CHAPTER 2

THEORETICAL FOUNDATION

2.1 Operating System

J. L. Peterson and A. Silberschatz said “Operating system is a program that acts as an interface between a user of a computer and the computer hardware.” which means operating system is an important component to connect between user and computer hardware [3].

2.1.1 Operating System History

Computer system can be divided into 4 components which are the hardware, the operating system, the applications programs, and the users.

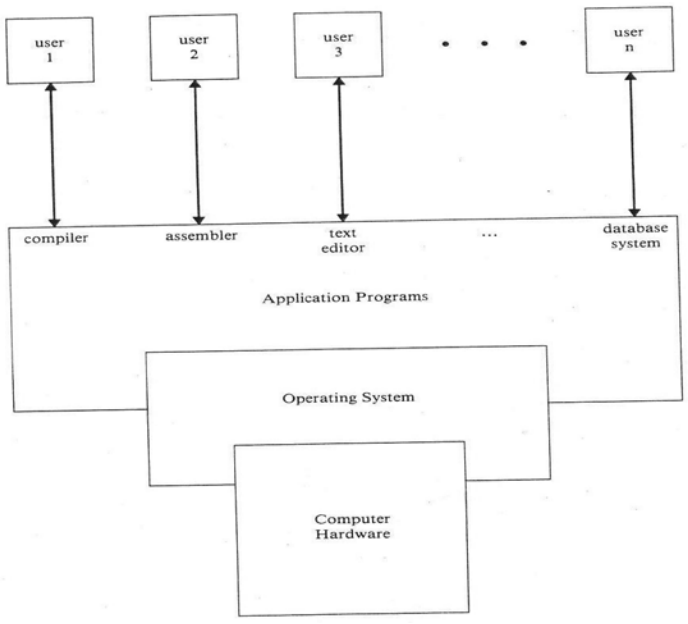

Figure 3: Abstract view of the components of a computer system

The hardware is about Central Processing Unit, memory, and input output devices. The purpose of an operating system is to accommodate the environment when the user executes any programs and to make the computer hardware is more efficient in use. Computers without operating system need full hardware specification to run correctly the task standard especially the first generation of computers. Operating system is the collection of software that provides a set of functions and it consist of data and program to make hardware usable. Operating system performs any simple piece of work, for instance identifying the keyboard for input, sending the information to give out to the display and saving the files, folders, and directories on the disk. In operating system, it can be considered as if manager of the resources. Operating system has three types of function. First, it is scheduling instructions by controlling and prioritizing jobs, and then it allocates the system resources like central processing unit, hard disk drive, application or software, input/output device, etc. Also it monitors all of the activities such as security monitoring. During the first generation, computers were new and unfamiliar; it was restricted to research activities and military application then the second generation came out while transistors came to replace electronic tubes for the primary computer component. By using transistors, it can reduce size, increase the speed, and improve reliability. In early third generation, transistors were replaced with solid logic circuits, and it made computers became even faster. While the computers speed is faster, and the speed divergence between the computer and input-output became more pronounced, so multiprogramming was the solution [4]. In design principles, there are two goals to achieve the requirements that are user goals and system goals. The system should be easy to use, easy to design, easy to implement, flexible, reliable, safe, and fast. In the past, there were many operating system vendor want to achieve that quality however it

was rather hard to achieve [5]. The first mechanical programmable binary computer is Zuse Z1 which designed by Konrad Zuse in 1938. It contains 64 word floating point memory of 22 bits floating point with clock speed 1 Hz, and the weight is 1,000 kg. It can do the arithmetic unit like add, subtract, multiply, and divide. The average calculation speed for addition is 5 seconds, and for multiplication is 10 seconds.

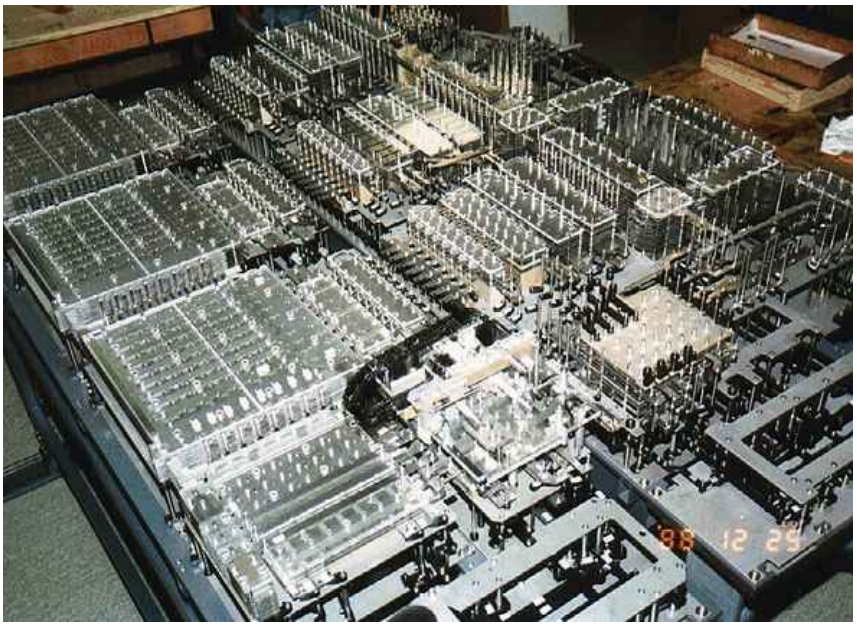

Figure 4: Zuse Z1

In 1954, International Business Machines (IBM) which is multinational technology and consulting from U.S was produced computer with floating point arithmetic for the first mass produced at that time that is called IBM 704. IBM is the world's largest to supply hardware computers mainframe. In 1956, GM-NAA I/O (General Motors and North American Aviation input/output) operates the first operating system IBM 704. The purpose is to execute programs without manual intervention or execute another after one is being executed. The first version of Windows is Windows 1.0 that was released in 1985 although it was designed in 1981, it was not yet released

