
5.2.4. Multimedia capabilities 66
5.3. Development tools comparison 68
5.3.1. Available IDEs 68
5.3.2. Emulator platforms 69
5.3.3. GUI designing 69
5.3.4. Packaging and Deploying 69

5.3.5. Help System 70

5.4. Industry Support Comparison 70

5.4.1. Market penetration and Community Support 70

5.5. Chapter Review 71

Chapter 6 Conclusion and possible project extensions 74

6.1. Conclusion 74

6.2. Project Achievements 74

6.3. Project limitations 75

6.4. Possible Project Extensions 75

6.4.1. A comparative study of Flash Lite 3.0 and Java Micro Edition 75

6.4.2. A comparative study of JavaFX Mobile and Flash Lite 75

Chapter 7 Bibliography 76

Appendix 88

Table of Figures

Figure 2-1: Global mobile content revenues 2001-2011 [Screen Digest 2007] 22

Figure 3-1: Use Case Diagram for the Mobile Movie Booking System 34

Figure 3-2: Hardware and Network Environment 35

Figure 3-3: Overview of three-tier architecture 36

Figure 3-4: *movieDetails* Servlet Logical Flow Chart 40

Figure 3-5: *bookedSeats* Servlet Logical Flow Chart 42

The *clientDetails* servlet is responsible for processing a booking request from a client (Figure 3-6). . 43

Figure 3-7: Middle tier web component classes overview 45

Figure 3-8: *movies* database showing related tables 47

Figure 4-1: *Mobile Booking* system front tier Logical Flow Chart 50

Figure 4-2: Java Technology for the Wireless Industry (JSR 185) architecture [Sun 185] 53

Figure 4-3: Flash Lite 2.1 architecture 53

Figure 4-4: JME front tier class diagram 55

Figure 4-4-5: User interfaces in JME and Flash Lite 57

Figure 4-4-6: Custom elements in JME and Flash Lite 58

Figure 4-7: JME Mobile Media API (MMAPI) classes 60

Figure 4-8: Video playback under JME and Flash Lite 2.1 61

Figure 5-1: Average Time required by Flash Lite and JME to access XML data 66

Figure 5-2: Time required for video play in Flash Lite and JME development platforms 67

Table of Figures

Table 2-1: A causal model for wireless data services [Preez, and Pistorius, 2002] 13

Table 2-2: Factor analysis of mobile phone use motives [Wei 2006] 15

Table 2-3: Eleven main attributes of mobile data services 17

Table 2-4: US Mobile Data Revenues, by Category, 2009 (billions and % of total revenue) [Belcher 2007] 20

Table 5-1: Flash Lite vs. JME overview 72

Chapter 1 : Introduction

1.1.Background

Initially, speech quality was the most important factor for customers in selecting mobile communication services [Mattila 2003], but with the advancement of technology leading to improved audio quality, the difference is less noticeable and speech quality is no longer a competitive factor in attracting and retaining customers. This increases the already high levels of volatility and rapid rates of change experienced in the mobile industry. For example, in 2006, voice calls for the majority of UK users declined by 28 % for prepaid customers and by 22 % for postpay customers [Ahonen 2007]. Over the same period SMS text messaging grew by 43 %. Whilst voice revenue continues to fall, there are an estimated 350 billion text messages sent every month globally [Kona LLC. 2007]. This shows a paradigm shift in the factors that are contributing to the increase of revenue for mobile operators. In addition to the nullifying of voice as a competitive factor, mobility companies are faced with great expenses in the acquiring of licenses to offer 3G services. In the majority of countries this is done by way of an auction. More than $95 billion has been spent on 3G licenses and $125 billion invested on technology infrastructure by major mobility companies such as Vodafone, France Telecom and Deutshe Telecom [Forrest Research 2000]. It is expected to take a long time to recoup these costs. Another challenge faced by operators includes high levels of customer churn (customers switching to another MNO) and the lack of Mobile Network Operator's (MNO) intelligence on customers' usage patterns. According to Preez et al. [Reinhardt et al. 2001], customer churn is exacerbated by trends such as shorter contract lifecycles (12 months instead of 24) and number portability, where a customer keeps their number when they switch to another operator. To address these concerns, mobility companies are now looking to mobile data services. A mobile data service is any service offered on a mobile phone besides voice. Data services are a source of additional revenue, which could slow the current trend of falling Average Revenue per User (ARPU) and support the recovery of 3G license costs. Data services could also provide operators with customer information since they may be required to register for the service and in the process complete a questionnaire regarding preferences about the potential client. In addition, data services could reduce customer churn by offering unique and vibrant services. As discussed in the next chapter, there may also be lucrative relationships that develop as a result of mobile data service usage. For example, research shows that there is a positive correlation between mobile data service usage and increase in voice usage. That is, the more a customer uses data services the more they are like to use voice [Wei 2006]. As an example, a customer may make a voice call on receiving e-mail from a friend or an SMS about a promotion hosted by a company.

1.2. Project Introduction

1.2.1. Motivation

Mobility companies realize the great opportunities offered by mobile data services. However, significant challenges exist in deploying these services. Key among these challenges is the ability to quickly and easily create, deploy, and manage content and applications on mobile devices. With worldwide mobile phone shipments expected to reach 930 million units in 2009 [Linsalata et al, 2005], it is critical that wireless carriers, content developers, and handset manufacturers have the right tools that respond to the challenges of this complex and growing mobile market. Several mobile development environments that attempt to address these challenges exist. The Java Micro Edition (JME) and Adobe Flash Lite mobile development environments are two highly contended rivals that are of particular interest to this project.

Java Micro Edition is the most well-established platform for creating applications for a variety of mobile devices. JME has become a ubiquitous platform with over 1.2 billion Java technology-powered phones shipped by the end of 2006 [OpenLaszlo, 2006], and over 700 JME-enabled devices available [Sun devices]. JME includes robust security, built-in network protocols, and support for networked and offline applications that can be downloaded dynamically. Applications based on JME are portable across many devices, yet leverage each device's native capabilities [Sun Home].

Adobe Flash Lite is a lightweight version of Flash Player suitable for the processing and memory capabilities of mobile phones and handheld multimedia computers. Flash Lite is emerging as a global phenomenon, enabling for the rapid and efficient development of rich user interfaces and delivery of rich multimedia content to mobile devices. There has been a rapid growth of devices that can run Flash software increasing from 38 million in 2005 to more than 220 million in early 2007. Adobe expects the number of such devices to reach the 1 billion mark by 2010 [Nokia, 2007]. As of June 2007, there were 300 Flash-enabled mobile devices available [Adobe products].

With such astounding figures and projections, led by the growing demand for mobile data services, it is of importance to study and compare the various implementations of mobile data development offered by the mature JME platform and the emerging Flash Lite development environment. This will enable developers to make informed decisions as to which environment offers tools best suited for a particular application.

1.2.2. Project Objective

The primary objective of this project is to conduct a comparative study of the Java Micro Edition and Flash Lite development environments for the development of mobile data services. The conclusions drawn will enable a trade-off decision as to which platform to use for development of a particular mobile data service. This will inevitably optimize the creation, deployment, and management process of the mobile application.

1.2.3. Project Approach

A mobile application, incorporating key features that influence the wide adoption and development of mobile data services, was developed under both JME and Flash Lite platforms. These features involved multimedia content playback, dynamic content handling, and client-server communications. Based on the analyses and results obtained from both design and implementation exercises, a comparative study was made of the two development environments and their associated run-time support systems. Finally, conclusions were drawn up from the study.

1.2.4. Thesis Structure

Chapter 2 outlines several factors that determine the wide adoption and development of mobile data services. This chapter also discusses current mobile technologies ranging from the wireless network infrastructure to the available mobile data services, as well as the projected trends and expectations in the mobile industry. Chapter 3 discusses the design and implementation of the mobile application that was developed to compare the capabilities of the JME and Flash Lite platforms. This is then followed by an analysis into the development of the JME and Flash Lite mobile applications in Chapter 4. Chapter 5 gives a detailed comparison between the two mobile development environments. Chapter 6 concludes the project by giving the conclusion and stating the possible future research work in relation to this project.

Chapter 2 : Related work

This chapter outlines several factors that determine the wide adoption and development of mobile data services. We also discuss current mobile technologies ranging from the wireless network infrastructure to the available mobile data services, as well as the projected trends and expectations in the mobile industry.

2.1.Mobile phone data evolution

2.1.1. The dynamics of mobile phone data evolution

With increasing functionality and services offered, the mobile phone as a hybrid medium has become an integral part of mass communication presenting an alternative channel of communications and entertainment. Given the high penetration rate of mobile phones and an increasing number of mobile data services as illustrated in the previous chapter, the mobile phone can no longer be viewed simply as a peer-to-peer mobile talking device. This section draws on the uses and gratifications framework to examine and gain a better understanding of the expanded use of the mobile phone for mass communications and entertainment. Most research on this subject has only focused on one aspect that may contribute to the expanded use of the mobile phone and mobile data services. For example, one may focus on reasons why people use the new functions on a mobile phone and who tends to use mobile data services, whilst another may simple focus on the spectrum of technologies in the mobile industry as a key contributor to mobile phone data evolution. This approach might not present a realistic view of the development of this industry as it focuses on a single subset of an otherwise vast universe of contributing factors and also tends to ignore relationships and trends that may exist between factors. Hence, a broader approach encompassing several factors that contribute to the development of mobile data services is necessary. Instead of immediately focusing on the trend or development itself, the forces that produce the change or drive the trend are first examined. This is a more reliable way of analysing the dynamics of technological change since the factors that cause change are normally not themselves volatile over the short term [Preez and Pistorius 2002]. Table 2-1 shows a causal model compiled for the 2.5/3G wireless data development [Preez and Pistorius 2002].

Table 2-1: A causal model for wireless data services [Preez, and Pistorius, 2002]

Force producing change/driving trend	Trend	Impact/effect
• More and more of work and personal lives are spent on the move • Telecommuting and organisations with mobile workforces are on the increase • Globalisation	Increase in time spent away from home or office where users have access to Internet and/or corporate information sources	Demand for ubiquitous access to information and services (personal and business)
		Demand for greater convenience—ability to control home appliances from anywhere (monitor alarm, set VCR/central heating, etc.)
	Increase in time spent away from home town or city	Demand for access to location-based information from mobile devices (e.g., directions to get from X to Y; location of nearest restaurant, pharmacy, etc.)
Various enablers facilitate easier access to a wider range of information (e-mail, eRooms, electronic newletters, Internet)	Information overload	Demand for ability to filter information and customise the presentation according to personal preferences
Dramatic decrease in costs of mobile services	Increase in mobile usage	Mobile phones starting to replace wireline (fixed line) phones
Advances in semiconductor technologies	Smaller components; devices with improved display and computing functionality	Mobile access devices capable of offering complex, multimedia information or services
• Widespread adoption of mobile phones and other mobile access devices, e.g. PDAs • Charging mechanisms such as prepaid instead of contract terms	Increase in number of mobile users	Greater potential customer base for mobile services
	Some users who do not have PC access to the Internet will have mobile phone access	Ability to bring Internet access to new users
• Shorter product life cycles • Increased rates of technological and product innovation	Swift rate of adoption of new technologies and services	Potential rapid adoption of mobile data services
Introduction of new device linking technologies such as Bluetooth	• Increase in number of networked peripherals • Pervasive computing	• Greater usefulness and convenience of mobile phones and other access devices • Enables a greater number of possible data services
Information or services are accessed from a wide range of devices	Use of metalanguages such as XML, which makes the manipulation of device and format independent	Information consistency can be achieved regardless of access device utilised

As can be seen, one of the greatest strengths of the causal model is the fact that it provides a cohesive view of technological, social, political/regulatory and economic/market forces that affect a specific technological development. Thus the forces illustrated in Table 1 could represent subsets of a universal set of factors that affect the development of mobile data services. Hence, now that we have a broader and cohesive view of the contributing factors, subsets can be analysed further enabling a better understanding of the universe. We begin by discussing the widespread adoption of mobile phones as a driving force in the mobile data service evolution.

2.1.2. Widespread adoption of mobile phones

The mobile phone has evolved from a symbol of status to a necessity, and then to a mobile lifestyle. According to Blinkoff [Blinkoff 2001] and Ling [Ling 2000], the motivating forces of mobile use for adolescents were social networking and peers, whereas family and security drove the use among adults. Work-related, emergencies, and social uses were identified as the primary categories of use among Finnish users [Roos 1993]. While the motivations for mobile phone use include newer dimensions of status symbol, mobility, and immediate accessibility [Leung and Wei 2000] [Ozcan and Kocak 2003], Ruggiero [Ruggiero 2000] suggests that new concepts like interactivity, demassification, and asynchronicity should be included when studying interactive communication media within the uses and gratifications framework. Thus, we can note that the mobile phone expanded boundary roles of users, for example, to take on both care giving roles and standby roles in emergencies [Geser 2004]. With the introduction of versatile mobile data services ranging from television (news, weather, sports, and alerts of breaking events – the news of the SARS outbreak in China broke first by mobile phone users' text messaging), music to gaming, subscribers can customize this mobile content and stay informed and entertained anywhere, anytime. This is an important service as there is an increase in the number of work and personal lives spent on the move which is another driving force in the development of the mobile industry (Table 1**)**. From this we observe a relationship between subsets of factors that contribute to mobile data services development. Other interesting and important relationships amongst factors have also been noted. For example, Wei [Wei 2006] predicted that the stronger the motivations of mobile phone users to pursue instrumental use (e.g., reassurance) from the mobile phone, the more likely they will use the mobile phone to seek news and information. Results of correlation tests from his research showed this prediction to be true. Wei further predicted and proved that the stronger the motivations of mobile phone users to seek ritualistic use (e.g., to pass time) from the mobile phone, the more likely they will use the mobile phone for entertainment. Table 2-2 shows results obtained from Wei's research. The construct was measured by 20 gratification items adapted from users who were asked to rate to what extent the mobile phone helped them meet their communication needs on a five-point scale where 1 meant "strongly disagree" and 5 "strongly agree". For example, the first factor, named "pass time", reflected six items focusing on the capability of the mobile phone to help users pass time.

Table 2-2: Factor analysis of mobile phone use motives [Wei 2006]

The mobile phone helps you...	Pass time	Sociability	Reassurance	Instrumentality	Communication facilitation
Keep company	**.83**	.16	.05	.14	.14
Because the mobile phone is entertaining	**.82**	.13	.06	.23	−.03
Because using the mobile phone is fun	**.76**	.21	.10	.32	−.03
Because using the mobile phone relaxes you	**.75**	.15	.11	.31	.01
Pass the time	**.72**	.32	.12	.18	.19
Chat or gossip	**.65**	.41	.03	−.26	.38
Let others know you care for them	.11	**.78**	.11	.26	.13
Stay in touch with people you don't see often	.30	**.76**	.05	.09	.23
Keep up-to-date on people and events	.37	**.67**	.11	.10	.24
Feel involved with what's going on with other people	.50	**.67**	.05	.07	.17
Get a sense of security	.20	−.01	**.86**	−.05	.00
Have a feeling of safety	.08	.00	**.82**	−.04	.11
Give you peace of mind	.21	.23	**.76**	.12	−.12
Have on hand in case of emergencies	−.11	.04	**.60**	.09	.09
Seek information about products or services	.28	.05	.01	**.74**	.25
Schedule appointments	.21	.37	.04	**.71**	.05
Order things	.46	.10	.11	**.68**	.16
Get news and info	.30	.08	.03	.22	**.80**
Stay informed and in touch anywhere any time	−.04	.27	.12	.07	**.64**
Multitask	.028	.47	−.05	.14	**.61**

2.1.2.1. Culture

We shall now discuss another important aspect regarding widespread adoption of mobile phones as a driving force in the mobile data service evolution, and this is culture. Hofstede [Hofstede 1980] defines culture as "the collective programming of the mind which distinguishes the members of one group of people from another". According to Choi et al. [Choi et al.,2005], "culture cannot be understood by studying one individual; rather, culture can only be read clearly as a set of shared characteristics within a group of people that affects the behaviours of individual members by providing norms for that group". Culture has a great influence towards the system interface of a device as diverse groups of people interpret interface designs differently which could lead to the acceptance or rejection of a service. Hence, Human Computer Interaction (HCI) practitioners are faced with the challenge of offering usable products and services to an enormous variety of users [Khaslavsky 1998]. It is not enough to simply translate messages (or in any case; software) into a different language to localize them culturally [Russo and Boor 1993]. Several important factors need to be considered relating cultural aspects of the locales to the software under discussion (mobile data services in this case). Choi et al. [Choi et al. 2005] identify key factors that differentiate cultures from one another. The first factor mentioned is uncertainty avoidance. This can be defined as “the extent to which the members of a culture feel threatened by uncertainty and ambiguity, along with their eagerness to avoid such situations” [19]. When the quality of a mobile data service is uncertain or uneven as compared to the familiar, users may refrain from using it. Web pages, for example, belonging to the same site may be presented with contracting interfaces on different devices and the interface unfamiliar to the user may cause the user to feel uncomfortable and refrain from using that site or service. The next factor involves individualism versus collectivism. Users with individualistic tendencies select data services based on personal appropriateness, and therefore will opt for personalized (or interfaces that they can customize) mobile data services. On the other hand, users with a collective mindset tend to use services that enable them to feel more connected to other people, for example Instant Messaging (IM) and Location based (LB) services. Context is another factor and is defined by Hall [Hall 1976] as the information that surrounds an event. People in high-context cultures tend to rely on visual elements and symbols, whereas those in low-context cultures tend to rely on hard facts and statistical data [Choi et al. 2005]. Hence high-context users may prefer the use of animated mobile data services, whereas low-context users would prefer text-based mobile data services. The fourth and final factor discussed is time perception. There are two distinct notions of time that have been identified and these are monochronic and polychronic [Hall 1959]. People who carry out one task at a time, proceeding in a sequential and linear manner are said to be monochronic. Polychronic cultures carry out many tasks at once and proceed in a simultaneous and concurrent manner. Since polychronic users execute several tasks at a time they become less organized [Hoft et al. 1996] and might use mobile data services for scheduling or reminder purposes. Rose et al. [Rose et al. 2002] found that participants from polychronic societies were less troubled by download delays and perceived the delays to be shorter than people from monochronic cultures did. Polychronic users, as defined, can multitask and so whilst waiting for a download to complete may partake in another task, becoming preoccupied in the process, whereas monochronic users would perform no other task beside wait for the download process to complete and might become impatient in the process. Choi et al. [Choi et al. 2005] carried out research by investigating participant preferences among mobile data service attributes. The results obtained presented eleven attributes (Table 2-3) commonly considered important by interviewees in three different countries namely, Korea, Japan and Finland.