until 1985. Calculator, Calendar, Notepad, Paint, and Control Panel were support Windows 1.0 application. After next two years, Windows 2.0 was released. The user interface were more sophisticated and memory management were improving by provide additional memory to DOS (Disk Operating System) more than the base memory limit. Only a few months after Windows 2.0, Windows released Windows 2.1x. Windows 3.0 was released in 1990 and Windows 3.1 was released in 1992. It allows the user to share between multitasked DOS windows. Windows 95 was separated MS-DOS (Micro Soft Disk Operating System) and Windows. It was improving their graphical user interface by plug and play features. Also, it was changed from 16 bit architecture to 32 bit architecture. Within two years, Windows 95 had become the most successful operating system that ever had produced. After Windows 95, Windows 98 was released in 1998 and support USB (Universal Serial Bus) that was not supported in Windows 95. In 2000, Windows 2000 was released as the successor of Windows NT 4.0 then it was succeeded by Windows XP. Windows Me or Windows Millennium Edition also was released in 2000. Windows Me was to be reached more specifically home users and Windows 2000 was to be reached more on business. Both Windows 2000 and Windows Me were combined into Windows XP that was released in 2001. From market research, International Data Corporation (IDC) shows that Windows XP sold over 400 million copies in 2006. Windows XP helps the user to prevent suspicious attachments, viruses, and hackers by adding the online security updates. The latest version is Windows 7, it can be used for personal computers, netbooks, laptops, and tablet PCs. Snap is one of the new features from Windows 7 to make user simplifies their task that is a new way to resize and compare other windows. Besides Microsoft Windows, Mac OS is one of the other operating system competitors. Macintosh or Mac OS has been invented in 1984

which is called MacOS 1 with Macintosh File System (MFS) as disk file system. Macintosh is an operating system developed by Apple and it has been famous by the graphical user interface. In 1985, Mac OS 2 was released and made improvement on Finder and menu. After 1 year, Mac OS 3 came out with Hierarchical File System which is a file system. There is one new exciting new feature of System 7 which is MultiFinder; actually it has been used for more than two years. It runs multiple applications at single time and leaves the application when user switches the other. In System 7, MultiFinder utility is no longer used because its features were integrated into System 7, then it would be referred to the multitasking features of System 7. Multitasking allows one or more programs to be used and opened concurrently; also it allows the user to use the time and assets with maximum efficiency [6].

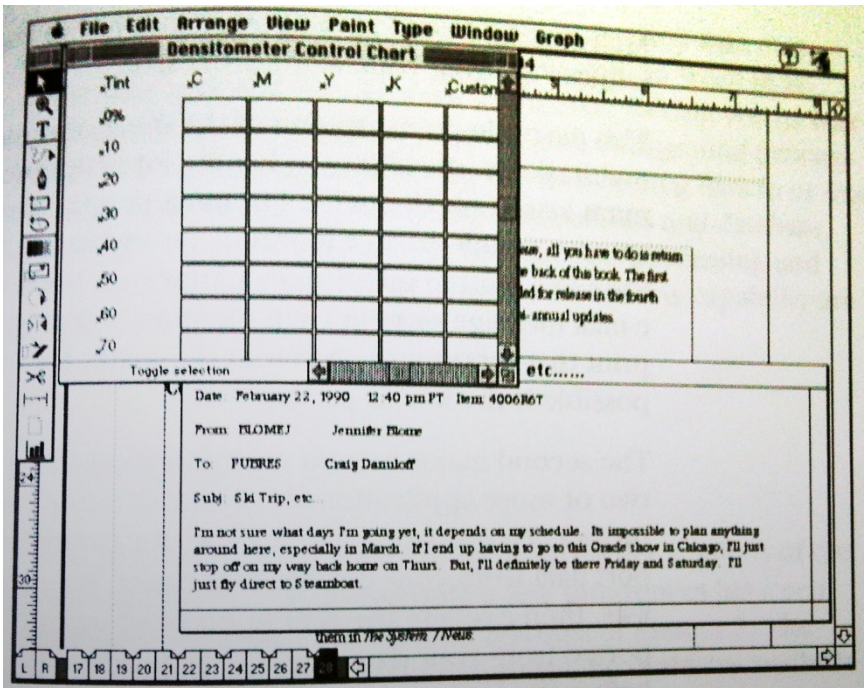

Figure 5: Example of Mac multitasking on system 7

Now, the latest version of Mac is Mac 10.6 or Mac OS X Snow Leopard. It was released worldwide in 2009, and the latest version 10.6.6 was released on January 6, 2011. Time machine backup and connection establishment in Snow Leopard are faster. The other new feature is Boot Camp that allows reading and copying files in Windows partitions from HFS+ (Hierarchical File System) partitions. Although Mac is good with their graphical user interface, Microsoft Windows is one of the most popular modern operating system for personal computers. Microsoft Windows released their updates not only for personal computers but also for smart phones.

2.2 Smartphone

Smart phone is a mobile phone with advanced computer features that able to collaborate with computerized systems. “Feature phones are taking on more of the physical characteristics of Smartphone, and often offer greater exposure to carrier services,” Rubin said. “Although their user interfaces continue to improve, the depth of their applications generally lags behind those of Smartphone. With the price gap between Smartphone and feature phones narrowing, to remain competitive feature phones need to develop a better Web experience, drive utility via widgets, and sidestep the applications arms race.”[7]. Smart phones are cooperated with operating system software like Palm, Symbian, BlackBerry, Android, and iPhone. IBM Simon personal communicator which is an advanced cellular telephone at that time was the first Smartphone, it was designed in 1992 and one year later, it was released to the public. IBM Simon has many features such as mobile phone features, pager, PDA (Personal Digital Assistant), even fax machine. It had no physical button, so it had used touch

screen and optional stylus with a predictive QWERTY keyboard. In 1996, Nokia Communicator which was a business name to maximize mobile phones market by Nokia Corporation released Nokia 9000 as the first Nokia's Smartphone with GEOS operating system version 3.0 and using Intel 80386EX for the processor. After next few years, Nokia released their Nokia 9210 Communicator which was the first color screen model with Symbian open operating system version 6.0. One of Sweden's companies which are Telefonaktiebolaget L. M. Ericsson or Ericsson also wants to compete with the other smart phones, so they released GS88 with GEOS [8]. Ericsson R380 was released as a Smartphone with touch screen, and it was the first device using Symbian operating system [9]. The other competitors operating system in smart phones are Symbian, BlackBerry OS, Android, and iPhone. Symbian is maintained by Nokia and it is an open source operating system. Symbian is using C++ programming language and the latest stable version is Symbian 3.