Table 2-3: Eleven main attributes of mobile data services

Attribute	Description
Minimal Steps or Keystrokes	Service requires minimal steps or keystrokes in search for desired contents.
Iconic Menu Style	Menu items are represented by icons.
Secondary Information about Contents	Service provides additional information about contents, such as ranking points, movie ratings, or related pictures.
Variety of Contents	Service provides a wide assortment of contents to choose from. For example, for games, number of games, game genres; for movie ticket reservations, number of movie theaters; for ring tone downloads, number of ring tones, musical genres; for sports news, number of news items.
Logical Ordering of Menu Items	Service orders menu items or contents logically.
Clear Menu Labeling	Menu labels tell users clearly what they can find behind them.
Efficient Layout or Space Usage	Service uses small the screen space of the mobile phone efficiently.
Variety of Font Sizes	Service menus use a variety of font sizes for different menu types.
Variety of Font Colors	Service uses different colors for different menu items.
Large Amount of Information within a Screen	Service displays a large amount of information on a given screen.
Various Options for Contents	Service provides various options for contents. For instance, for games, stage option, difficulty option; for movie ticket reservations, seat selection; for ring tone downloads, chord selection; for sports news, choice of amount of information to display

The results in Table 2-3 show main attributes concerning mobile data services which have contributed to their development and widespread use trans-cultures. This information can also lead to an effortless acceptance of future mobile data services.

2.1.2.2. Wireless Technologies

So far we have discussed several factors, centred on customer uses and gratifications, which have contributed to the development of mobile data services. The advent of new technologies is another factor that is of principal importance to the development of mobile data services. As shown in Table 1 earlier, technological factors are segmented into several different forces that produce change or drive trends in the mobile phone industry. Included are advances in semiconductor technologies, which have led to the manufacturing of smaller components, pioneering the introduction of devices with improved display and computing functionality. These include colour displays, integrated cameras, enhanced download capabilities, increased memory size (this has taken an even higher dimension with the introduction of Apples' iPhone capable of storing up to 8GB of storage [Apple Inc. 2007a]), and improved sound quality and input methods. Mobile phones are now capable of offering complex, multimedia information or services and hence, the evolution of highly interactive and advanced mobile data services. Wireless technologies have also contributed to the evolution of mobile data services immensely. These range from first generation (1G) networks through to third generation (3G) networks. Increased rates of technological and product innovation have enabled the potential introduction of forth generation networks (4G). This section discusses the contributions of these networks toward the development of mobile data services. Section 2.3 presents a more detailed discussion about the network architectures. Evolution of wireless technologies have enabled improvements from analog to digital signalling, upgrade of data transfer rates, and efficient use of resources for data services through packet-switching. These improvements are the factors that actually differentiate the wireless technologies. Initially, wireless networks were not designed for data transmission as in the case of first generation (1G) technologies [Trillium Inc. 2000]. Second generation (2G) wireless networks introduced digital signalling and enable limited services such as SMS and fax to be offered. The data transfer rates offered by 2G systems nevertheless could not handle advanced mobile data services such as web browsing and multimedia applications. The low data transfer rates also frustrated users due to slow download times [Preez and Pistorius 2002]. Moreover, 2G systems were circuit-switched resulting in users paying for a connection whether or not data was accessed or transmitted over that time. This resulted in expensive billing systems experienced by users. However, popularity of Internet services brought about increased demand for wireless data services [Bettstetter and Vogel 1999] and this led to the introduction of 2.5G networks. These networks introduced packet-switched data transmission and higher data transfer rates into the mobile industry. In a packet-switched environment information is split into "packets" of data that are transmitted and received in bursts rather than through a continuously open or dedicated radio channel [Preez and Pistorius 2002]. This is more attractive for users as they are only charged for the amount of data that they access or transmit and not for the duration of the connection. Third generation wireless technologies have brought about data transfer rates of 2 Mbps (megabits per second). This has immensely contributed to the development of mobile data services by offering value added services that are both affordable and globally accessible [Selian 2002].

2.1.2.3. Independent manipulation of devices

We shall look at a final aspect of mobile data services development involving information consistency, regardless of access device or access format is of extreme importance. The introduction of “metalanguages” such as Extensible Markup Language (XML) has made the manipulation of device and format independent. XML is a cross-platform, software and hardware independent tool for transmitting information [W3Schools. 2007]. Information in XML can easily be translated into Wireless Markup Language (WML), Hypertext Markup Language (HTML) or Voice Markup Language (VoxML) [Preez and Pistorius 2002]The great development and adoption of XML by software vendors has enabled mobile data services to seamlessly interact with servers, personal computers, personal digital assistants and a vast number of other devices. Hence, the availability of a higher dimension of interactive, value-added mobile data services has evolved.

We note from the above discussion that there are several forces that have contributed to the development of mobile data services. Correlations and trends amongst factors where also identified and this enabled a broader understanding about mobile data service evolution. Moreover, most of the factors discussed in this section are still further developing. For example, research into fourth generation (4G) technologies are at an advanced stage which will introduce much higher data transfer rates enabling a new and wider range of interactive, content-rich mobile data services [ESTO Project., 2004] [Hussain et al. 2006]. Technological and product innovations keep advancing, presenting more features on mobile phones and mobile data services can then be created which would interact with these features. Hence, it is expected that mobile data services will continue evolving, presenting greater opportunities of revenue for mobility companies and a wider range of compelling services to mobile phone users. The next section gives a discussion into the currently available mobile data services.

2.2. Types of mobile phone data services

There are over 2 billion mobile subscribers worldwide with a projected figure of over 3.9 billion expected by 2010. With this increase in number of mobile phone subscribers, usage of mobile data services has increased in recent years. This section discusses some of the various mobile data services that are currently available. A mobile data service is any service offered on a mobile phone besides voice.

2.3. Short Message Service

The first commercial mobile data service was a Short Message Service (SMS) sent over the Vodafone GSM network in December 1992. Mobile data services have increased exponentially and are projected to generate large amounts of revenue for mobile phone operators (Table 2-4).

Table 2-4: US Mobile Data Revenues, by Category, 2009 (billions and % of total revenue) [Belcher 2007]

US Mobile Data Revenues, by Category, 2009 (billions and % of total revenue)

	% of total	Revenues
Messaging	**51%**	**$8.2**
Text messaging	33%	$2.7
Multimedia messaging	29%	$2.4
E-Mail	24%	$1.9
Instant messaging	15%	$1.2
Entertainment	**29%**	**$4.6**
Graphics/logos	6%	$0.3
Games	26%	$1.2
Ringtones, other music and audio	31%	$1.4
Interactive entertainment and communities	16%	$0.7
Adult	4%	$0.2
TV and film	17%	$0.8
Information	**20%**	**$3.1**
Productivity	4%	$0.1
Non-voice directory	33%	$1.0
News, sports, travel, etc	63%	$2.0
Total	-	**$15.9**

Currently, the most popular mobile application is SMS [Scharl et al. 2004]. According to the Data-monitor [Hsu et al. 2007], the value of the messaging market will increase from US$ 17.4 billion in 2002 to more than US$ 29 billion in 2006. It is projected that 80% of mobile expenditure while be on messaging services by 2007 [Hsu et al. 2007]. According to Kona Survey, 350 billion text messages are sent every month worldwide [Kona LLC. 2007] There are multifunction uses of SMS that lead to its success. Firstly, advertising agencies may send text messages to clients or potential clients including weather, news, and traffic reports, market rates, and details about movies currently showing. Secondly, SMS are less intrusive than phone calls. Recipients can read text messages at their leisure time and choose when to respond, if at all [Geser 2005]. Finally, SMS can be integrated into other mobile data services. For example, Loopt [Loopt Inc. 2007] is a United States based mobile data service and integrates SMS with Global Positioning System (GPS) and Instant Messaging. When the GPS locates a registered contact within certain proximity, a notification SMS is sent to the user. Other mobile data services currently offered by mobile operators include mobile music. This service was started in Japan, and during 2003 and 2004, KDDI Corporation, the second largest operator in Japan, sold and delivered more downloads of high-quality music to mobile phones in Japan than Apple did with its i-Tunes services worldwide [Weber 2007]. These were about 100 million downloads until mid-2004 [Fasol 2005].

2.4. E-commerce services

Wallet mobile data services are also currently available. These present functions such as electronic money and electronic credit cards and enable users to purchase goods using their mobile phone. This feature is prevalent in Japan [Weber 2006]. In addition, data services offering QR-code readers (a 2D square barcode for reading information using the phone's camera as a scanner) have been integrated into mobile phones. Hence, a user may scan the barcode of some goods to obtain the price and then pay for it using their *wallet* facility available on their mobile phone. This presents an insight into the degree of dependency that customers may have for mobile data services and this will in turn increase the development of data services in the mobile industry.

2.4.1. Mobile Gaming

One of the earliest mobile data service offered was gaming. The gaming market is currently worth Euro 1.6 billion, with 50% of that revenue based in South Korea and Japan. By 2011 it is projected to be worth Euro 2 billion [Screen Digest 2007]. As noted, the long-term growth potential for mobile games is limited. This is imposed by niche segment appeal of service and the growing complexity and escalating costs of game development [Telecom 2005].

2.4.2. Mobile Television

Finally, one of the upcoming mobile data service available is television (TV). Research shows that this service is set to emerge as the strongest performer globally, delivering Euro 4.7 billion of revenue from 140 million subscribers by 2011 [Screen Digest 2007]. Figure 1 shows projected revenues from TV, music, and games applications. With the large amounts of revenue generated by the immense number of mobile data services currently available, mobile operators are set to introduce even more compelling data services in order to surpass such figures. A contributing factor that will enable the introduction of more compelling mobile data services is the development of wireless technologies. These technologies are discussed in the next section.

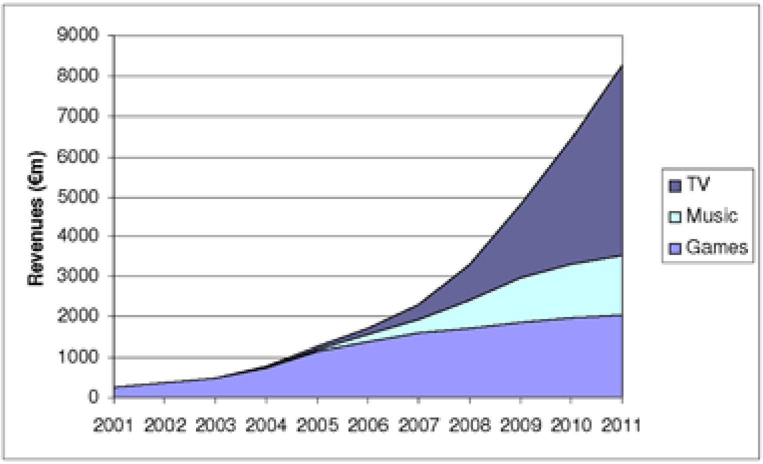


Figure 2-1: Global mobile content revenues 2001-2011 [Screen Digest 2007]

2.4.3. Mobile data service Technologies

Mobile telephony has become one of the most convenient information exchange tools since the introduction of circuit-switched, Global Systems for Mobile Communications (GSM) networks [Scharnhorst et al. 2006]. Mobile carriers can now provide data services in a more bandwidth-efficient way over the cellular network with the introduction of packet data services such as General Packet Radio Service (GPRS) [Kang and Nath 2005]. The advancement of wireless technologies has a pivotal role in the development of mobile data services. This section discusses the evolution of wireless networks and presents the various features of each network. Table 5 shows the evolution of mobile technologies including the types of systems implemented, data transfer rates and available features.

Table 2-5: Evolution of Mobile Networks [ESTO Project. 2004]

	System		Bandwidth	Features
1st Generation	AMPS	Advanced Mobile Phone System	9.6 kHz	analogue voice no data transmission capabilities
	TACS	Total Access Com.Syst.		
	NMT	Nordic Mobile Teleph.		
2nd Generation	GSM	Global System for Mobile Communic.	9.6->14.4	digital voice, advance messaging, global roaming, circuit switched data
	CDMA/IS	Intermediated Standard 95	64	digital voice, data, integrated voice mail
	PDC	Personal Digital Communication	-> 28 kbps	digital voice, data, i-mode
	HSCSD	Switched Data	9.6->57.6	extension of 2G/GSM higher data speeds
	GPRS	General Packet Radio System	9.6->115	Extension of 2G/GSM always-on connectivity packet switched data
	EDGE	Enhanced Data Rate for GSM Evolution	64->384	Extension of 2G/GSM always-on connectivity faster than GPRS
3rd Generation	IMT2000	International Mobile Telecommunications 2000		
	UMTS	System	64->2.048	always-on connectivity global roaming, IP-enabled
	CDMA2000	Multicarrier CDMA		IP-enabled
	TD- SCDMA	Time Duplex - Space Code Div. Multiple Access		
4th Generation	WWICP	Wireless World Integrated Communication Platform	-> 1,000,000	Integration of Multiple Wireless technologies, introduction of new high capacity transmission scheme

2.4.3.1. First generation communication

The first generation (1G) of wireless communication was based on analog signalling. 1G networks were circuit-switched technologies and primary focused on voice communications and provided localized wireless services [Selian 2002]. Systems implemented in North America were known as Analog Mobile Phone Systems (AMPS), while systems implemented elsewhere were identified as a variation of Total Access Communication Systems (TACS). However, first generation systems had no data transmission capabilities.

2.4.3.2. Second generation communication

Second generation (2G) systems were introduced in the late 1990s and were based on low-band digital signalling. They had enhanced voice capability in comparison to analog systems, better spectrum management, wider coverage area and better mobility. 2G technologies were composed of Global Systems for Mobile Communications (GSM), Frequency Division Multiple Access (FDMA) and Time Division Multiple Access (TDMA) and its introduction brought about dramatic growth rates. At the end of 2003, the number of mobile subscribers reached 64.8 million [Doganoglu et al. 2006]. 2G technologies provided data transfer rates of 9.6-14.4 kbps (kilobits per second). This could handle some data capabilities such as fax and SMS but it is not suitable for web browsing and multimedia applications. GSM can provide better voice quality, network capacity, SMS, data encryption and roaming [Tseng et al. 2006]. Unfortunately, 2G systems could not meet the increasing demand for wireless data services. Firstly, the typical data transfer rate on a GSM network is 9.6 kbps, which is too low and severely limits the richness of information and complexity of the wireless data services and applications that can be offered. This also leads to user frustration with long download times [Preez and Pistorius 2002]. Secondly, mobile data services were provided based on circuit-switched (CS) radio transmission, where a channel is exclusively allocated for a single user for the entire call duration, regardless of whether the user is transmitting data packets or not at that moment. This results in highly inefficient use of resources for data services with disintegrated traffic characteristics [Chung et al. 2006]. In addition, the user pays for the entire connection time instead of for the amount of data processed or transferred during that time. Lastly, most operators offering data services on a GSM network have billed for services in the same way as for voice service, that is, duration-based billing [Preez and Pistorius 2002]. With these negative factors, accessing wireless data services on the GSM network has been both frustratingly slow and prohibitively expensive.

2.4.3.3. 2.5 generation communications

2.5G technologies were introduced and these had the advantage of providing services based on packet-switched radio transmission. General Packet Radio Service (GPRS) and Enhanced Data Rates for Global Evolution (EDGE) are two common 2.5G technologies. The concept behind GPRS was to reserve some physical channels (that is, time slots), in this case called packet data channels, exclusively for data traffic [Tangemann et al. 2000]. Data transmission on GPRS is packet-switched, which means that information is split into “packets” of data that are transmitted and received in bursts rather than through a continuous open or dedicated radio channel [Preez and Pistorius 2002]. The radio spectrum is used only when data is actually transmitted. Thus, billing is only charged for the amount of information that is accessed or downloaded and not for the duration of the connection. The fact that GPRS is “always-on”, gives it another advantage over a GSM network, as it eliminates the need for call and connection set-up each time a service or application is accessed. EDGE represents the final step in the evolution of mobile telephony from GSM towards UMTS, that is, from 2G to 3G [Halonen et al. 2003]. Maximal available data transfer rates up to 192kbps were achieved with this technology [Schnabel 2003]. Services such as voicemail, e-mail, location-based services (LBS), and web surfing using Wireless Application Protocol (WAP) become available with 2.5 systems. Hence, 2.5 generation systems enabled a wide range of mobile data services to be offered.

2.4.3.4. Third generation communications

Third generation (3G) systems represent the convergence of various 2G technologies into a single global system that includes both terrestrial and satellite components [Trillium Inc. 2000]. An important aspect of 3G is the ability to integrate existing cellular standards, such as GSM and TDMA, into one component. Therefore, 3G can have an integrated network for circuit-switched and packet-switched services presenting several advantages [Trillium Inc. 2000] [Kang and Nath 2005]. For example, GSM networks provide a better call quality whereas GPRS consumes less radio bandwidth when transmitting data [Kang and Nath 2005]. Universal Mobile Telecommunications System (UMTS) is a 3G wireless technology. It has a data transfer rate of 2 Mbps (megabits per second) enabling complex and content-rich applications to be offered such as videoconferencing. The main features of 3G systems are "always-on connectivity", "IP network", "Global roaming" and value added services. Some disadvantages associated with 3G systems include high licensing fees required by mobile operators, great difference in the terms of acquiring licenses governed by state authorities [Preez, and Pistorius, 2002], and the high pricing of 3G enable mobile phones.

2.4.3.5. Higher bandwidth capabilities

From this discussion, we note that immense progress has been made to provide users with content-rich, highly interactive, and affordable mobile data services with regard to wireless technologies. Although there are still some limitations on data transfer rates achievable with the available technologies, research is underway for the introduction of fourth generation systems capable of data transfer rates of up to a Gigabit per second [ESTO Project., 2004] [Hussain et al. 2006]. Japan's leading mobile network operator, NTT DoCoMo, plans to implement High Speed OFDM Packet Access (Super 3G) networks by 2010, which will be capable of data transfer rates of up to 300Mbps [Cheng 2007]. Such high speed networks will be critical to the success of services such as mobile TV and video, and high-speed Internet access, which require high bandwidths for efficient delivery. This will inevitably bring about a new breed of mobile data services, increasing revenue for mobile operators and enhancing user experience for mobile customers.

2.5. Mobile Data Services in South Africa

This section discusses the development of mobile data services in South Africa. In most cases, Japan will serve as a precursor to the South African mobile market. As Japan is the world's leading mobile industry [Weber 2007], this comparison will enable us determine the level to which mobile development has been achieved in South Africa, and the strategies that have been implemented to reduce the gap between the two markets.

2.6. Wireless Technologies in South Africa

Since the introduction of GSM and GPRS networks in South Africa, in 2002, the mobile phone industry has evolved exponentially. With a population of about 44 million people, South Africa is the leading mobile market in Africa with an estimated 34 million mobile subscribers and a penetration rate of about 70% [Global Telecoms 2007]. This figure is more than in the Canadian and Australian markets combined and close behind the mobile market in Spain [Research 2007]. 3G technologies become available to South Africa's leading cellular network, Vodacom, in February 2006 [Vodacom 2007]. These dates may be contrasted by Japan's GPRS systems introduction in 1997, 3G network implementation by 2001, and the introduction of advanced technologies faster than W-CDMA by 2003 [Weber 2007]. Japan has 98.8 million subscribers in total and a 77.6% penetration rate [Answers. 2007]. Whilst this may be viewed as slower development and adoption of mobile infrastructure and services in the South African market, this may have an advantage in that, research can be carried out detailing successful implementation strategies used by advanced mobile markets. These results would then be used when implementing the technologies locally.

2.7. Mobile Operators in South Africa

South Africa has three competing mobile networks namely, Vodacom, MTN and Cell C. This is not that different compared to the five competitors in Japan [Answers 2007]. With the introduction of the number portability mobile data service customer churn can easily be experienced between the three South African competitors. Hence, each should offer unique and compelling data services to maintain customers. A number of strategies to achieve this are in place. For example, MTN has partnered with Cisco to deliver advanced multimedia mobile services, such as mobile TV [Cisco Inc. 2007], whereas Cell C partnered with Europe's Virgin Mobile to offer Virgin Mobile branded services [Global Telecoms 2007], and

Vodacom partnered with Europe's Vodafone network to offer Vodafone branded services [Cellular 2007].

2.8. Data services in South Africa

Most services offered in Japan are also available in South Africa. These include, Internet browsing, e-mail, mobile music, ringtone downloads, SMS, MMS, Instant Messaging, e-commerce, and weather and news reports. This indicates the extent to with the mobile market in South Africa has grown within the past decade. SMS is the most popular mobile data service in South Africa [Global Telecoms 2007]. Other popular mobile services include Instant Messaging and MMS. It is also expected that MMS usage will grow in the lead up to the 2010 football World Cup Tournament [Global Telecoms 2007].

With the high competition among mobile operators, and advanced wireless technologies available in South Africa as discussed in this section, a wider range of mobile data services are expected in the market and the South African mobile industry is set to continue growing with a projected 37.8 million subscribers by the end of 2011 [Global Telecoms 2007].

2.9. Future of Mobile phone data services

As discussed in the previous sections, mobile data services have evolved from simple applications to complex and content-rich, interactive services, generating large amounts of revenue for mobile operators and enhanced customer experience for mobile phone users. Increased rates of technological and product innovation are enabling a new dimension of mobile data services to be offered and quickly adopted among mobile phone users [Preez and Pistorius 2002]. This section discusses some of the upcoming mobile phones and mobile data services that are expected to increase revenue and user experience in the mobile market.

2.9.1. Mobile phone innovation

Innovative mobile phones are set to initiate the introduction of a new range of advanced mobile content and services. The new advanced features and capabilities on mobile phones are enabling mobile data developers to be less constrained when considering possible data services that can be implemented. For example, at the beginning of 2007, LG and PRADA released the first completely touch screen mobile phone. It includes a wide LCD screen which maximizes visual impact, allowing the user to benefit from several key features of the phone [LG 2007]. It also hosts an array of additional multimedia functions, including an MP3 player and a music multitasking function for messaging. An external memory slot is included allowing the user to increase the memory capacity for images, music and video clips. Another example is Apples's iPhone, which includes a 3.5 inch 480 x 320 touch screen display with multi-touch support. It can offer a maximum of eight Gigabits of storage and has support for Widgets, Google Maps, and iTunes. Apple quotes five hours of battery life for talk and video, with a full 16 hours in music mode [Ziegler 2007]. These highlighted features and functionalities show the development of storage capacity, processor speed, screen size and resolution on mobile phones. Thus, some services that could not be offered on mobile phones at one time, due to hardware and software constraints, can now be easily implemented in the mobile industry. This will bring about a new dimension of mobile data content and advanced user interfacing in the mobile industry.

2.9.2. Upcoming Mobile data services

Mobile TV is the latest of all mobile content offerings, and looks set to emerge as the strongest performer globally, delivering Euro 4.7 billion of revenue from 140 million subscribers by 2011. Mobile TV's revenue potential is greater than that of games or even music due to the mass market nature of the product [Screen Digest 2007]. A rich media TV service can contain arbitrary types of multimedia elements, leading to a rich user experience. Personalisation of TV content is also possible in two aspects [Rauschenbach 2006]. Firstly, additional information is supplied with the main TV programme, from which the user can select the pieces they are interested in. Secondly, by sending metadata with the programme, the Home Media Server can record those segments of the TV programme which are of interest to the user according to a specified or learned user profile. This way, a user can create a personalised news show [Rauschenbach 2006]. Mobile music is another high revenue earner and is projected to generate even higher revenues in the future due to the availability of subscription services which offer more than just audio tracks. The introduction of Apple's iPhone is also expected to bring about mobile music growth. Forecasts predict that the global over-the-air full track music download market will grow exponentially over the next five years, reaching Euro 1.47 billion by 2011, an eight fold increase from 2006. SMS is still expected to be one of the greatest revenue earners among mobile data services. There are currently over 90 million SMS users in the US and it is estimated that there are over 350 billion text messages sent every month globally [Kona LLC. 2007] Location-based services (LBS) is a service category which is consistently mentioned as an important category of new services in practically all comprehensive research that deals with future mobile data services

[Li 2005]. Location-based services enable the provision of value-added services based on location and traffic data. In 2011, the total population of GPS-enabled location-based services (LBS) subscribers will reach 315 million, up from 12 million in 2006 [Alleven 2007]. Several mobile data services now seek to use the widespread adoption and success of SMS and LBS by integrating the capabilities of these two services as additional components of the new data service. For example, Loopt is a US mobile data service that has become popular among mobile users in that region. Loopt notifies users when a registered contact is within a defined proximity, and enables the user to send a text message to that contact [Loopt Inc. 2007]New services are also now available from major companies such as Goggle and Yahoo, and these services are expected to generate more revenue in the future. For example, Google is offering services that initially were not feasible on some mobile phones due to lacking capabilities such as Web browsing. A user can still conduct a search by sending an SMS to a Google number and receiving the search results a reply. This indicates that future mobile data services will be made available to users in a way that can bypass the limitations of the user's mobile phone. Revenue from mobile data services such as mobile entertainment, including games, gambling and adult content, is projected to double from US$ 18.84 billion in 2006 to US$ 38.12 billion in 2011 [Slocombe, M.,2007].

The developments discussed in this section show that even though the mobile market has reached maturity, technological and product innovations will enable a new dimension of mobile data services to be offered in the future. Hence, it is expected that mobile data services will continue to deliver increased revenue for mobile operators and deliver gratification to the mosaic requirements of mobile phone users.

2.10. Development Environments/Platforms

As the mobile market continues to evolve, several mobile development environments become available enabling compelling data service creation. Symbian, Windows mobile and Palm OS are examples of operating systems designed for mobile devices. Java Micro Edition (JME), Flash Lite, Binary Runtime Environment for Wireless (BREW), Python and .Net Compact Framework are examples of development software that can run over the mentioned operating systems. In this section we shall discuss the various capabilities and features of these mobile development environments.

Symbian

Symbian OS is a proprietary operating system (OS) produced by Symbian Limited. Symbian is the market leading provider of open OS software with a 70% share of the smartphone market to date [Symbian Ltd. 2007]. It is very powerful for general purposes and can support 2D, 3D graphics as well as several widgets. C++ is used as the foundation language with full phone data access. Symbian has an average run time speed largely due to limited functionality of handsets where Symbian is available. The developer and community support is extensive and the Symbian based S60 platform is strongly supported by Nokia and Sharp [Symbian Ltd. 2007]. In 2006, global smartphone shipments totalled 72.9 million units, up 50% from 2005, with Symbian leading the market holding 71.7% market share [Symbian Ltd. 2007].

Palm OS

This is a compact operating system developed and licensed by Palm and designed to be easy-to-use and similar to desktop operating systems such as Microsoft Windows. It holds about 2.3% of the smartphone market share [Symbian Ltd. 2007]. C and C++ are the foundation languages used, with support for 2D, 3D graphics and several widgets. Palm OS has the largest developer network compared to its competitors.

Windows CE

Windows CE is a variation of Microsoft's Windows operating system for mini computers and embedded systems, and has a distinctively different kernel rather than a trimmed-down version of Windows available on desktops. It is ideal for enterprise applications with an existing PC infrastructure, however it is not cross platform and is limited to Microsoft devices. C and C++ are the foundation languages and it has support for 2D, 3D graphics and many widgets. It also has a very good runtime speed [Yao 2007].

Java Micro Edition

Java Micro Edition (JME) is an established mobile development platform from the Java Community and has an extensive number of developer community and support. JME uses subsets of Java Standard Edition components designed for desktop computers, and includes a set of technologies and specifications developed for smaller devices such as pagers and mobile phones. Eclipse and Netbeans are the main integrated development environments (IDE) available for JME. JME requires a Java Virtual Machine embedded on a device for it to run and is therefore not completely platform independent. It has support for 2D, 3D graphics and many widgets, and some limited phone data access varying according to the type of handset. JME has an average runtime speed due to Java bytecode and includes flexible user interfaces, robust security, built-in network protocols, Bluetooth APIs, and support for networked and offline applications that can be downloaded dynamically [Li and Knudsen 2005]. JME is widely used for creating games and has an extensive developer community of over one million [Sun Microsystems Inc. 2007].

Adobe Flash Lite

Flash Lite is the Adobe Flash technology specifically developed for mobile phones and consumer electronics devices. Flash Lite accelerates the delivery of rich content and browsing, and customized user interfaces. Even though it is a new competitor in the mobile industry, Flash Lite has developer and community support of over one million [Adobe Inc. 2007a]. This growth is driven by the mature Flash authoring environment and rendering engine that delivers enhanced content and browsing, customized user interfaces and rich mobile experiences across devices [Adobe Inc. 2007b]. Over 200 million Flash-enabled devices had been shipped by the start of 2007 [Adobe Inc. 2007c]. Actionscript is the foundation language used with Flash Lite and has support for 2D, 3D graphics including several widgets. Flash Lite uses a compressed file format called SWF, that can be reused by a player running on any system and enables faster download speeds of graphically rich applications. Flash Lite offers support for high-end video manipulation as video clips can be embedded into animations using the Flash 8 Professional interactive development environment IDE) [Vander Veer 2006]. Flash Lite supports loading and parsing of XML data in Flash content enabling a wider range of interactive devices to communicate, thereby also enabling more interactive and content-rich mobile data services to be offered [Adobe Inc. 2007b]. Phone data access is also possible which provides the ability to locally store and retrieve relevant, application-specific information such as preferences, high scores and usernames. This provides a much more robust development environment.

The various types of mobile development platforms available, as discussed above, enable for the efficient and rapid creation, deployment and maintenance of mobile data services. This in turn allows for the development of compelling and highly interactive mobile data services. Therefore, just as wireless technologies and user gratifications are key contributors to the enhancement of mobile data services; mobile development environments play an important role in the mobile market.

2.11. Chapter Review

In this paper, we discussed factors that influence the wide adoption and development of mobile data services. These factors have a direct effect as to which mobile development platform will receive a high market penetration rate. A mobile development environment should provide developers with key functionalities that allow for the creation of compelling services. We noted that concepts such as interactivity, demassification, and asynchronicity are important factors that contribute to the wide adoption of mobile data services. Hence a mobile development platform that allows for the creation of services that provide easy and efficient interactivity between the user and also other external devices, will receive better developer adoption. Such interactivity can be provided through dynamic text input, Bluetooth APIs, Markup languages such as XML, and in-built network protocols. Mobile data services with dynamic multimedia such as mobile TV and GPS are also driving developers toward platforms that enable creation of sophisticated graphics and animation, as well as video capabilities. Hence mobile development platforms that offer such capabilities, efficiently and seamlessly, receive a wider adoption by developers. A scripting language that allows portability across devices will enable developers to port their applications to a wider audience, and this will inevitably offer a greater potential customer base for mobile data services. Hence, a mobile development environment which supports such a scripting language will gain developer and user support. Culture also plays a pivotal role in the adoption of mobile data services. Hence, there arises a demand to filter information and customise the presentation according to personal preferences. Thus, mobile development platforms that enable the creation of customized user interfaces will attract a greater number of developers working under that platform. We also noted two popular mobile development platforms namely, Java Micro Edition and Flash Lite, which support a large number of functionalities that bring about mobile data service adoption and growth. As a result these two platforms have a great potential for growth and adaptation, both in the developer community and in user support. We note that, the functionalities of these two platforms may differ; hence it is imperative to study and compare the environments. This will enable developers to make a trade-off as to which platform to use, depending on the particular specification of the required mobile data service.

Chapter 3 Design and Implementation

In order to compare the development of mobile data services under the established Java Micro Edition (JME) platform and the upcoming Flash Lite environment, it is imperative to incorporate in an application key features that influence the wide adoption and development of mobile data services as discussed in the previous chapter. Such features include the ability of the mobile data service to interact efficiently and seamlessly with the user as well as with external components such as web servers and databases. In addition, features such as rich graphics, sophisticated animation and dynamic multimedia capabilities within mobile data services are projected to bring about a new dimension of mobile data content within the mobile industry. It would be of interest to investigate how the upcoming Flash Lite platform would compare with the more mature JME platform in regard to these upcoming features. This chapter discusses the design and implementation of the *Mobile Movie Booking* system, the mobile application that has been developed to compare the capabilities of the JME and Flash Lite platforms.

3.1. The Mobile Movie Booking System

The *Mobile Movie Booking* system offers mobile phone users the ability to query movie details, obtain information regarding available seats as well as view movie trailers. Furthermore, the System enables a user to make a booking for a particular showing and, if successful, they are issued with a reference number as well as the details of the movie they selected. A replica of the details issued to the client is stored in the database component of the booking system. The user is then required to present the reference number at the cinema house in order to authenticate them as the holder of the booked seats referenced by that number. Hence, the details issued after successfully making a booking are stored persistently on the mobile device.

Thus, there are various possible interactions between the user and the *Mobile Movie Booking* system. These include querying movie details, booking available seats, playing movie trailers as well as querying the reference number (Figure 3-1).

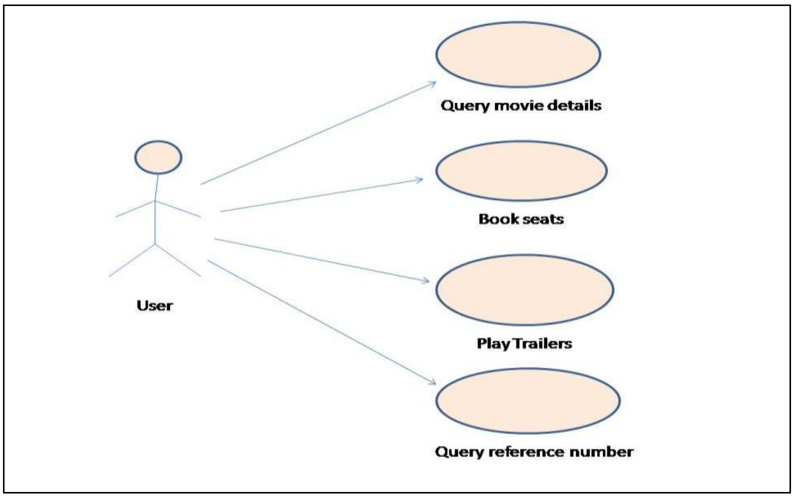


Figure 3-1: Use Case Diagram for the Mobile Movie Booking System

Given the outlined definition of the *Mobile Movie Booking System*, we note that it incorporates the key features mentioned earlier. Firstly, it allows user interaction; whereby such interactions may in turn require the application to communicate with a web server and ultimately a backend database. Secondly, the booking system renders the cinema seats and plays back movie trailers, and therefore presents rich graphical interfaces as well as dynamic multimedia capabilities to the user. Hence, the *Mobile Movie Booking System* allows for key features to be tested between the JME and Flash Lite development platforms.

3.2. Hardware, Software and Network Environment

Both the JME and Flash Lite applications share the same hardware and network environments as shown in Figure 3-2.