2.2.1 Smartphone Features

In terms of features, almost all Smartphone is supported email capabilities such complete personal organizer such calendar and address book. One type of Smartphone is Personal Digital Assistant. Other Smartphone features are touch screen, wireless connectivity, and synchronization facility. Synchronizing data with PC is an important function and it can do with several ways for instance Microsoft Outlook, PC, and third party synchronization software.

2.2.2 Smartphone Specifications

In this section, actually in every Smartphone it has different specifications and it must differentiate of each Smartphone. The author will give more information in the BlackBerry specifications section and Android specifications section includes the author case study of BlackBerry Torch 9800 and Samsung Galaxy S.

2.2.3 Smartphone Security

The most secure computer is computer without power or turn off the computer and it is fully secure. In fact, total security cannot be achieved. There are four levels of security. First, physical access to Smartphone must be secured, then human users, network access, and the operating system must secure itself. Authorization used when data is accessed and to be given authority. When a process is grant access to system, so it must be authenticated. Authentication is the most important part of security, because it is verified with identifying characteristics. Authentication has three elements: what you know, what you have, and who you are. Smartphone is a single user devices and do not require user authentication that it makes more difficult to make secure [10].

2.2.4 Smartphone Applications

In order to distribute the application, some companies made the application stores such Google launched the Android Market, RIM launched BlackBerry App World, Nokia launched Ovi Store, and Samsung launched Samsung Apps.

2.3 BlackBerry

BlackBerry is a Smartphone that has been developed Research in Motion. BlackBerry became more popular due to email, text messaging, web browsing, organizer, instant messaging, and phone features.

2.3.1 BlackBerry Operating System

BlackBerry is one of the operating system that has been used in Smartphone and it is a way between mobile electronic mail and Smartphone devices [11]. It has been designed and developed by Research in Motion (RIM) in Canada on 1999. Research in Motion elaborates software, hardware, and services to support network. BlackBerry also works as mobile device with personal information manager that able connect to the internet to perform some jobs like receive and send email, Facebook, Twitter, MySpace; then perform instant messaging via BlackBerry Messenger, Google Talk, ICQ, Windows Live Messenger, Yahoo Messenger, and AOL Messenger. BlackBerry operating system also provides multitasking on their handhelds, and supports unique input devices especially trackball, touchpad or track pad, and touch screen. Trackball is an input interface to input spatial with a ball. Touchpad or track pad is an input interface to input spatial with tactile sensor (it is sensitive to touch and pressure). Touch screen is to detect subsistence and position in the display area by touching in electronic device. According to Gartner, from the third quarter of 2009 until the third quarter of 2010, mobile phone sales grew 35 percent and 96 percent increase sales of Smartphone. Based on the statistics, BlackBerry sold 11,9 million devices to end users, and the Smartphone market fell 14,8 percent, because the effect of iPhone 4, many new android devices such

Motorola Droid X, HTC Incredible, and Samsung Galaxy S. Even so BlackBerry still has the new devices like BlackBerry Torch 9800 to maintain RIM market share [12].

2.3.1.1 BlackBerry Operating System History

In Late 1999, the first BlackBerry 850 was introduced as two way pager and it was programmed in C++. After it was released, BlackBerry became more popular due to support internet and web browsing, able to send and receive internet email by using push email, support the Office applications, and the basic phone functionality. BlackBerry also cooperates through Mobile Information Device Profile (MIDP) that is part of Java Platform to perform better email quality and for browser it used WAP or Wireless Application Protocol which is a commonly used internet browser for mobile phone or Smartphone. MIDP 1.0 released on 2000 and used monochrome user interface. BlackBerry focused more on email for their first touch to the marketplace, also they used grayscale or "black and white" display. Then, it came with BlackBerry 857/957 series which is more on personal digital assistant style. After the pager models, 5000 series and 6000 series still used monochrome but it had changed into Java based device from 5810. BlackBerry converts to Java because Java provided with Java Virtual Machine then it made more secure, and in term of size, Java code can be smaller than C++ code. For the first color models were 7200 series, 7500 series, and 7700 series and it still used QWERTY keyboard. For 7100 series, it is no longer QWERTY keyboard, but "candy bar" form [13]. In 2006-2008 modern models BlackBerry which is using BlackBerry OS 4.5.0 were introduced some handhelds like 8700 series (electron), 8100 and 9100 series (pearl), 8200 series (pearl flip), and 8300 series (curve). The latest BlackBerry models

that used BlackBerry OS 4.6.0 and 5.0.0 also were introduced in 2008-2009 like BlackBerry Bold 9000, BlackBerry Curve 8900, BlackBerry Tour 9630, BlackBerry Storm 9500/9530, and BlackBerry Curve 8520/8530. In 2009, BlackBerry Storm2 9550 which is the latest version of BlackBerry Storm 9500 and BlackBerry Bold 9700 (onyx) which is the next version BlackBerry Bold 9000 also were introduced. Although the user BlackBerry always increasing, they improve the quality of their handhelds by launching several handhelds in 2010, example BlackBerry Bold 9650 which is the next version after BlackBerry 9630; BlackBerry Bold 9780 which is the latest version of BlackBerry Bold 9700; BlackBerry Pearl 3G 9100; BlackBerry Torch 9800 which is the combination Qwerty keyboard with sliding multi touch screen display and integrated on the latest BlackBerry OS 6.0.0.448 on march 2011; and BlackBerry Curve 9300 which is the next version after BlackBerry Curve 8900 and it is integrated with 3G.