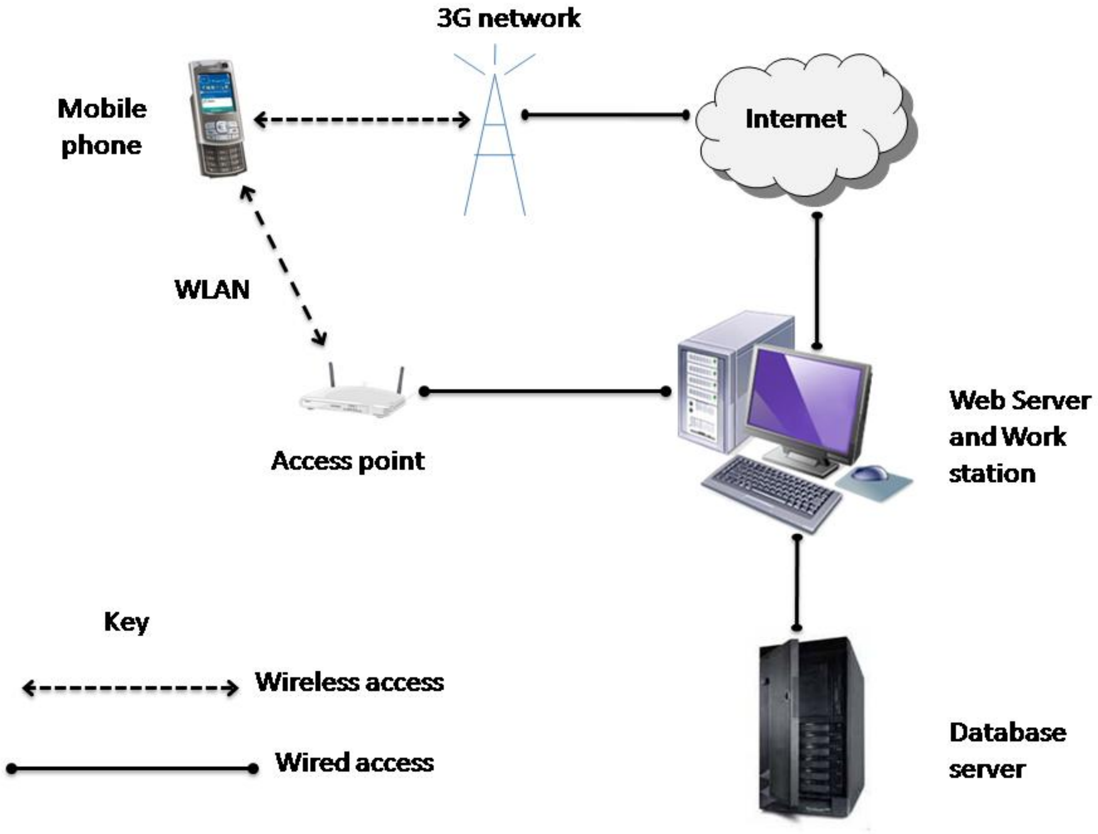


Figure 3-2: Hardware and Network Environment

The *Mobile Movie Booking* system runs on a mobile phone with WLAN capability. Client-server communication occurs either through the WLAN via a specified Access point or through a 3G network. Movie details contained within the database server can be queried by the mobile device client via the web server.

As illustrated by the hardware and network configuration, the *Mobile Movie Booking* system adopts a three-tier architecture. This consists of a client-side (front tier mobile component), server-side (middle tier web component) and database (backend tier data component) (Figure 3-3).

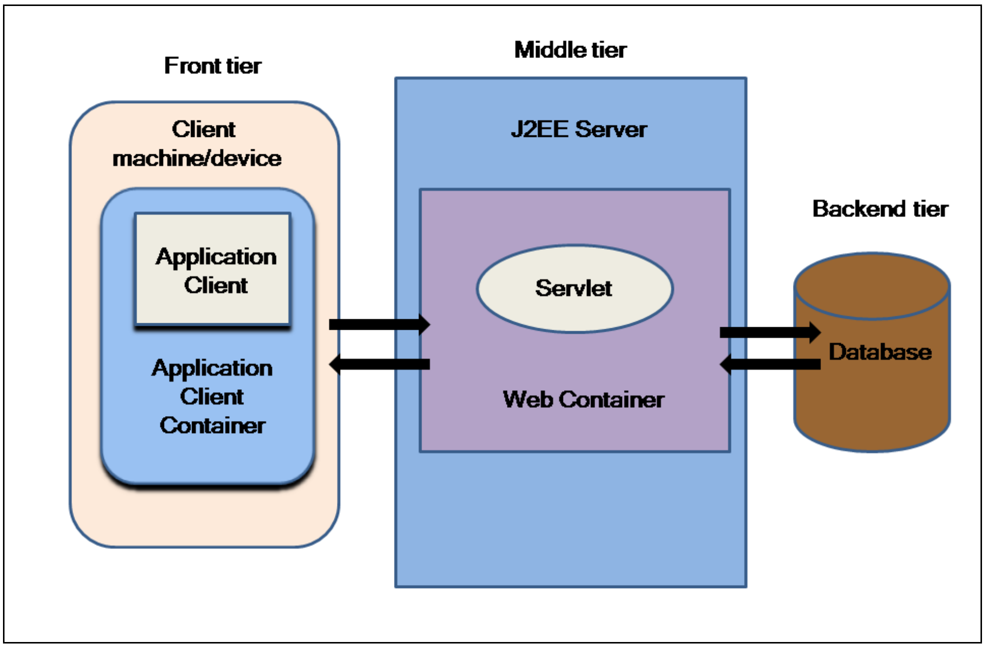


Figure 3-3: Overview of three-tier architecture

During an application's life cycle, the three-tier approach provides benefits such as reusability, flexibility, manageability, maintainability, and scalability. Furthermore, as mobile devices differ significantly from desktop computers in terms of having limited processing power and small memory size, going the server route enables heavy processing to be done on the server-side instead of on the mobile phone. Most importantly, since the presentation and the underlying data models are separated, a better comparison and analysis can be made of how the JME and Flash Lite development platforms manipulate and interact with the same data domain.

Hardware and Network Environment specifications:

The client device (front tier) for the *Mobile Movie Booking* system consists of a Nokia N80 series cellular phone with WiFi 802.11g support and multimedia capabilities. The web server (middle tier) and database server (backend tier) run on a workstation with an Intel® Core™ 2, 1.86 GHz CPU, and 2 GB of RAM. A WiFi network using a Gigabyte GN-WLBZ101 802.11b USB adapter as an Access Point, running at 11Mbps, was used to test the *Mobile Movie Booking* system on the client device. The servers run on an Ethernet LAN network at 100Mbps.

Software specifications:

Apache Tomcat 5.5.17 [Apache 2007] was the web server used for this project. Apache Tomcat is the servlet container that is used in the official Reference Implementation for the Java Servlet and Java Server Pages technologies. Tomcat powers numerous large-scale, mission-critical web applications across a diverse range of industries and organizations. NetBeans 5.5.1 IDE [Sun 2007a] was used for the development of the servlets running within the Apache Tomcat container as well as for the development of the JME front tier under the Sun Java Wireless Toolkit 2.5 SDK. NetBeans 5.5.1 IDE is a powerful integrated development environment for developing cross platform Java desktop, enterprise and web applications. The Sun Java Wireless Toolkit is a software development kit for developing wireless applications. This toolkit was chosen as it includes the emulation environments, performance optimization and tuning features, documentation, and examples that developers need to bring efficient and successful wireless applications to market quickly [Sun 2007b]. Adobe Flash Creative Suite 3 Web Standard Edition was used to develop the Flash Lite front tier. The Creative Suite enables developers to deliver rich interactive content and compelling data services to consumers [Adobe 2007d]. Microsoft Office Access 2007 [Microsoft 2007c] was used as the database management system. Access 2007 is quite different from previous versions, and has a thoroughly redesigned user interface. With its Microsoft Office Fluent user interface and interactive design capabilities, Microsoft Office Access 2007 helps track and report information with ease.

The following sections discuss the development of the middle and backend tiers for the *Mobile Movie Booking* system. The front tier development is discussed in Chapter 4.

3.3. Developing the Middle tier Web Component

Java Servlet technology has been used to implement the middle tier web component for the *Mobile Movie Booking System*. In this section we introduce Java Servlets as well as analyse the servlets written for the *Mobile Movie Booking System*.

3.3.1. Java Servlet technology

3.3.1.1. Servlets

A servlet is a Java programming language class that is used to extend the capabilities of servers that host applications access via a request-response programming model. Although servlets can respond to any type of request, they are commonly used to extend the applications hosted by web servers. For such applications, Java Servlet technology defines HTTP-specific servlet classes. The `javax.servlet` and `javax.servlet.http` packages provide interfaces and classes for writing servlets. All servlets must implement the Servlet interface, which defines life-cycle methods. When implementing a generic service, you can use or extend the `GenericServlet` class provided with the Java Servlet API. The `HttpServlet` class provides methods, such as `doGet` and `doPost`, for handling HTTP-specific services [J2EETutorial].

3.3.1.2. Servlet tasks

Servlets run on a Web server, acting as a middle layer between requests coming from a Web browser or other HTTP client and databases or applications on the HTTP server. Their task is to:

1. **Read any data sent by the user.**
   This data is usually entered in a form on a Web page, but could also come from a Java applet or a custom HTTP client program.
2. **Look up any other information about the request that is embedded in the HTTP request.**
   This information includes details about browser capabilities, cookies, the host name of the requesting client, and so forth.
3. **Generate the results.**
   This process may require talking to a database, executing an RMI or CORBA call, invoking a legacy application, or computing the response directly.
4. **Format the results inside a document.**
   In most cases, this involves embedding the information inside an HTML page.
5. **Set the appropriate HTTP response parameters.**
   This means telling the browser what type of document is being returned (e.g., HTML), setting cookies and caching parameters, and other such tasks.
6. **Send a document back to the client.**
   This document may be sent in text format (HTML, XML), binary format (GIF images), or even in a compressed format like gzip that is layered on top of some other underlying format.

3.3.2. Developing servlets for the Mobile Movie Booking System

Three servlets namely, *movieDetails*, *bookedSeats* and *clientDetails* were written to form the middle tier Web component of the *Mobile Movie Booking*. Partitioning the tasks of the middle tier Web component between three servlets enables modularity of the middle tier of the *Mobile Movie Booking* system. This in turn allows the Web components to be scalable for future extensions of the system as well as making the task of debugging much easier as each servlet is tested and monitored individually.

In all three servlets, an Extensible Markup Language (XML) response is generated and then sent to the client. XML is a cross-platform, software and hardware independent tool for transmitting information [W3Schools 2007]. The great development and adoption of XML by software vendors has enabled mobile data services to seamlessly interact with servers, personal computers, personal digital assistants and a vast number of other devices and this has inturn brought about a higher dimension of interactive, value-added mobile data services. Hence, it will be of interest to investigate how JME and Flash Lite compare in the manipulation of XML documents.

3.3.2.1. The movieDetails Servlet

The primary goal of the *movieDetails* servlet is to transfer movie details that include the movie names, show days and times, as well as the names of the cinema houses from the database to the client's mobile device (Figure 3-4).

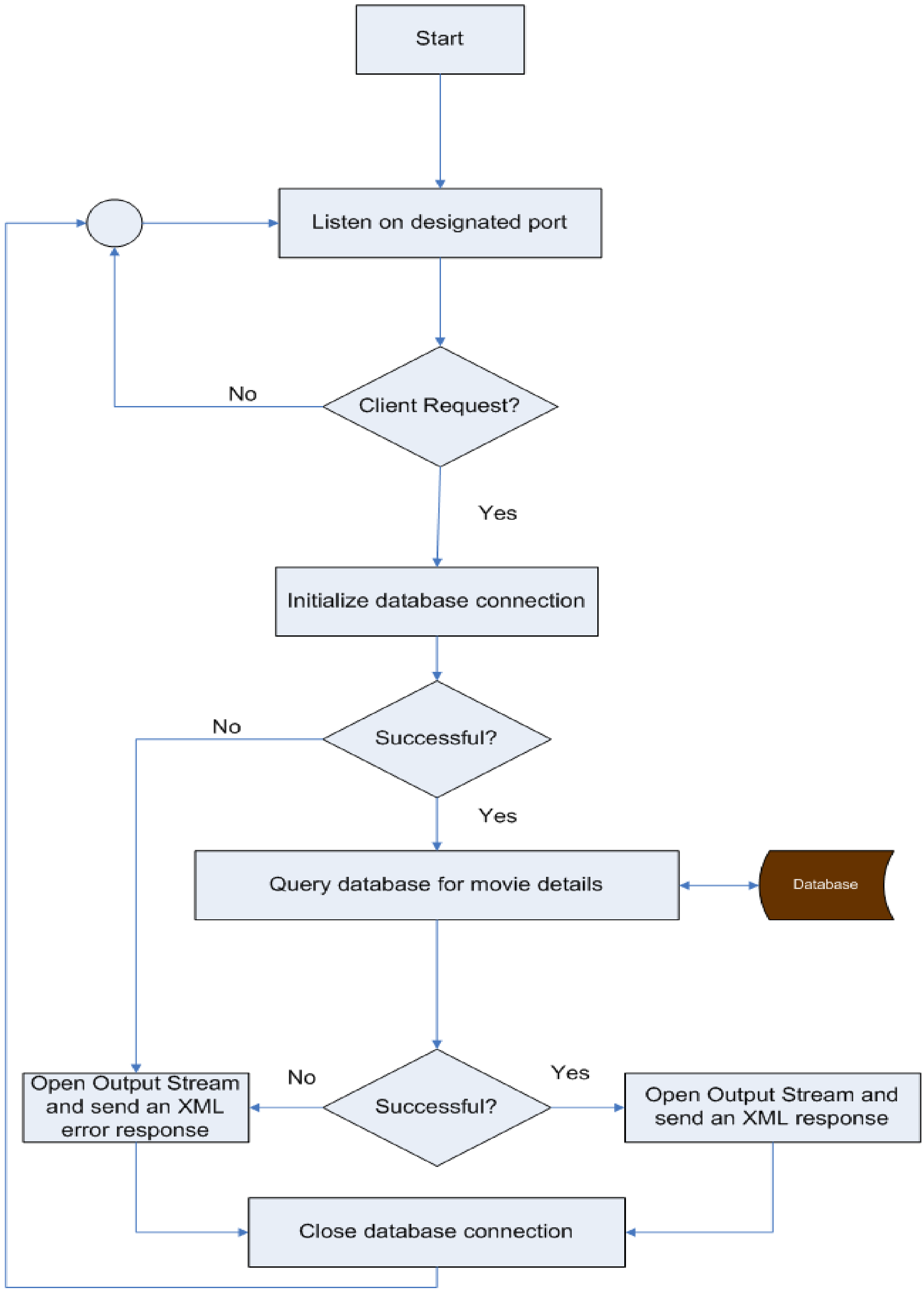


Figure 3-4: *movieDetails* Servlet Logical Flow Chart

The *movieDetails* servlet runs within the Apache Tomcat container listening on the designated port. On receiving a client request from the mobile device, via the `HTTP GET` method, a connection is made to the database component. The servlet-database connection is enabled by the Sun Microsystems JDBC-ODBC Bridge driver [Sun., 2007c]. If the connection is successful the database is queried for movie details through SQL statements. The servlet then generates an XML response back to the client. An XML error response is generated and sent to the client in the event of an error. Once the movie details are received on the front tier, the client will be able to view the names of the movies being screened as well as their show days and times.

3.3.2.2. The bookedSeats Servlet

On request, the *bookedSeats* servlet should query the database for an enumeration of booked seats for a particular showing and transfer this information to the client [Figure 3-5]. A showing consists of the movie name as well as the show day and time for that specified movie.

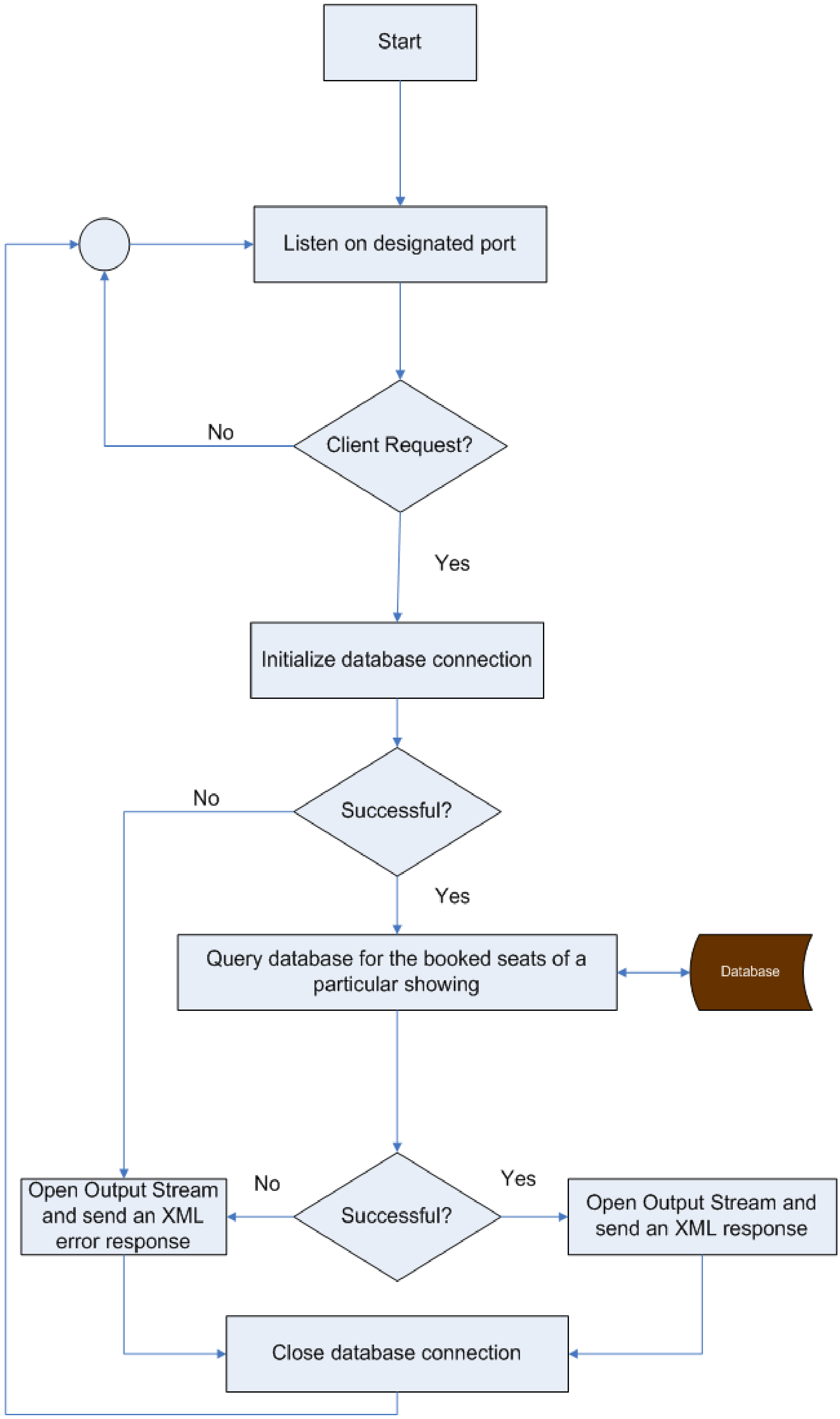


Figure 3-5: *bookedSeats* Servlet Logical Flow Chart

The *bookedSeats* servlet listens on the designated port and when a request is received from the client, via `HTTP GET`, a connection is made to the database. If the connection is successful a SQL query is sent to the database and an enumeration of seat details is returned to the servlet. The seat details include the identity number for a particular showing as well as the seat numbers for those seats that have already been booked for that particular showing. The servlet then generates an XML response back to the client. An XML error response is generated and sent to the client in the event of an error. The seat details are used by the client when intending to make a booking for a particular showing.