2.3.1.2 BlackBerry Operating System Architecture

One of the reasons nowadays BlackBerry became popular is able to send and receive electronic mail by using push email. In this section, the author gives the information on how BlackBerry OS architecture works through BlackBerry Enterprise Server that is a common use in United States. Actually, BlackBerry Enterprise Server is not common use in Indonesia, because it is more popular with BlackBerry Internet Service, so in the next section the author also gives brief explanation about BIS. BlackBerry architecture is to approach more complex structure, context, data, and information. Here is the figure how BlackBerry architecture works as mention below [14]:

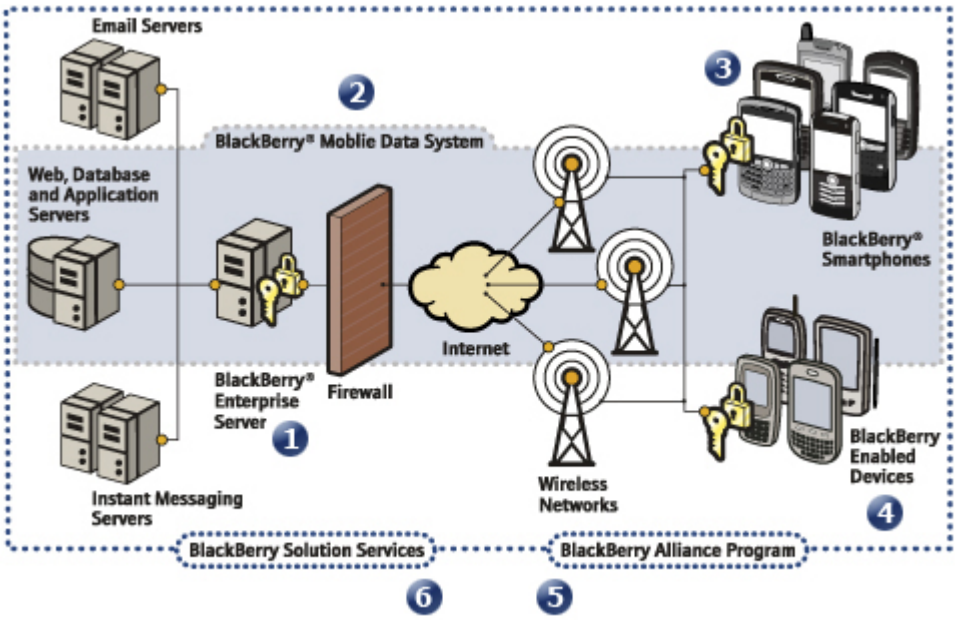

Figure 6: BlackBerry Enterprise Solution Architecture

There are few key elements of BlackBerry Enterprise Solution architecture include BlackBerry Enterprise Server, BlackBerry Mobile Data System (BlackBerry MDS), BlackBerry Smartphone, BlackBerry Connect software devices, BlackBerry Alliance Program, and BlackBerry Solution Services. BlackBerry Enterprise Server is powerful software in the middle of enterprise applications, wireless networks, and wireless device. BlackBerry Enterprise Server is integrating with Instant Messaging Servers, Email Servers, and Database Application Servers. BlackBerry Mobile Data System is the BlackBerry Enterprise Solution improvements for creating, deploying, and managing programs. BlackBerry MDS Runtime; BlackBerry APIs and Java ME are the BlackBerry Application using BlackBerry MDS. BlackBerry devices and BlackBerry Enabled Devices are collaborating to connect to the internet through Wireless Networks. BlackBerry Alliance Program is a huge community to provide services, software vendors, and solutions for BlackBerry Enterprise Solution. BlackBerry Solution Services

is a grouping service in order to technical support service, training, and development program. Here is the example of sending a message from a BlackBerry device process flow:

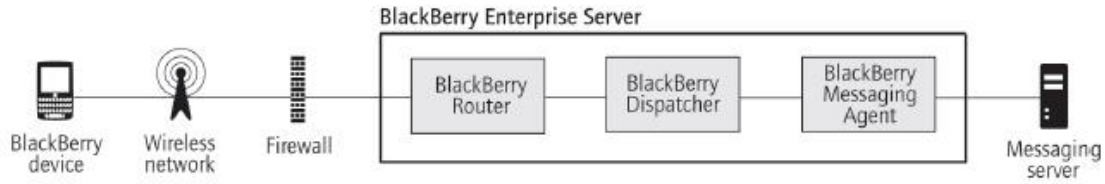

Figure 7: Sending a message from a BlackBerry device process flow

First, a user sends a message from BlackBerry device, and then the BlackBerry device detects RefID to the message. The message is encrypted and sent the message to the wireless network port 3101, if it is using Wi-Fi so it is using port 3101. Then the message sends to BlackBerry Enterprise Server via wireless network. In BlackBerry Enterprise Server there are 3 elements used in this process which are BlackBerry Router, BlackBerry Dispatcher, and BlackBerry Messaging Agent. BlackBerry Dispatcher are decrypting and decompressing the message with transport key. If the BlackBerry device shows an error message, it means that the BlackBerry Dispatcher failed to decrypt the message using device transport key, and the BlackBerry Enterprise Server ignores the message. After BlackBerry Dispatcher successfully decrypts the message, the BlackBerry Messaging Agent sends the message to the email of user. In the user email, BlackBerry Messaging Agent sends copy the message to Sent Items view. Finally, Messaging Server sends the message to the recipients.