3.3.2.3. *The clientDetails Servlet*

The *clientDetails* servlet is responsible for processing a booking request from a client (Figure 3-6).

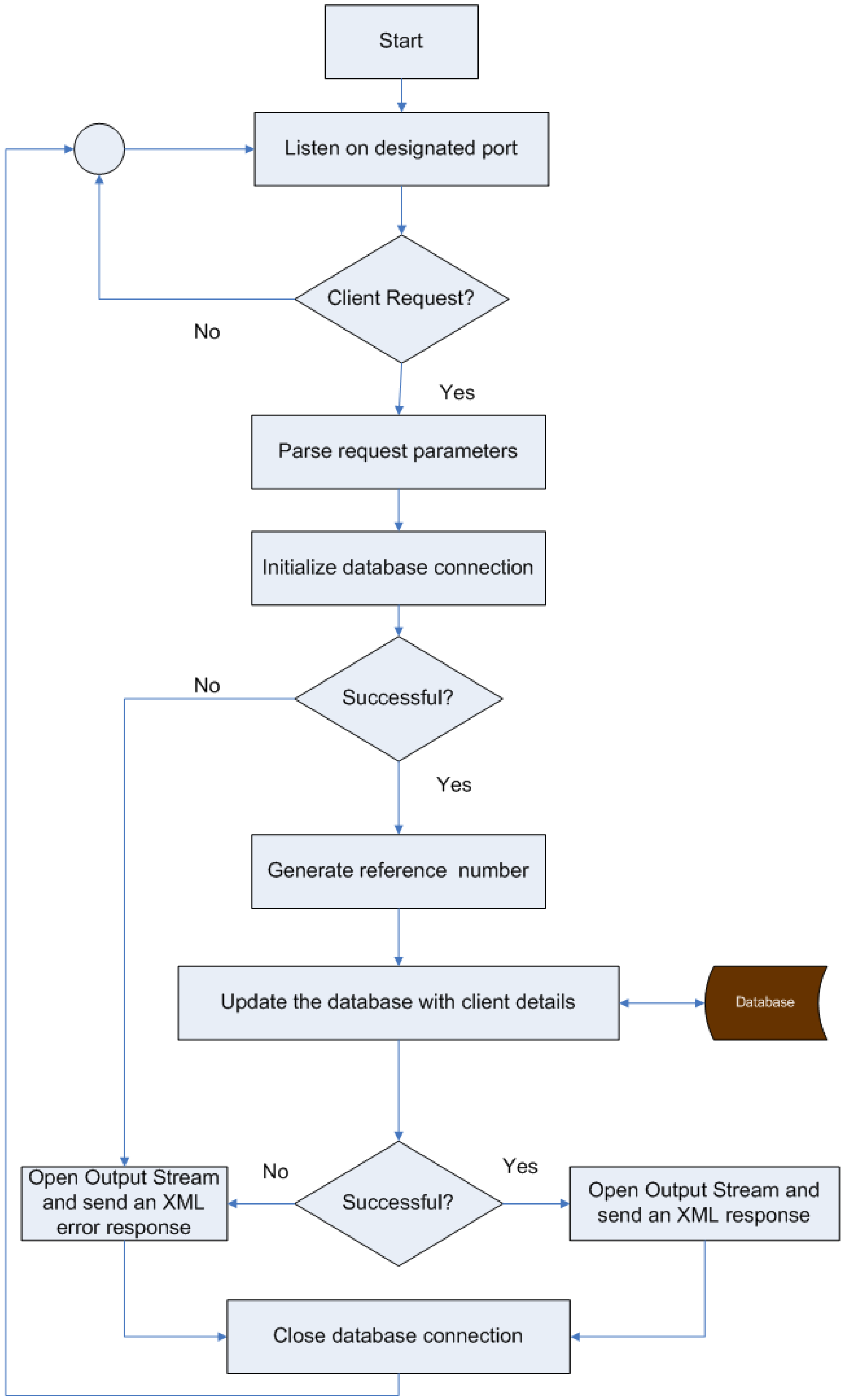


Figure 3-6: *clientDetails* Servlet Logical Flow Chart

As with the other two servlets, the *clientDetails* servlet runs within the Apache Tomcat server listening on the designated port for client requests. On receiving a request via `HTTP POST`, the servlet parses the client's request parameters containing the selected seats, the number of selected seats and the show identity number which identifies the particular showing. A connection is then made to the backend database component and, if successful, the servlet generates a reference number for the booking and updates the database with this number as well as with the show identity number and the seats selected by the client. If the update is successful, the servlet then generates an XML response containing the particular reference number and this is used by the client to authenticate their booking.

3.3.3. Middle tier web component classes overview

Figure 3-7 shows an overview of the three servlets that form the middle tier web component for the *Mobile Movie Booking* system.

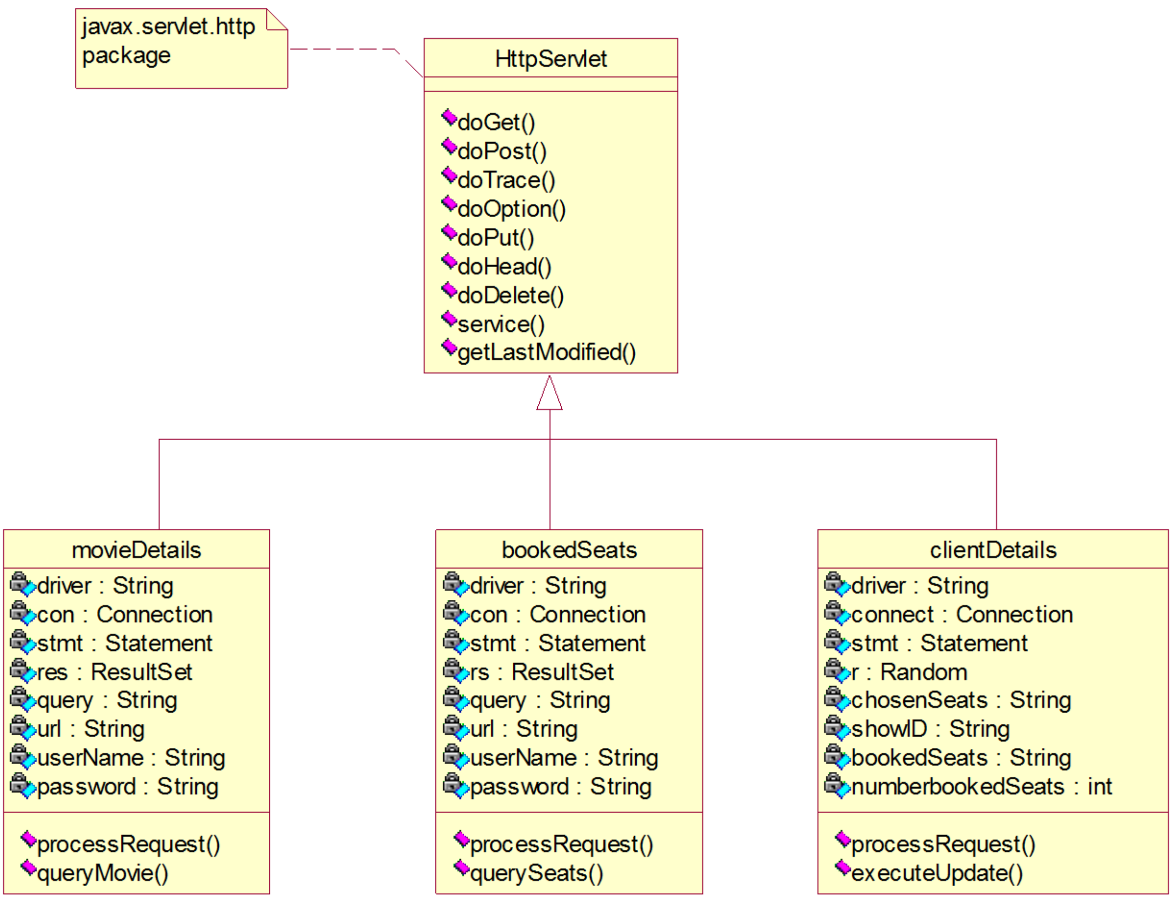


Figure 3-7: Middle tier web component classes overview

The three servlets overwrite the following methods:

1. The `doGet` method

The *movieDetails* and *bookedSeats* servlets receive queries concerning movie details and booked seats respectively, and as these are considered safe interactions, the `HTTP GET` request is implemented. On receiving a request the `doGet` method then passes the request to the `processRequest` method.

2. The `doPost` method

The *clientDetails* servlet implements the `HTTP POST` method as it is required to update the database as well as send sensitive data to the client. As with the `doGet` method, the *doPost* method sends the request to the `processRequest` method.

3. The `processRequest` method

The `processRequest` method parses the request parameters, registers the JDBC-ODBC driver and establishes a connection to the database. The `processRequest` method then calls the `queryMovie`, `querySeats` or `executeUpdate` method depending upon which servlet has been requested. The database is then queried or updated, using SQL statements. An XML response is generated and sent back to the client.

3.3.4. Packaging the servlets

This step involves packaging the compiled servlet into a Web Application Archive (WAR) file, which is a Java Archive (JAR) similar to the package used for Java class libraries. The WAR file is used to distribute the servlets in a production environment. The WAR file contains a directory called WEB-INF which, in turn, contains a file named web.xml (the web application deployment descriptor) which defines the structure of the web component. If the web component uses servlets, then the servlet container uses web.xml to ascertain which servlet a URI request should be routed to.

The NetBeans IDE has been used to package the *MobileMovieServlets* project which consists of the three servlets that make up the Web component for the *Mobile Movie Booking* system.

3.4. Designing the backend data component

Microsoft (MS) Access 2007 edition serves as the backend database management system for the *Mobile Movie Booking* system. MS Access 2007 offers a GUI interface for creating and manipulating the database. This enables rapid, efficient and flexible generation of tables and relationships within the database. In addition, the new Navigation Pane available in the 2007 edition provides a comprehensive view of tables, forms, queries, and reports.

3.4.1. The movies database

The *movies* database is the database that forms the backend tier data component for the *Mobile Movie Booking* system. Figure 3-8 shows the relationship between the two tables that form the *movies* database.

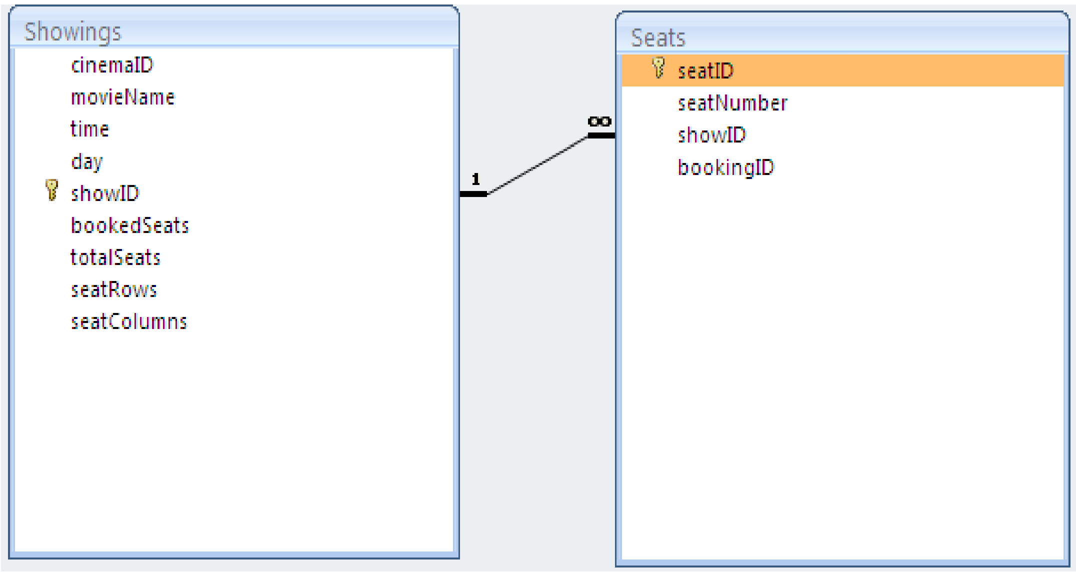


Figure 3-8: *movies* database showing related tables

The Showings table

The *Showings* table contains information about the available movies, show days and times of movies, number of booked seats, the show ID, the seating capacity and structure for a particular cinema house. The table is queried by the client via the *movieDetails* servlet at application start-up. It is also updated by the client once a showing has been selected and booked. This is done via the *clientDetails* servlet.

The Seats table

The *Seats* table contains the seats that have been booked for a particular showing, the show ID, the seat ID and the client's booking ID. The table is queried by the client via the *bookedSeats* servlet when intending to book seats for a particular showing, that is, once a movie's name, show day and time have been selected. It is also updated by the client via the *clientDetails* servlet once a booking has been made.

3.5. Chapter Review

In this chapter we discussed and analysed the design and implementation of the mobile application used to compare the JME and Flash Lite platforms. We discussed its functionality as well as analysed the architecture upon which it was developed. The hardware, software and network environment on which the application runs was then presented. We also discussed the advantages of going the servlet route for this project as well as outlined the need to investigate how the two mobile development platforms manipulate dynamic data in the form of XML. An analysis of the middle tier was then made, by first introducing Java Servlet technology and thereafter discussing the middle tier Servlet development process. Lastly, we looked at the design for the backend tier database component.

Chapter 4 Development of the JME and Flash Lite front tier

In the previous chapter we discussed the design and implementation of the *Mobile Movie Booking* system, as well as analysed the middle and back end tiers of the system. This chapter discusses and analyses the development of the JME and Flash Lite front tier. The front tier presents an interface to the user by which they can interact with the system. These interactions will enable various features to be tested and compared between the JME and Flash Lite development platforms. These features include XML handling, GUI designing, network connection implementation, multimedia content handling as well as persistent storage capabilities. Figure 4-1 shows a flow chart illustrating the various possible interactions between the user and the front tier component for the *Mobile Movie Booking* system.

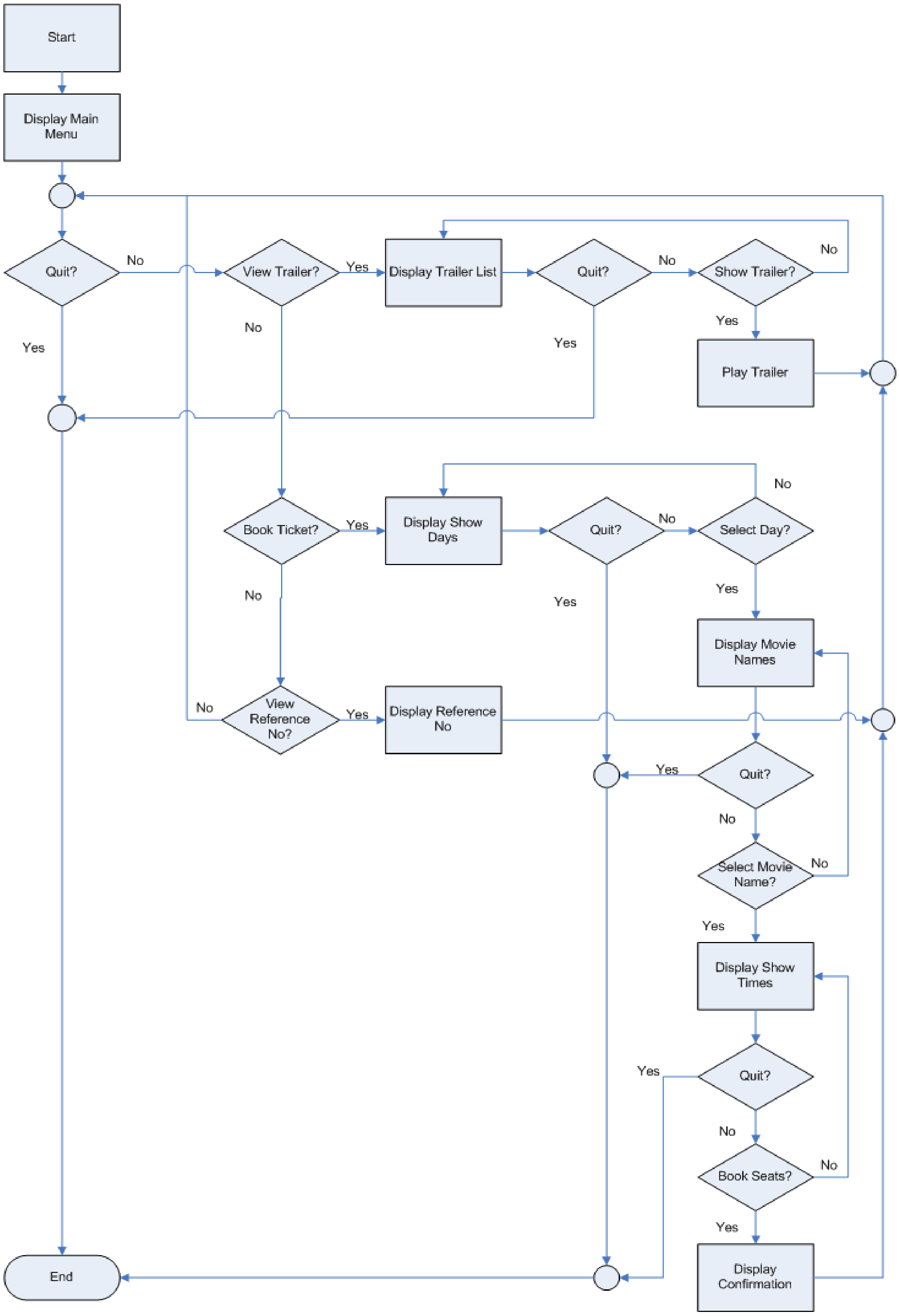


Figure 4-1: *Mobile Booking* system front tier Logical Flow Chart

Before we analyse the development of the front tier for the *Mobile Movie Booking* application, we need to first give an overview of the JME and Flash Lite development environments.

4.1. JME overview

Java Micro Edition is a set of technologies and specifications developed for small devices like mobile phones, pagers, and set-top boxes. Java programs running on such devices are called MIDlets. A MIDlet is represented by inheriting and instantiating the *`javax.microedition.MIDlet`* class. Java Micro Edition (JME) forms a subset of the Java Standard Edition (JSE) designed for desktop computers. JME consists of a much smaller virtual machine compared to the default JSE virtual machine supplied by Sun Microsystems [Wells 2004]. The JME architecture also allows for the exclusion of parts of the JSE platform such as Java language components and Java libraries. This enables a MIDlet to run within the constraints of the limited resources available on micro devices.

JME is divided into *configurations*, *profiles* and *optional APIs*, which provide specifications for different groups of mobile devices. A *configuration* is designed for a specific kind of device based on memory constraints and processing power. It specifies features such as the required virtual machine, a strict subset of JSE APIs, as well as additional APIs that may be necessary [Li and Knudsen 2005]. Device manufacturers are responsible for porting a specific configuration to a device.

A *profile* builds on a configuration but adds more specific APIs to make a complete environment for building applications. The additional APIs enable implementation of the application life cycle and also include features such as persistent storage and user interfacing.

An *optional package* provides functionality that may not be associated with a specific configuration or profile. The *Mobile Media API* (JSR 135) is an example of an *optional package* which provides a set of APIs for rendering and recording media data.

4.2. Adobe Flash Lite overview

Adobe Flash Lite is a lightweight version of Flash Player suitable for the processing and memory capabilities of mobile phones and handheld multimedia computers. Different versions of Flash Lite are available. These include Adobe Flash Lite 1.0 and 1.1, which are based on Flash Player 4, and Flash Lite 2.0 and 2.1, based on a subset of Flash Player 7. The developer edition of Flash Lite 3.0, which was released in October 2007 [Adobe 2007e], is also based on Flash Player 7, and it introduces support for Flash Video, for browsing most Flash 8 content, as well as numerous performance improvements [Adobe 2007f]. The developer edition is only a standalone player and will allow developers to test and play back Flash files that are published as Flash Lite 3.0 [Nokia 2007ed]. The Flash Lite authoring environment is integrated into the Adobe Flash Authoring IDE which initially, was solely for the development of desk-top applications [Vander Veer E.A, 2006]. The Flash Authoring IDE contains all the relevant development tools, from design tools to a full-featured ActionScript code editor, enabling for the efficient and rapid creation and deployment of content and interfaces to mobile devices.

4.3. Developing the Mobile Movie Booking System front tier

In this section, we will discuss the development of the JME and Flash Lite applications that form the front tier component of the *Mobile Movie Booking* application. Focus will particularly be on key features including the GUI design, network connection, multimedia content handling, dynamic XML handling, and persistent storage capabilities.

4.3.1. Design and implementation

The *Java Technology for the Wireless Industry* (JSR 185) specification provided the application environment for the JME front tier. The JSR 185 specification defines a common architecture and programming interface for wireless handsets, based on the Connected Limited Device Configuration (JSR 30), Mobile Information Device Profile 2.0 (JSR 118), Wireless Messaging API (JSR 120), and Mobile Media API (JSR 135) [Figure 4-2] [Sun 2007d].

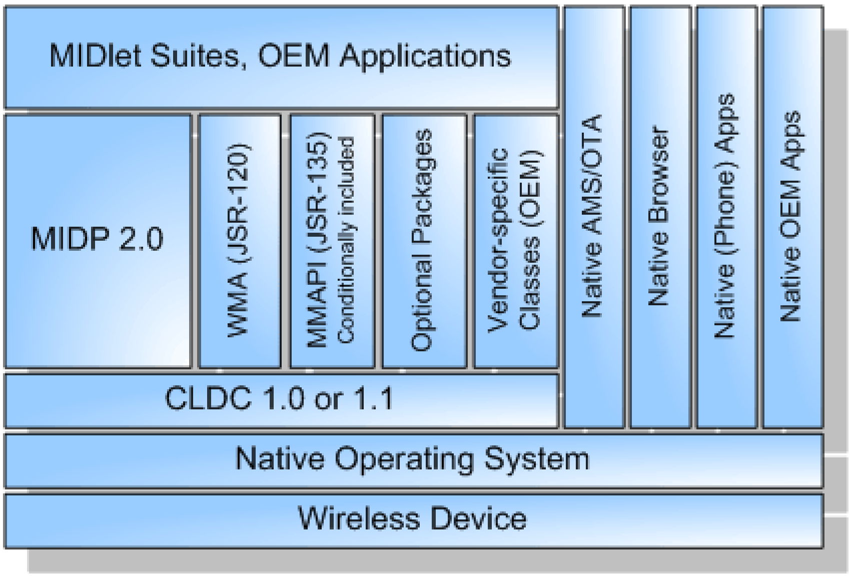


Figure 4-2: Java Technology for the Wireless Industry (JSR 185) architecture [Sun 185]

Flash Lite 2.1 provided the application environment for the Flash Lite front tier. The Flash Lite application was developed in Flash Lite 2.1 as Flash Lite 3.0 enabled devices will be available only in the first quarter of 2008 [Nokia 2007ed]. Figure 4-3 shows the Flash Lite 2.1 architecture implemented in the Flash Lite front tier.

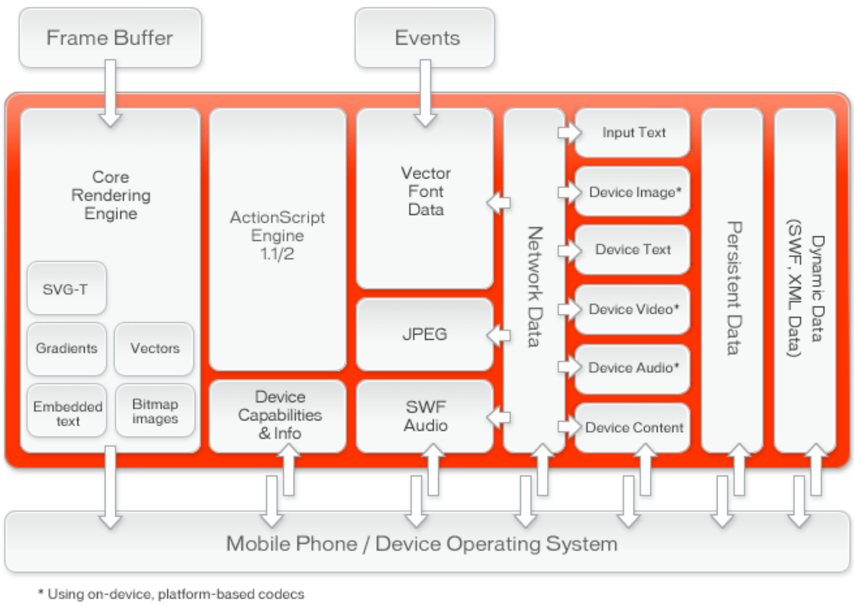


Figure 4-3: Flash Lite 2.1 architecture

As discussed in chapter 3, the JME front tier was developed using the NetBeans 5.5.1 IDE and the Sun Wireless Toolkit SDK. Figure 4-4 shows a class diagram illustrating the components that make up the JME front tier for the *Mobile Movie Booking* system.

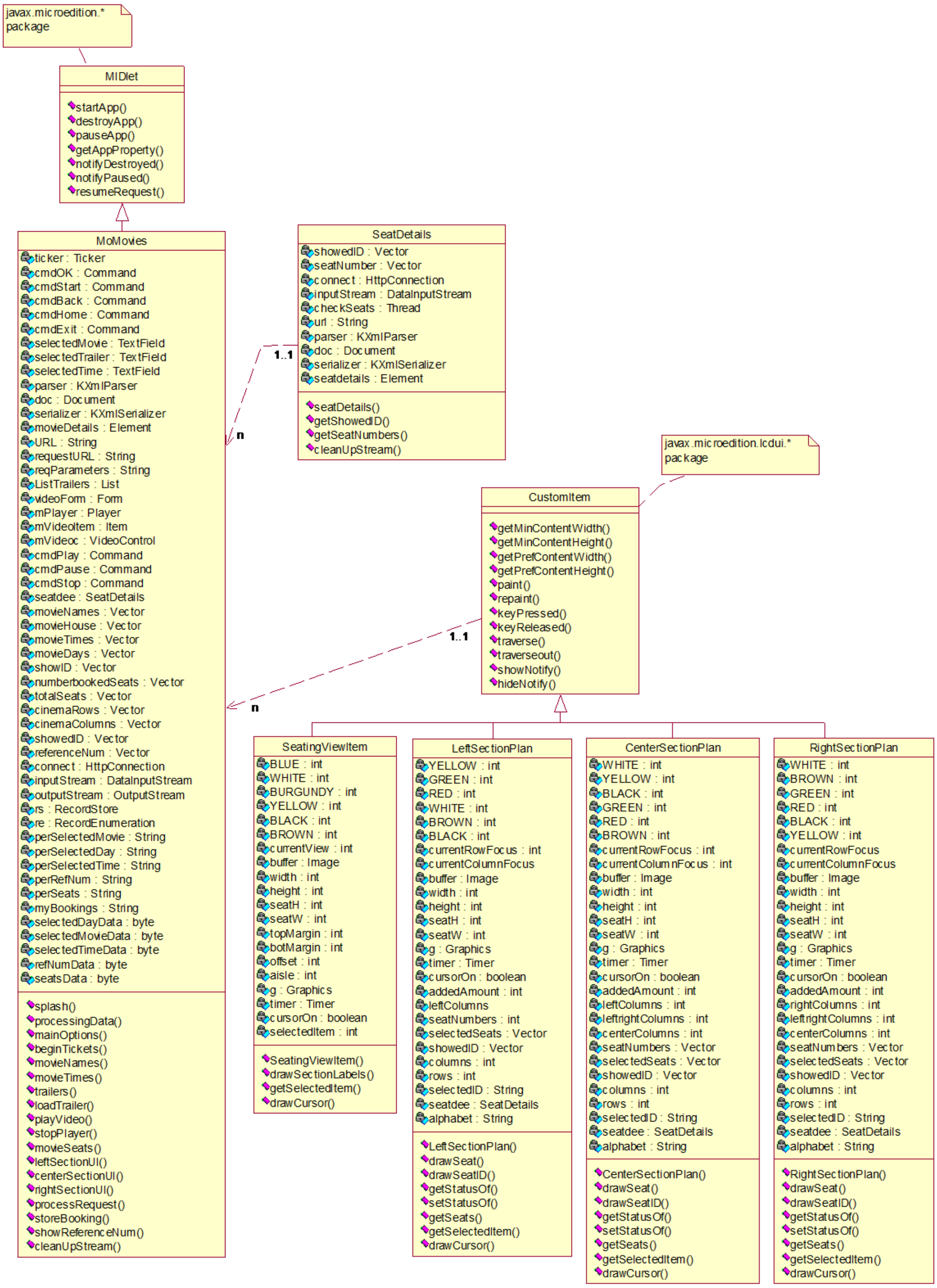


Figure 4-4: JME front tier class diagram

From Figure 4-4 we note that there are six classes that form the JME front tier component for the *Mobile Movie Booking* application. The *MoMovies* MIDlet forms the core part of the front tier component and carries out several functions such as retrieving and displaying movie details, managing video playback as well as storing user details to persistent storage. The `SeatsDetails` class is responsible for querying a server for seat details, which includes a list of unavailable seats for a particular showing. The four classes that extend the `CustomItem` class are responsible for rendering the various seating arrangements within the movie house.

The Adobe Flash Creative Suite 3 Web Standard Edition and Adobe Device Central were used for the development of the Flash Lite front tier. Instead of creating ActionScript classes to structure the application's logical flow, the time-line-based method was used. This method uses the timeline to define states that the application can exist in. Code is then written directly in frames on the timeline [Leggett et al. 2006].

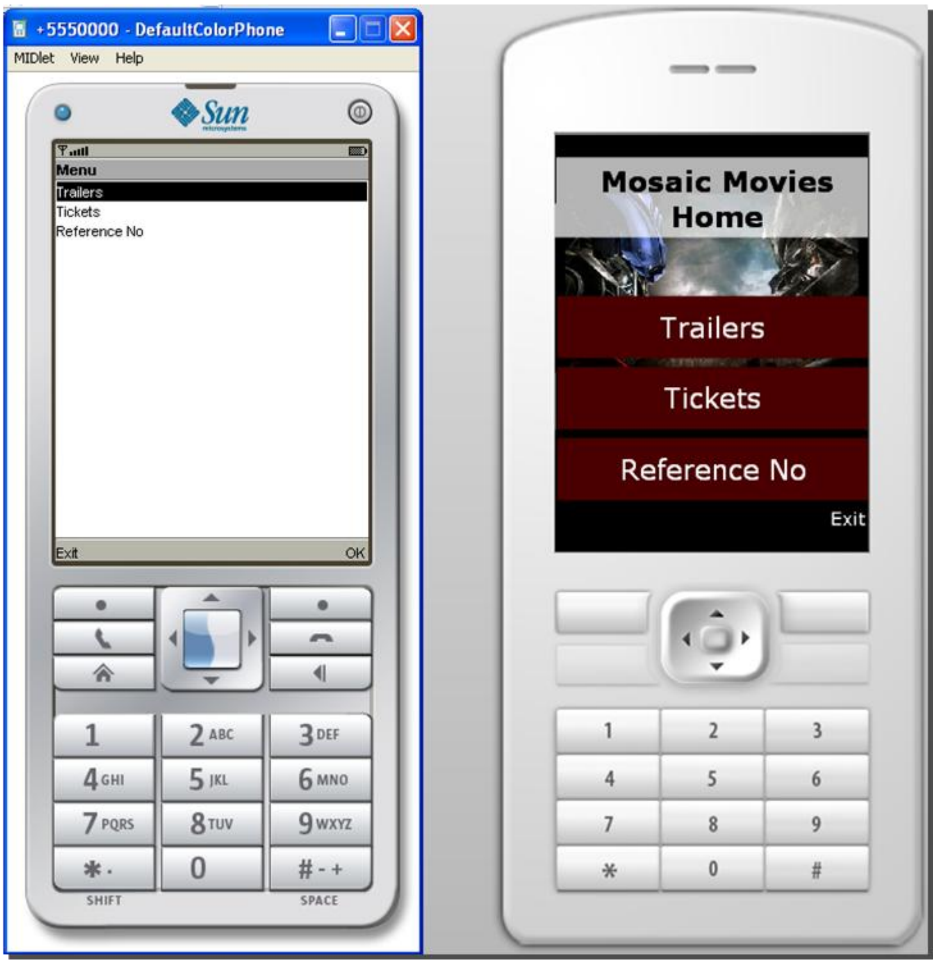
Both JME and Flash Lite applications developed for the *Mobile Movie Booking* system have similar functionality and thus have the same key features implemented. We will now analyse these features.

4.3.1.1. Creating graphical user interfaces

Form and List are the two commonly used classes for the creation of user interfaces for the JME application. A List allows users to select items (called elements) from a list of choices whereas a Form is a screen that can include an arbitrary collection of user-controls, called items [Li and Knudsen 2005]. To create customized graphical user interfaces in JME, such as the movie house seats, a subclass of `CustomItem` is defined by implementing five abstract methods. The `CustomItem` class is available from the `javax.microedition.lcdui` package. The `getPrefContentWidth()` and `getPrefContentHeight()` abstract methods define how big the custom item intends to be, and the `getMinContentWidth()` and `getPrefContentHeight()` methods return information about the minimum size of the item. This is the smallest size that the custom item can tolerate. The `paint()` method is the method that is called to render the custom item.

Graphical user interfaces were dynamically created under the Flash Lite development platform. This was achieved by dragging and dropping graphical elements available within the Flash Authoring IDE, and modifying their properties such as size and colour. These graphical elements were then dynamically attached to the application at runtime using the `attachMovie` method in ActionScript.

Figure 4-5 shows a list of elements from the *Mobile Movie Booking* application that was generated after implementing the List class in JME and dynamically attaching graphical elements in Flash Lite.



JME Flash Lite

Figure 4-4-5: User interfaces in JME and Flash Lite

Figure 4-6 shows custom elements from the *Mobile Movie Booking* application that was generated after extending the `CustomItem` class in JME and dynamically attaching graphical elements in Flash Lite using the `attachMovie` method.