2.3.1.2.1 BlackBerry Enterprise Server

BlackBerry Enterprise Server is the integration of an email system and BlackBerry devices with a software package and it is designed to be secure. There are some BES versions which are Lotus Domino, Microsoft Exchange, and Novell GroupWise [15]. Lotus Domino is a server product from IBM to provide enterprise email and custom application platform. Microsoft Exchange is group support systems to help people achieve their goals and it is developed by Microsoft. Like others, Novell GroupWise is a workgroup support systems platform from Novell to support email, personal information management, and document management. BES usually runs with the company of multiple users on their own network. BlackBerry PIN is the ID of every BlackBerry that BES used to identify the device. BES Express is free BES software. BlackBerry Enterprise Server supports AES and Triple DES encryption to ensure integrity and to protect the data between BES components and BlackBerry devices. There are a few components of BlackBerry Enterprise Server include to provide productivity tools and data of the organization, to control other BES services, connect with wireless network, to compress and encrypt data.

2.3.1.2.2 BlackBerry Internet Service

BlackBerry Internet Service, also known as BIS is used for BlackBerry users to gain email account information via web based Post Office Protocol 3 (POP 3), IMAP or Internet Message Access Protocol, and Microsoft Outlook web access without BlackBerry Enterprise Server. Mobile phone service providers like Verizon wireless, AT&T, Sprint, and T-Mobile support the BlackBerry Internet Service. BlackBerry

Internet Service allows up to 10 email accounts including Hotmail, Yahoo, and Google mail. Also, BlackBerry Internet Service supports the instant messaging capability via Google Talk, ICQ, Yahoo Messenger, and Windows Live Messenger. BlackBerry Internet Service is not only supports instant messaging but also social networks such Facebook, Twitter, and MySpace. Based on the official BlackBerry website, there are some new features of BlackBerry Internet Service 3.2. It requires BlackBerry Device Software 5.0.0.176 or later to perform Google mail calendar synchronization. An automatic login enhancement is now available to user so the user just needs to type their user name and password once to manage email address. Also, there is show and hide password option. Last, the password criteria have changed, it must include at least one letter and one number, and it must include 8 to 16 characters.

2.3.2 BlackBerry Features

In this section, the author will give the information about what the BlackBerry features are. Actually, BlackBerry divides their features into 3 sections which are communication, information, and multimedia. If you have friends that live in different places or cities or even nations, usually you want to always communicate with your friends, that is why BlackBerry support their users to always have connected among the others for instance Email and Text Messaging. Also with BlackBerry it allows you to connect internet 24hours to get the information or the latest information like Browser, GPS, and BlackBerry Maps. Media Player, Camera, and Video recording are also support the BlackBerry multimedia. Last, BlackBerry also supported with the BlackBerry App World to support their application distribution [16]. Social feeds and

views are the additional features in BlackBerry OS 6. It helps the user to update once and send it to selected network. Now, the user can search everything by Universal search on device at once [17].

2.3.2.1 Communication

As the author mentions above about the example of communication, if you have friends that live in different places or cities or even nations, usually you want to always communicate with your friends, that is why BlackBerry support their users to always have connected among the others for instance Email, Text Messaging, Instant Messaging, and Social Networking. It supports the BlackBerry users to have more than 1 email account or multiple email accounts into his/her BlackBerry device. When the BlackBerry user receives any files attachment through email, the BlackBerry user can easily view his files, and it supports the attachment format from Microsoft Word, Excel, Power Point, Adobe PDF, ASCII documents, HTML documents, and images (JPG, BMP, GIF, PNG, and TIFF). SMS (Short Message Service) and MMS (Multimedia Messaging Service) are the features to communicate with contacts either they are using Smartphone or mobile phone. One of the most favorites BlackBerry application is the BlackBerry Messenger which is part of Instant Messaging. Instant Messaging is a direct communication between two or more people in a real time based on text. No matter where the user are or what the user is doing, BlackBerry makes the user always keep in touch with his personal contacts through instant messaging. Windows Live Messenger, Yahoo Messenger, Google talk, and AOL Instant Messenger cooperate with BlackBerry so, the BlackBerry user can use its applications on his device. Social Networking in

BlackBerry communication is no less intense among the other Smartphone competitors. It allows the user to get the automatic notifications through network, trade messages with friends, and upload photos. Facebook, Twitter, and MySpace are the application examples of social networking on BlackBerry.

2.3.2.2 Information

In this rapid era that almost everything is in a hurry likewise the information lately, especially digital information. More information you have, and you can do more. It same like if you have the BlackBerry gadgets and you will find out more resources especially from the internet. BlackBerry supports the user to go online and explore the web anytime and anyplace. GPS or Global Positioning System is already featured in BlackBerry Smartphone. GPS is to provide reliable location information in the Earth [18]. BlackBerry Maps also to support the information resources. It allows the user to view maps, and receive directions into the BlackBerry device. Mobile Streaming like YouTube also integrated with BlackBerry to give the user get more knowledge easier. Personal organizer such calendar, address book, task list, calculator, and MemoPad are integrated with BlackBerry device to provide users with the tools to stay on time, in touch, and on track.

2.3.2.3 Multimedia

Camera, video recording, and Media player are the part of multimedia features in BlackBerry. Camera features include digital zoom, built in flash, up to 5 MP, and self

portrait mirror. And for the video recording it is support until BlackBerry Torch 9800, then the users can manage and share their videos and or photos through BlackBerry media sync which is synchronize personal computer music and photo collections with BlackBerry devices.

2.3.3 BlackBerry Specifications

Figure 8: BlackBerry Torch 9800

In this section, the author uses BlackBerry Torch 9800 specifications as a case study represent BlackBerry OS device because BlackBerry Torch is using the latest BlackBerry OS 6 with combination QWERTY keyboard and multi touch slide screen display.

The specifications of BlackBerry Torch 9800, as listed below:

Size	111mm x 62mm x 14.6mm (closed) 148mm x 62mm x 14.6mm (open)
Operating System	BlackBerry OS 6
Processor	Marvell PXA940 running at 624 Mhz
Memory	Internal Flash Memory: 512MB Internal: 4GB External: 4GB (up to 32GB)
Image System Processor (ISP)	STmicroelectronics STV0987
Camera	5.0 MP camera with flash, 2x digital zoom, image stabilization and auto-focus
Display	3.2 inch HVGA+ 480x360 pixel Synaptics controlled touch screen
Video	up to 480p resolution
Battery	1300 mAhr removable/rechargeable lithium-ion cell
Battery Life	Standby time 18 days (GSM) or 14 days (UMTS) Talk time 5.5 hours (GSM) or 5.8 hours (UMTS)
Video format support	MPEG4, H.263, H.264, WMV3
Audio format support	MP3, AMR-NB, AAC-LC, AAC+, eAAC+, WMA, WMV, FLAC, Ogg Vorbis

Networks	Tri-band 3G UMTS/HSDPA networks: 2100/1900/850/800 MHz Quad-band GSM/GPRS/EDGE networks: 850/900/1800/1900 MHz

Figure 9: BlackBerry Torch 9800 Specifications

2.3.4 BlackBerry Security

One of the critical hindrances of mobile technology is the security. The fear of data loss and data leakage is the regulatory compliance. The author will give the information about what security features are malware vulnerabilities on BlackBerry devices, security options, and guideline to keep private data safe.

In order to make an operating system secure, there are number of important components for instance authentication, data vaulting, and reliability. BlackBerry allows two authentication and secure peripheral authentication like card reader. The user does not be able to reset his/her policy, if the IT has already set the authentication policy. BlackBerry provides to encrypt all data on the device including in memory cards, in order to prevent data vaulting. Data vaulting make more protection on device against hacking. In BlackBerry reliability, it also has exhibited a high degree of stability, lack of freezes, crashes, and devices rarely require a reboot [19].

A system susceptibility/flaw, access attack to the flaw, and exploit attack to the flaw are the vulnerability in three elements. The goals malware or malicious software vulnerabilities on BlackBerry device are to steal personal and corporate data; and to

create Denial of Service that will make network unusable. Malware is designed with malicious intent with third party java applications, examples viruses, Trojan horses, worms, and spyware. Virus is replicating itself to legitimate applications. Trojan horse is software that looks legitimate. Worms are similar to viruses, because it can replicate them, and worms do not require a host program to reproduce [20].

The author will explain the BlackBerry security features including browsing, email and instant messages, firewall, attachments, and encryption. First, BlackBerry uses SSL (Secure Socket Layer) to make secure connection in browsing like banking web sites. SSL usually used in online banking transactions, e-commerce transactions to protect the user against unauthorized person. Email messages and instant messages also use the security features of encryption. BlackBerry device firewall is made to block incoming text messages, and PIN messages from unwanted persons. Here are some guidelines from BlackBerry newsletter to keep private data safe [21]:

- ❖ Use strong password

Passwords:

- Must be 4–14 characters in length
- Cannot be identical characters (1111) or sequences (1234)

Set your password:

1. On the **Home** screen or in a folder, click the **Options** icon.
2. Click **Password**.
3. Change the **Password** field to **Enabled**.
4. Press the **Menu** key.
5. Click **Save**.
6. Type the new password, and click **Enter**.
7. Type the new password again, and click **Enter**.

- ❖ Change the number password attempts

User can change the number of attempts to 3–10:

- On the **Home** screen or in a folder, click the **Options** icon.
- Click **Password**.
- Set the **Number of Password Attempts** field.
- Press the **Menu** key.
- Click **Save**.

❖ Encrypt the data

- On the **Home** screen or in a folder, click the **Options** icon.
- Click **Security Options**.
- Click **Encryption**.
- Change the **Encryption** field to **Enabled**.
- To encrypt data in the device memory, set the **Device Memory** field to **Enabled**.
- To encrypt files stored on a media card and on your device, set the **Media Card** field to **Enabled** and perform one of the following actions:
    - To encrypt files using an encryption key that your device generates, change the **Mode** field to **Device Key**.
    - To encrypt files using your device password, change the **Mode** field to **Device Password**.
    - To encrypt files using an encryption key and your device password, change the **Mode** field to **Device Password & Device Key**.
- To also encrypt media files such as pictures, songs, and videos, set the **Include Media** Files field to **Yes**.
- Press the **Menu** key.
- Click **Save**.

❖ Automatic lock the phone after a certain amount of time

- On the **Home** screen or in a folder, click the **Options** icon.
- Click **Password**.
- Set the value in the **Security Timeout** field to the amount of inactive time you want to permit your BlackBerry smartphone before it automatically locks.
- Press the **Menu** key.
- Click **Save**.

❖ Lock down Bluetooth

- On the **Home** screen, click the **Manage Connections** icon.
- Click **Bluetooth Options**.
- Press the **Menu** key.

- Click **Options**.
- Set the **Discoverable** field to **No**.
- Press the **Menu** key.
- Click **Save**.

2.3.5 BlackBerry Applications

BlackBerry App World is the other BlackBerry features and it is a place to distribute application by browsing, downloading, and updating its application. From BlackBerry App World, it provides with featured items, categories, top 25, search application, and My World. There are many categories such Business, Education, Entertainment, Finance, Games, Health & Wellness, IM & Social Networking, Maps & Navigation, Music & Audio, News, Photo & Video, Productivity, Reference & eBooks, Shopping, Sports & Recreation, Test Center, Themes, Travel, Utilities, and Weather. In top 25 there are few menus like top 25 newest, free apps, paid apps, themes, and recently updates. Also in My World, it helps the user to check what applications installed, uninstalled, and updated are. It is also support with barcode scanning capabilities, credit card, and wireless billing options. There are 31.546 free and paid applications on BlackBerry App World.

2.4 Android

Android is a software stack for mobile phones including operating system, middleware, and applications and it has been developed by Google.