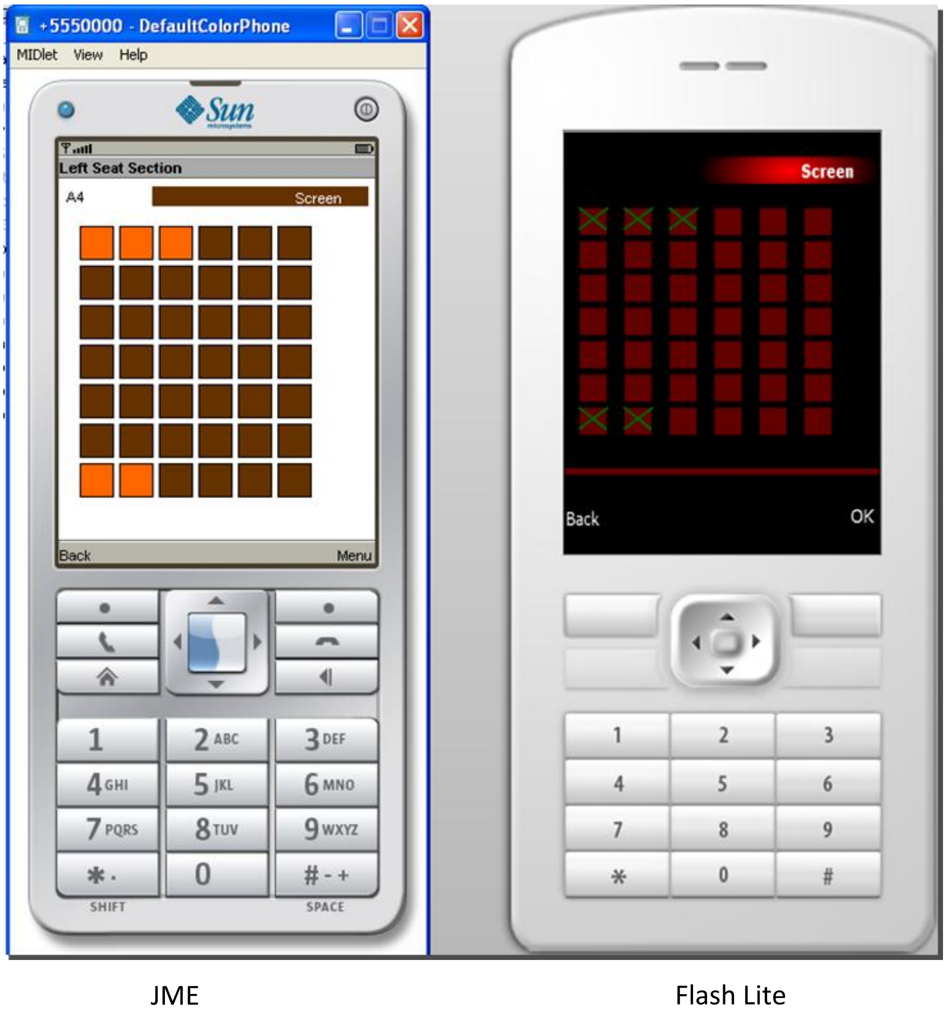


Figure 4-4-6: Custom elements in JME and Flash Lite

4.3.1.2. Network connection

The *Mobile Movie Booking* application allows users to query movie details from a server as well as book seats for a particular showing. An `HttpConnection` interface from the `javax.microedition.io` package is used to set up an HTTP connection between the MIDlet and the web server. Requests from the user are then sent to the web server through an output stream on the particular HTTP connection and responses are received through an input stream on the same connection. Flash Lite implements the `sendAndLoad` method. This method takes as input the requested Uniform Resource Indicator (URI), as well as an XML document that receives the response from the server.

4.3.1.3. Handling Dynamic XML in JME

On receiving a request from the front tier, the middle tier web component generates and sends back a response in the form of an XML document. In order to access the data within the XML tree under the JME environment, it is programmatically required to parse the XML document and thereafter access specific nodes using selected APIs.

XML parsing in the JME front tier was implemented using the kXML parser. kXML is an open source XML parser that is compatible with all JME environment configurations [Yuan 2004]. The Document Object Model (DOM), XmlPull, and Simple API for XML (SAX) are models which can be used in JME to access data within the XML tree. The DOM model was chosen over XmlPull and SAX as it requires less coding, provides easier debugging and enables the random access to any node in the XML tree [Yuan 2004].

Under the Flash Lite environment, no code is required to parse XML documents. This is automatically done by the Flash Lite runtime engine. To access data within the XML tree the `onLoad` method is implemented. This method reads data from the XML nodes and passes the values to a string array.

4.3.1.4. Multimedia content handling

The Mobile Media API (MMAPI) is used to handle multimedia content under the JME development environment. MMAPI extends the functionality of the J2ME platform by providing audio, video and other time-based multimedia support to resource-constrained devices. The MMAPI interface is an optional package available from the `javax.microedition.media` package. The MMAPI is built on a high-level abstraction of all the multimedia devices that are possible in a resource-limited device. This abstraction is manifest in three classes that form the bulk of operations that carried out by the API. These classes are the `Player` and `Control` interfaces, and the `Manager` class [Figure 4-7]. The `DataSource` abstract class is another MMAPI class used to locate resources, but is hardly used as reading data from a resource is predefined by the Java Virtual Machine implementation [JME tutorial].

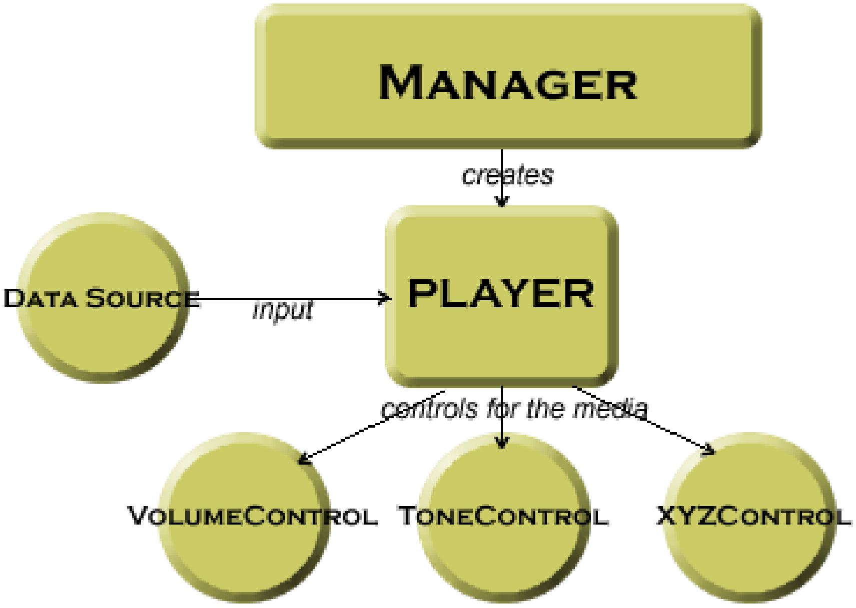


Figure 4-7: JME Mobile Media API (MMAPI) classes

The `Manager` class creates `Player` instances for different media by specifying `DataSource` instances. A `Player` is responsible for interpreting and controlling media data. For example, almost all `Player` instances would theoretically support a `VolumeControl` to control the volume of the `Player`. The `DataSource` transports media data from its original location to a `Player`.

The Flash Lite runtime environment depends on the device video player for video playback. Very few methods are available that control the playback of multimedia content under the Flash Lite environment and these include the `play`, `pause`, `resume` and `stop` methods. Figure 4-8 shows video playback under the JME and Flash Lite platforms.

JME Flash Lite

Figure 4-8: Video playback under JME and Flash Lite 2.1

4.3.1.5. Persistent Storage

In JME, persistent storage is based on record stores. A *record store* is a small database that contains pieces of data called *records*. Record stores are represented by instances of `javax.microedition.rms.RecordStore`. Record stores are identified by a name. Within a MIDlet suite's record stores, the names must be unique [Li and Knudsen 2005]. The `openRecordStore` method from the `RecordStore` class is used to create a new record store if it does not already exist otherwise it is used to open an existing record store. Data from a JME application that is to be persistently stored, gets stored as a byte array using the `addRecord` method. The data can then be retrieved using the `getRecord` method.

The `SharedObject` class is used to read and store data under the Flash Lite development environment. Flash Lite shared objects store a set of name-value pairs to the device. The `getLocal` method is used to create a shared object. Data can then be added, read or removed from the shared object. To guarantee that the shared object will be written to the device, the Flash Lite application must force a write operation by calling the `flush` method. The `clear` method purges all the data from the shared object and deletes the shared object from the disk.

4.4. Chapter Review

In this chapter we discussed and analysed the development of the JME and Flash Lite front tier. We started by illustrating the logical flow of the front tier component of the Mobile Movie Booking system. We then gave an overview of the JME and Flash Lite platforms, highlighting the architecture implemented in the development of the front tier component. Finally, we presented the various methods available in both platforms that enabled the incorporation of the required features into the JME and Flash Lite applications.

Chapter 5 Benchmarking Flash Lite against JME

This chapter discusses and analysis how the upcoming Flash Lite development platform compares with the more mature JME development environment. Several key factors have been tested through the development of the *Mobile Movie Booking* system as discussed in chapters 3 and 4. These have allowed extensive analysis to be made between the two mobile application development platforms. The objective of these comparisons is to enable developers to make trade-off decisions when considering the creation of mobile applications.

5.1. General Comparisons

5.1.1. Foundation Language

ActionScript 2.0 is the language used to develop Flash Lite applications. The JME platform uses the Java language to develop mobile applications.

Both languages allow for platform independence. However, Java is more robust and secure compared to ActionScript 2.0. Firstly, Java byte code (compiled java source code) is verified before execution. This process validates the configuration of class files and prevents the execution of malicious code which could corrupt the target device. Secondly, JME applications never escape from the confines of the Java Virtual Machine (JVM). Hence, if a JME application crashes it will not affect other sensitive data on the mobile device.

5.1.2. Mobile device diversity (fragmentation)

The Flash Lite platform defines different versions of Adobe Flash Lite runtime engines for specific groups of mobile devices. As discussed in the previous chapter, JME is divided into configurations, profiles and optional APIs standardized through JSR 185.

The available spectrum of mobile devices presents diversity and fragmentation in terms of the APIs offered by target devices. As these APIs vary across devices due to different development implementations by manufacturers and mobile carriers, developers are left guessing the application environment capabilities for target devices.

Both Flash Lite and JME platforms provide effective features to address mobile device diversity. Flash Lite defines different versions of Adobe Flash Lite runtime engines for specific groups of devices. A developer is only required to know which runtime engine is supported by the target device. The developer then simply creates an application that is supported by that runtime engine. However, with Flash Lite, features such as multimedia playback and persistent storage size definition are handled by the operating system running on the device. This has the effect of limiting the capabilities or even portability of an application across devices with different operating systems yet having the same Flash Lite runtime engine.

The Java Specification Request (JSR) 185 is a specification that addresses API fragmentation under the JME environment. JSR 185 provides developers with a full-featured, stable, standard application environment for which they can develop. The specification standardizes features such as the type of Java Virtual Machine, the heap memory available to the application, the persistent storage size as well as the protocols for accessing multimedia content.

JME offers a better approach compared to Flash Lite as none of the application capabilities is dependent on the device's operating system thus greatly reducing the level of device fragmentation.

5.2. Mobile device comparison

5.2.1. Runtime environment

Adobe Flash Lite runtime engine is the runtime environment for Flash Lite. As JME is written in Java it relies on the Java Virtual Machine (JVM) to run.

In order to run Flash Lite applications on mobile devices, the required runtime engine can either be built in by the device manufacturer or alternatively installed by the user. For JME applications to be supported on a mobile device, chips designed specifically for Java byte code execution should be embedded into the device by the manufacturer.

Flash Lite is therefore more adaptable for a wider range of mobile devices as Flash Lite applications require no special hardware implementation. However, there are significantly more mobile devices enabled with the JME runtime environment compared to Flash Lite, as will be discussed later in the chapter.

5.2.2. Persistent Storage

The storage size available to the application is determined by the target device. ActionScript 2.0 offers methods that can be used to query the storage size allocated by the device. The Flash Lite platform does not support the sharing of persistent data with other applications. For the development of the *Mobile Movie Booking* application it required 7 lines of code to save user data to persistent storage. The Java Specification Request 185 standard specifies a minimum and maximum size of 8KB and 30KB respectively allocated for persistent storage. Under the JME platform, stored data can be accessed by other JME applications. For the development of the *Mobile Movie Booking* application it required 27 lines of code to enable user data to be stored persistently.

JME is the recommended development platform if other applications will be required to access stored data. Flash Lite is an advantage when considering the number of lines of code that are required to store the data persistently and this could also reduce error occurrences. This will speed up the application development process as less coding will be required and less time will be spent debugging errors.

5.2.3. Dynamic XML handling

As discussed in the previous chapter, the Flash Lite runtime engine automatically parses XML documents. Code is required only when accessing specific nodes within the XML tree. In the *Mobile Movie Booking* application it required 11 lines of code to access data within the XML document received from the web server. JME requires the developer to programmatically parse the XML document using either the Simple API for XML (SAX), XmlPull or Document Object Model (DOM) method. Once parsing is complete, the XML tree can then be accessed using a set of available Java API methods. DOM was used to parse the XML document in the *Mobile Movie Booking* application under the JME development platform. Parsing and accessing data within the XML document received from the web server required 29 lines of code.

Figure 5-1 shows the average time, in milliseconds, after 10 test runs for the Flash Lite and JME platforms to send a request to the web server, receive a reply in the form of an XML document, and to finally access the data within the XML tree.

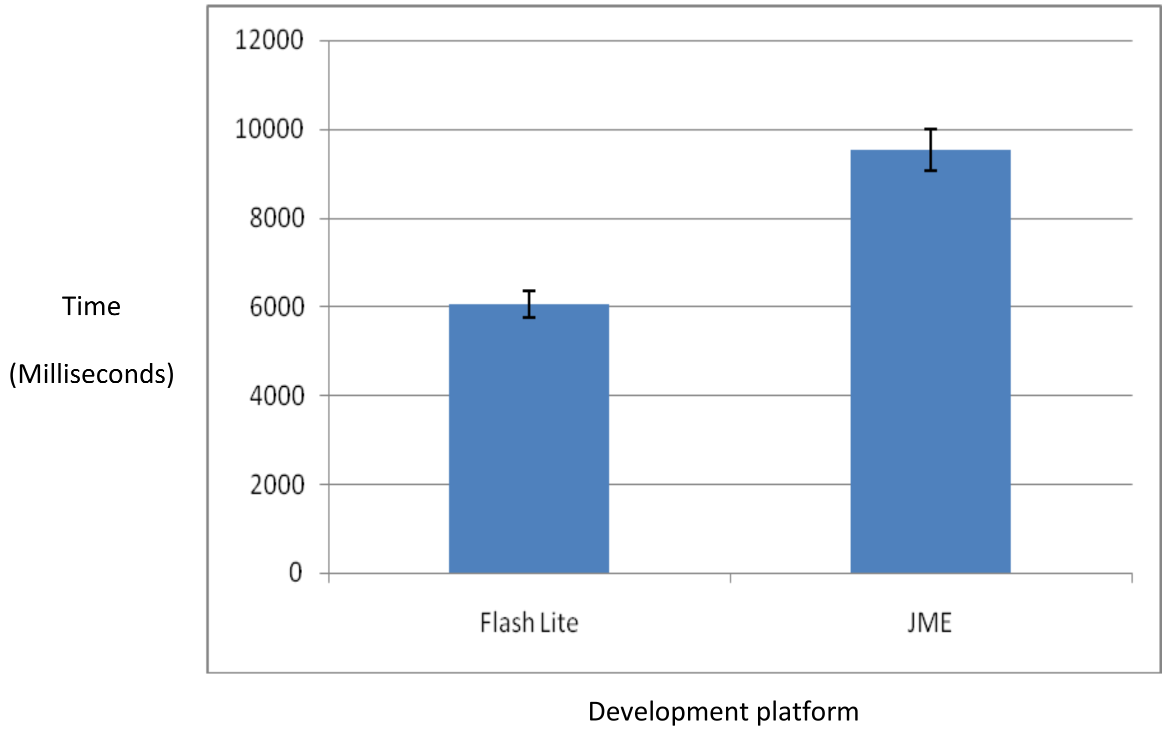


Figure 5-1: Average Time required by Flash Lite and JME to access XML data

Figure 5-1 shows that Flash Lite accesses data within XML documents faster than the JME environment. Analysis and results show that Flash Lite is recommended when developing mobile applications with extensive handling of XML documents. This is because Flash Lite parses the XML faster and requires less coding, reducing possible errors, application size as well as the time to develop mobile applications.

5.2.4. Multimedia capabilities

As discussed in chapter 4, Flash Lite depends on the device video player for video playback. Very few methods are available that control the playback of multimedia content under the Flash Lite environment and these include the play, pause, resume and stop methods. The video player within Nokia devices can handle only streamed multimedia content from a specialised server such as Helix or Darwin [MIT 2007][Adobe 2007g]. Therefore Flash Lite applications running on Nokia devices may only stream through multimedia content. The JVM is responsible for handling multimedia content under the JME platform. Several advanced Java APIs exist that control video playback beside the play, pause, resume and stop methods. These include rotation, scaling, volume, screen size as well as video recording methods. These enable developers to have a lot of control over multimedia content. HTTP download is the standard protocol used to play video content from a server although in a few cases Real-Time Streaming Protocol (RTSP) streaming is also possible. RTSP is a protocol for controlling a stream of real-time multimedia content. The streams are sent using Real-Time Transport Protocol (RTP), a transport protocol used for transmitting real-time multimedia content over networks [IETF 2007]. Figure 5-2 shows the average time after 10 test runs, in milliseconds, required for video play to start in the *Mobile Movie Booking* application under the Flash Lite and JME platforms.