2.4.1 Android Operating System

Nowadays, there are few operating systems integrated with Smartphone, for examples Palm, Symbian, iPhone, BlackBerry, and Android. In this section, the author is more focusing on Android operating system. First of all, Android is a bundle open source software which means everyone can change the operating system better for mobile devices contains operating system, middleware, and key applications. In 2005, Google officially purchased Android Inc. Android Operating System is modified from Linux Operating System. Android OS was released in 2008 for Smartphone. Also in the same year, an online software store which called Android Market was released and it was available for third party apps. Android runs on Java based to support Java application. There has been some confusion about what exactly Android is. Android is not a Java ME implementation. Java language used in Android applications, but they are not run within Java ME virtual machine. Android is not a mobile phone handset, Android designed to support many hardware devices [22].

2.4.1.1 Android Operating System History

Android was found by Andy Rubin in California, United States in October 2003. Andy McFadden and Chris White that worked with Rubin at WebTV involved in the founding Android Inc. In 2005, Google purchased Android Inc. Andy Rubin, Rich Miner, and Chris White which is the key employees of Android still stayed after the acquisition of Google. In 2007, Open Handset Alliance has been constructed by industry group leaders that cooperate with Android Platform. Some of participation members are Sprint Nextel, T-Mobile, Motorola, Samsung, Sony Ericsson, Vodafone, Google, Intel,

and Texas Instruments. The purpose of this collaboration is to respond better the customer needs and to innovate immediately [23]. Android version 1.0 was released in September 2008, and only few months later Android version 1.1 was updated, then T-Mobile G1 or HTC Dream which is the first Android mobile handset released in early 2009. The updates were API changes, a map adds details and reviews, screen timeout longer when speakerphone is used, and save the attachments in MMS. Each Android operating system version is developed a code name based on dessert item. Android version 1.5 or Cupcake was released in April 2009. New widgets and folder to populated Home screen, screen transitions with animation, and new soft keyboard with text prediction. In September 2009, Android 1.6 Donut SDK (Software Development Kit) was released with a new integrated camera, camcorder, and gallery interface, supports for Wide Video Graphics Array or WVGA screen resolution. Only 1 month later, the next version 2.0 / 2.1 Eclair was released with new browser UI, new contact lists, better contrast ratio for backgrounds, Bluetooth 2.1, and live wallpapers. The 2.0.1 SDK was released in December 2009, and 2.1 SDK was released in January 2010. In May 2010, Android OS 2.2 Froyo (Frozen Yoghurt) SDK was released. With Android 2.2, it is increasing speed and performance the user's device, better browser with Flash support, and add Wi-Fi hotspot tethering. The next version is 2.3 SDK Gingerbread which is the latest stable released in December 2010 with the updating user interface design, supports Wide extended Graphics Array (WXGA) resolutions, redesigned multi touch software keyboard, improving power management and application control. Honeycomb or 3.0 SDK was released on February 22, 2011. Motorola Xoom tablet which is the first device using Android OS 3.0 was released on February 24, 2011. It clarifies multi tasking, new

user interface for optimizing tablet, supports multi core processors, and supports video chat using Google Talk.

2.4.1.2 Android Operating System Architecture

The major components of Android operating system are shown as the following diagram [24].

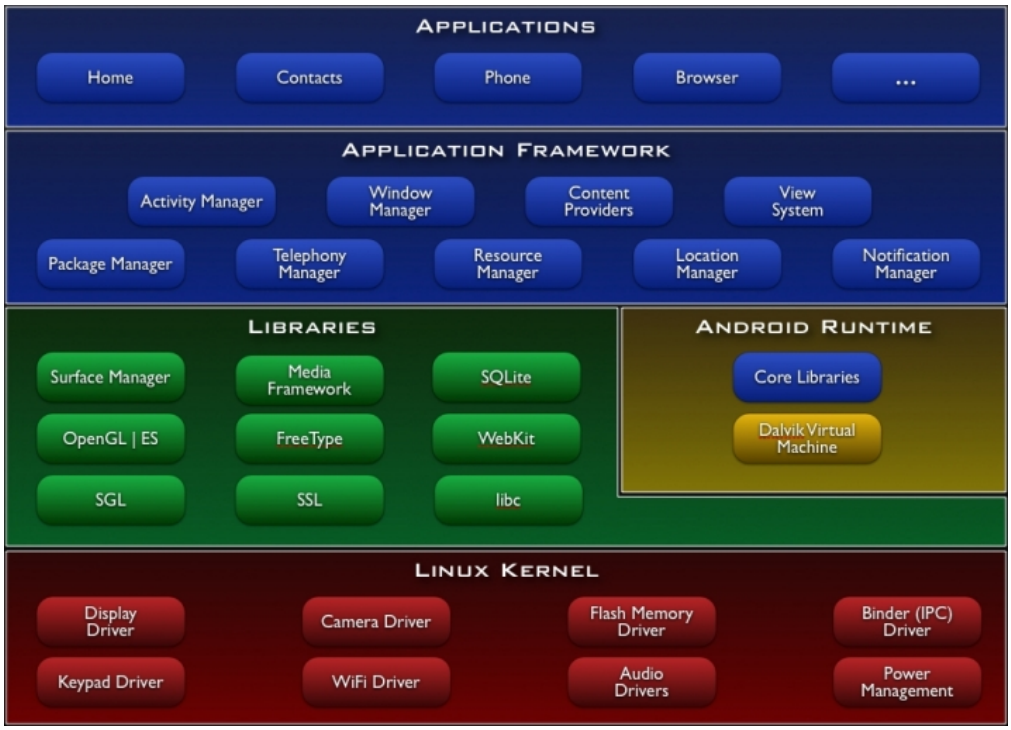

Figure 10: Android System Architecture

2.4.1.2.1 Linux Kernel

Hardware drivers, process and memory management, security, network, and power management are the core services that are handled by Linux 2.6 kernel. The kernel provides abstraction layer between the remainder of the stack and the hardware.

2.4.1.2.2 Android Runtime

Android Runtime is one of the main components that makes an Android phone is more an Android phone rather than a mobile Linux implementation. Android Runtime is the engine applications power including Core Libraries and Dalvik Virtual Machine.