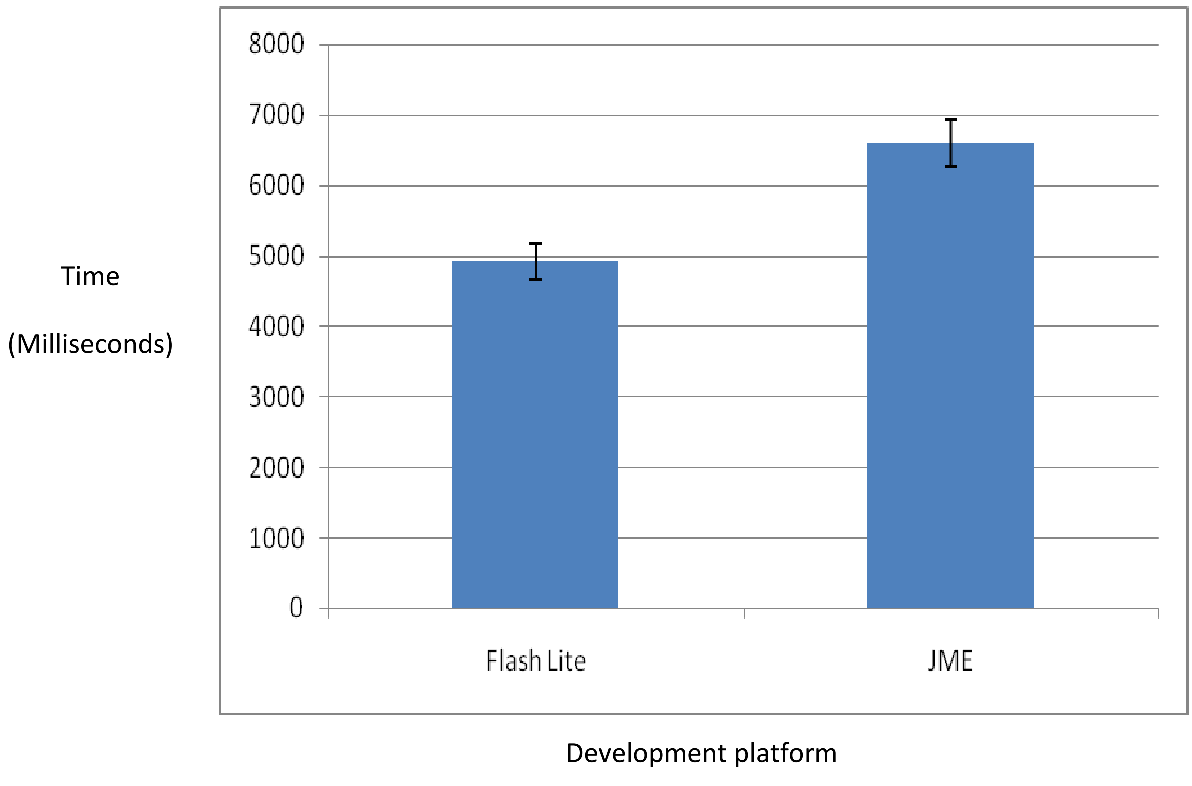


Figure 5-2: Time required for video play in Flash Lite and JME development platforms

Figure 5-2 shows that Flash Lite requires less time for video play to start compared to the JME platform. When using HTTP under the JME environment to play a video file, usually the entire file is required to be downloaded before play can begin. With RTSP video streaming in Flash Lite, it is not required to download an entire video file before play begins and therefore play starts faster.

Analysis and results show that Flash Lite video streaming is recommended when dealing with large video files. This is because play starts more quickly, as mentioned above, and memory space is also saved on the memory constrained target device as only portions of the video file are actually downloaded and played at any given time. It is important to exercise caution when opting to stream video as it may be blocked by firewalls sitting between the target device and the streaming server.

On the other hand, JME provides greater application portability as the JVM is responsible for handling the multimedia content compared to the device dependent Flash Lite platform. There is also a lot of video control available when developing under the JME environment. This provides greater interactivity between the user and video content from the mobile application.

5.3. Development tools comparison

5.3.1. Available IDEs

Adobe Flash Authoring IDE is the available IDE for Flash Lite applications. The proprietary software includes features such as debugging, code auto-complete as well as a powerful GUI designer. Netbeans IDE, Sun Wireless Toolkit, SunOne Studio and Eclipse are open source IDEs available for JME application development. As discussed in chapter 4, Netbeans 5.5.1 IDE was used for the JME front tier development of the *Mobile Movie Booking* system. The IDE offers features such as code auto-complete, syntax highlighting, refactoring, extensive debugging as well as an obfuscator. The obfuscator is an optional tool used to improve the size, performance, and security of a JME application just before the deployment stage [Java tools 2007].

Various IDE options are available for mobile application development under the JME environment. Each IDE provides JME developers with advanced features that enable quick and efficient writing of code. The JME IDEs also provide a cost effective option for the development of mobile data services as they are free for download as compared to the proprietary Adobe Flash Authoring IDE. However, Flash Lite is recommended for the development of rich GUI applications as the Flash Authoring IDE offers a more powerful GUI designer as compared to the designer offered by the NetBeans IDE.

5.3.2. Emulator platforms

The Adobe Device Central is the emulator platform used under the Flash Lite environment. The emulator is bundled with the Adobe Flash Authoring IDE. The Sun Wireless Toolkit and S60 SDE for Mobile Information Device Profile (MIDP) are common emulator platforms used when developing JME applications. The Sun Wireless Toolkit 2.5 was the emulator platform used for the development of the JME front tier of the *Mobile Movie Booking* system.

Key features are provided by the emulator platforms including memory analysis, network management and monitoring, object creation analysis (JME only) and persistent storage monitoring. JME emulator platforms are more mature than the Flash Lite emulator platform and provide a more comprehensive feedback in the form of tables and graphs. This allows for better application testing and monitoring.

5.3.3. GUI designing

The Adobe Authoring toolkit provides developers with a powerful GUI designer. Rich graphical user interfaces can be easily and rapidly created by simply dragging and dropping components from the tools panel to the stage as discussed in section 4-3. No code is required to create graphical components. GUI components in JME are usually composed through hard-code. The NetBeans 5.5.1 IDE has a GUI designer although it is relatively difficult to customizing the code generated automatically by the IDE.

Flash Lite is recommended for the development of mobile applications with rich graphical interfaces. The Adobe Authoring toolkit provides developers with fast, easy and efficient creation of rich graphical user interfaces not possible with JME.

5.3.4. Packaging and Deploying

There are three main package formats available with Flash Lite namely .swf (Flash file), .sis (Symbian installer) and .cab (Windows installer). The Flash Authoring IDE can be used to create .swf files. SWF2Go and Internet Explorer Administration Kit (IEAK) are used to create .sis and .cab files respectively [Orison 2007] [Microsoft 2007e]. The *Mobile Movie Booking* application was packaged into a .sis format and had a file size of 355KB. The Java Archive (JAR) file and Java Application Descriptor (JAR) are the package formats available under the JME platform. The JAR and JAD file can be created using the available JME IDEs. Both package files are required to be deployed to a target device before installing the application. For the *Mobile Movie Booking* application the JAD file had a size of 1KB whilst the JAR file had a size of 208KB.

Both Flash Lite and JME platforms produce small packaged file sizes. The difference in size is probably not attributed to lines of code, as there are more lines of code in the JME application. A probable cause could be attributed to the image files incorporated into the JME and Flash Lite applications. The Flash Lite application uses a 300KB Scalable Vector Graphics (svg) icon file whereas the JME application uses a 3.51KB Portable Network Graphics (png) file. Deployment of the packaged files is carried out in the same way them using USB, Bluetooth or over the air (OTA).

5.3.5. Help System

The Flash Authoring IDE provides a static help system. The help system has a search function that assists developers with quick and easy retrieval of information. The NetBeans 5.5.1 IDE used for the development of the JME front tier of the Mobile Movie Booking application provides a web based help system. However, there is no search facility to enable developers to retrieve specific information quickly.

Compared to JME, the Flash Lite help system offers better presented and organized topics and sample code. The time required to access information is greatly reduced due to the quick search function. This will inevitably speed up the development of mobile applications. The JME help system has the advantage of having updated help topics as compared to the static Flash Lite help topics. JME developers will be required to have an internet connection to access help topics and sample code. This may pose a major disadvantage as internet connection may not always be available, prolonging the development of the application.

5.4. Industry Support Comparison

5.4.1. Market penetration and Community Support

Flash Lite has extensive support from developers as well as mobile device manufacturers including the top five manufacturers namely Nokia, Motorola, Samsung, SonyEricsson and

LG [Adobe Partners]. As of June 2007, there were 300 Flash-enabled device models available [Adobe 2007f]. JME also has extensive support from several mobile operators, technology providers and device manufacturers including the top five manufacturers mentioned above. There are over 700 JME-enabled devices available [Sun devices].

Both platforms have extensive support from mobility companies and mobile application developers. However, there are significantly more mobile devices enabled with JME as compared to Flash Lite. This is because JME is a more mature development platform whereas Flash Lite is still an upcoming mobile development environment.

5.5. Chapter Review

In this chapter we analysed and discussed how the upcoming Flash Lite development platform compares with the more mature JME development environment. Several key features were tested and analysed enabling the strengths and weaknesses of each development platform to be realised. Generally, JME provides more control and functionality through its numerous APIs whereas Flash Lite allows for the rapid creation of applications with rich GUIs. These comparisons inevitably enable developers to determine which development platform best suites the creation of a particular mobile data service. Table 5-1 summarizes the differences and similarities between the Flash Lite and JME mobile development platforms.

Table 5-1: Flash Lite vs. JME overview

Mobile application development under Flash Lite and JME		
General comparisons		
	Flash Lite	JME
Platform independent	Yes	Yes
Foundation Language	ActionScript 2.0	Java
Device Fragmentation	Defines different versions of Adobe Flash Lite runtime engines	Divided into configurations, profiles and optional APIs standardized through JSR 185.
Mobile device comparisons		
	Flash Lite	JME
Runtime environment	Adobe Flash Lite runtime engine	Java Virtual Machine (JVM)
Persistent Storage	Device Dependent	JVM dependent
XML parsing	Automatic	Programmatically
Multimedia content handling	Depends on the Device player	Relies on the JVM
Control over video play	Limited	Extensive
Packaging	.sis, .swf, .cab	JAD and JAR files

Mobile application development under Flash Lite and JME (continued)		
Development Tools		
	Flash Lite	JME
Operating System	Windows, Mac	Independent
IDE	Adobe Flash Authoring IDE	Netbeans IDE, SunOne Studio, Eclipse
Application SDK	Adobe Device Central	Sun Wireless Toolkit, S60 SDE for Mobile Information Device Profile (MIDP)
SDK integration	Bundled with IDE	Standalone
GUI design	GUI designer	Text editor
Exception handling	Optional	Enforced
Debuggers available	Good	Excellent
Help System	Static	Dynamic
Support		
	Flash Lite	JME
Standard	Proprietary	Open Source
Development Community and Support	Extensive	Extensive
Market penetration	Good	Extensive

Chapter 6 Conclusion and possible project extensions

This chapter presents the conclusion and final analysis of the results detailed in the previous chapters. Also of particular importance the possible project extensions are given below.

6.1. Conclusion

With the advancement of technology, leading to improved audio quality, voice is no longer a competitive factor in attracting and retaining customers in the mobile industry. Mobility companies are now looking to mobile data services to generate substantial revenue in order to maintain or increase market share. However, to realize the full potential of mobile data services, the right development tools need to be implemented. This ensures the quick and easy creation, deployment, and management of content and applications on mobile devices.

The Java Micro Edition and Flash Lite development environments provide key features that address the need for efficient creation of mobile applications. Each development environment has received extensive community support and market penetration. However, the features prescribed by each platform are unique and therefore may be best suited for the development of particular groups of mobile applications. This project conducted a comprehensive and necessitated comparative study of the two mobile development platforms. The conclusions drawn enable developers to make informed decisions as to which platform offers tools best suited for the development of a particular mobile application. The conclusions obtained also reflect how the emerging Flash Lite platform competes with the more established JME development environment.

Generally, JME provides more control and functionality through its numerous APIs whereas Flash Lite allows for the rapid creation of applications with rich graphical user interfaces.

6.2. Project Achievements

The work undertaken in this project successfully meets the objective of the project which was to conduct a comparative study of the Java Micro Edition and Flash Lite development environments for the development of mobile data services. Comprehensive analyses and results were obtained from the design and implementation of the JME and Flash Lite applications. These results were clearly presented, with the weaknesses and strengths of the two platforms clearly evident.

6.3. Project limitations

The one aspect that could be a limit to the project was the unavailability of a 3G network preventing the testing of client-server communication over a real network. Client-server communication was carried out using a WLAN with the only traffic generated being that of the JME and Flash Lite applications. This prevented an analysis of how the JME and Flash Lite platforms perform over the typically slow, unreliable, and insecure live networks. To address this concern the web server should possess a public network address enabling the mobile phone to access it through a selected 3G network.

6.4. Possible Project Extensions

6.4.1. A comparative study of Flash Lite 3.0 and Java Micro Edition

With the release of Flash Lite 3.0 Developer Edition by Adobe, and Flash Lite 3-enabled devices expected in the first quarter of 2008, it would be of interest to investigate how this latest Adobe Flash Lite version compares with the Java Micro Edition. Advanced features have been incorporated into Flash Lite 3.0 including Flash Video support, which is the most popular video format on the Internet, support for rendering of Flash files for Flash Player 8, and a 25 to 30 percent faster performance across devices [Flash Lite 3, 2007].

6.4.2. A comparative study of JavaFX Mobile and Flash Lite

JavaFX Mobile technology is a complete, pre-integrated software system for advanced mobile devices, enabling developers to author rich, high-impact content and network-based services. Built around open and standards-based APIs and technologies (Java and Linux), JavaFX Mobile allows applications to be leveraged across a wide range of Java technology-enabled devices. JavaFX Mobile includes support for Java ME applications and other standard Java APIs.

With Flash Lite as the leading platform in providing rich graphical content it would be of interest to investigate how the new JavaFX Mobile platform compares with the Flash Lite development environment.

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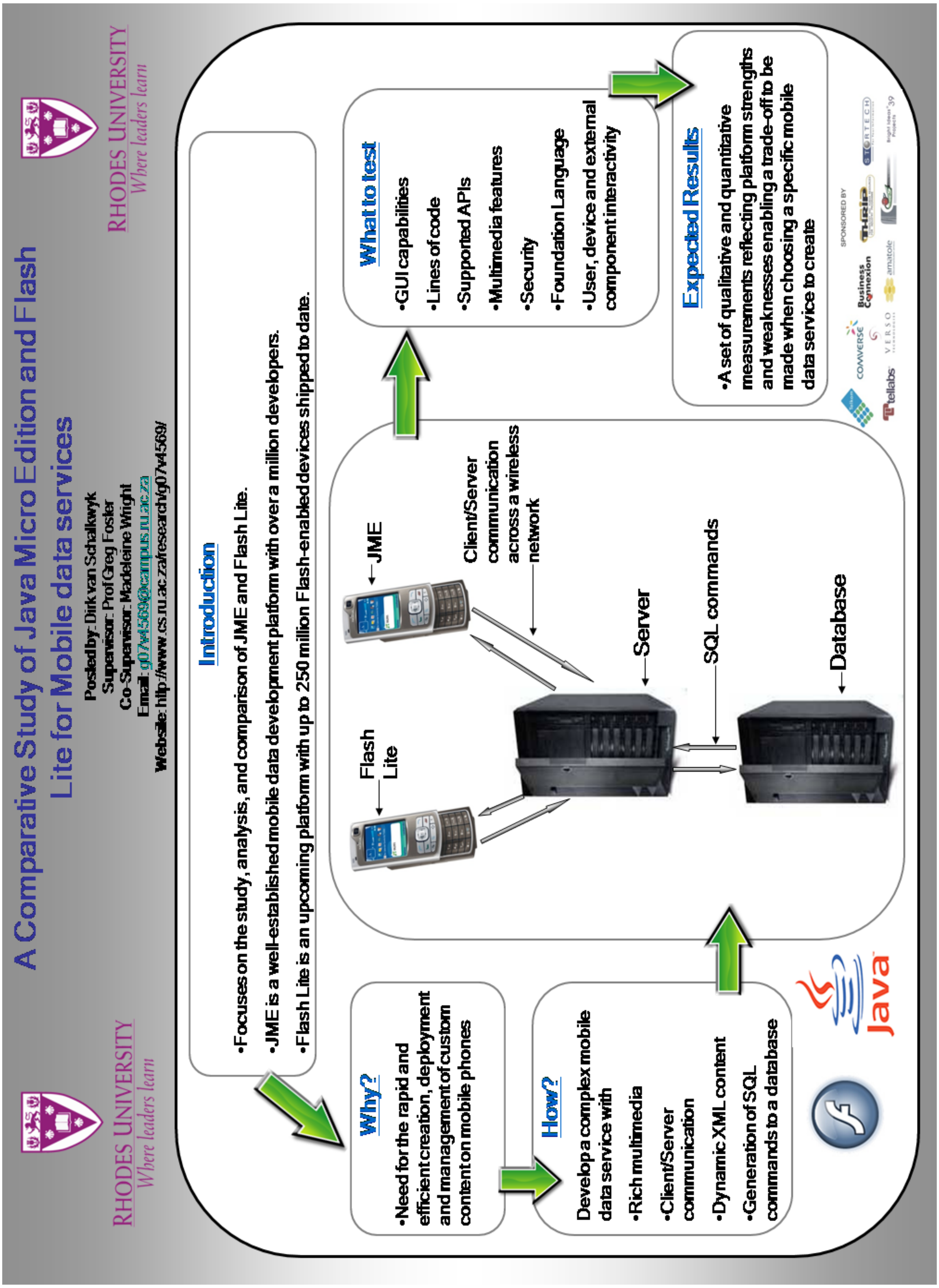
Appendix


A Comparative Study of Java Micro Edition and Flash Lite for Mobile data services
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Introduction
•Focuses on the study, analysis, and comparison of JME and Flash Lite.
•JME is a well-established mobile data development platform with over a million developers.
•Flash Lite is an upcoming platform with up to 250 million Flash-enabled devices shipped to date.
Why?
•Need for the rapid and efficient creation, deployment and management of custom content on mobile phones
How?
Develop a complex mobile data service with
•Rich multimedia
•Client/Server communication
•Dynamic XML content
•Generation of SQL commands to a database
Flash Lite
JME
Client/Server communication across a wireless network
Server
SQL commands
Database
Java
What to test
•GUI capabilities
•Lines of code
•Supported APIs
•Multimedia features
•Security
•Foundation Language
•User, device and external component interactivity
Expected Results
•A set of qualitative and quantitative measurements reflecting platform strengths and weaknesses enabling a trade-off to be made when choosing a specific mobile data service to create
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Business Connexion
THRIP
tellabs
VERSO
amatole