- Core Libraries

Dalvik is not a Java Virtual Machine, although Android development is done in Java. The most functionality in Java libraries are also provide in the core Android libraries.

- Dalvik Virtual Machine

Android uses Dalvik Virtual Machine as a custom VM rather than Java Virtual Machine. It is designed to ensure that multiple platforms run efficiently on a single device. Dalvik VM executes Dalvik executable files (.dex) to minimize memory foot print.

2.4.1.2.3 Libraries

Android offers a number APIs to develop applications, for examples android.util, android.os, android.widget, com.google.android.maps, android.graphics, android.text, android.database, android.content, android.view, and android.telephony. All Android devices support those APIs. The additional Android APIs which is the set of C/C++ libraries:

- OpenGL - the library to support 3D graphics based on the Open GL ES 1.0 API

- SSL - to secure Internet communications by using Secure Socket Layer cryptographic protocol
- SQLite - to store application data through the lightweight relation database engine
- libc - the standard C library optimized for Linux based
- SGL - provide a 2D graphics engine
- FreeType - support for bitmap and vector font rendering

2.4.1.2.4 Application Framework

The application framework provides the classes to create Android applications, make an abstraction for hardware access, and manage application resources and the user interface. The application architecture is designed to simplify component functions. Activity Manager is to provide navigation back stack and maintain the application lifecycle, and then the other application service is Views that are used to construct the user interface for activities. Notification Manager provides display custom alerts in the status bar for signaling user. Content Provider is to enable the applications data shared among applications. Last, Resource Manager is to support non-code resources for instance graphics and strings.

2.4.1.2.5 Applications

Application is one of the major components of the Android operating system. Java programming language used in all applications. Native apps, third party apps, and

all applications are built using the same API libraries on application layer. It runs within Android Runtime through classes and services made from application framework.

2.4.2 Android Features

Based on "Beginning Android 2" book, here are some features in Android Operating System [25]:

- Network

Almost all Android devices are using the Internet to communicate through Internet Protocol and it is integrated browser based on WebKit engine that is an open source web browser engine.

- Multimedia

Android devices is able to play back and record audio and video. It also supports for the audio format example MPEG-4 (.mp4, .m4a), MP3 (.mp3), 3GPP (.3gp), Ogg (.ogg), and WAVE (.wav). Image format and Video format are also support the multimedia improvements. Camera, The other advantages of the multimedia capabilities are taking picture with the camera, and using microphone for audio taking notes.

- Global Positioning System (GPS)

GPS used to get the information where the device is on the Earth, Android provides GPS in case the device has been stolen to track device movements.

- Phone services

Android devices is a Smartphone which is a mobile phone with advanced computing ability and connectivity, so Android can perform like an ordinary phone features like SMS.

- Storage

SQLite used in the Android device to store data as a lightweight relational database.

2.4.3 Android Specifications

Figure 11: Samsung Galaxy S

In this section, the author uses Samsung Galaxy S specifications as a case study represent Android OS device because Samsung Galaxy S is supported with the latest Android OS 2.3 Gingerbread for Smartphone. Also the author already has experienced with Samsung Galaxy S as a product trainer in Samsung from internship.

The specifications of Samsung Galaxy S, as listed below:

Size	64.2 X 122.4 X 9.9 mm (119g)
Operating System	Samsung Android 2.1 (Eclair) Upgradeable to Android 2.3 (Gingerbread)
Processor	1GHz CPU Speed
Memory	512 MB RAM 16GB/8GB+ MicroSD(Up to 32GB)
Camera	5.0 Megapixels Auto Focus cameras Self Shot, Action Shot, Add me, Cartoon Shot, Smile Shot
Display	4.0” WVGA(480x800) 16M SUPER AMOLED mDNIe(Mobile Digital Natural Image engine)
Video	HD Video Player & Recorder (1280 x 720) @ 30fps
Battery	Li-pol, 1,500mAh
Battery Life	Talk time: 2G/803 min, 3G/393 min. Standby time: 2G/750 hrs, 3G/576 hrs.
Video Format Support	3gp(mp4), AVI(divx), MKV, FLV, H.263Sorenson
Audio Format Support	MP3/AAC/AAC+/eAAC+/OGG/WMA/AMR-NB/AMR-WB/WAV/MID/AC3/IMY/FLAC/XMF
Network	HSUPA 900/1900/2100 EDGE/GPRS 850/ 900/1800/1900

Figure 12: Samsung Galaxy S Specifications

2.4.4 Android Security

Android is an open source operating system which means everyone or users are able to view, change, and even improve the source code behind the applications. Because Android is an open source, so the security is in a high risk. Based on Kaspersky Lab News, it has detected Trojan-SMS categorized as a malware that runs on Android OS. This malware distributed through Russian language porn sites while users access the desired content. It seemed like the predecessor, Trojan-SMS.Android.OS.FakePlayer.b pretends as media player. If the user installs application manually, so it can be infected. It just needs 16.4 KB of total size installation file. If the users launch Trojan-SMS.AndroidOS.FakePlayer.b, it starts sending short text messages to a premium rate number and it costs $6 each, then it transferred from user's account to the cybercriminals [26].

Security News Daily shows that even in Android Market, the infected applications has been found from software called DroidDream [27]. Basically, DroidDream is a Trojan that can steal user's private information and download malicious code from remote servers. DroidDream is also able to crush the Android Sandbox which is a mobile security feature to quarantine malware spread out. According to Symantec, there are also other lists of dangerous applications for instance Super Guitar Solo, Spider Man, Bowling Time, Falling Down, and Super History Eraser.

In March 8, 2011, Google removed 58 malicious Android applications by remote-kill; however it had been downloaded to 260,000 users. Google found vulnerability in Android OS 2.2.1 or older while includes the Android users around 99 percent in use. One of the ways to protect the user to prevent malicious software is pay

more attention in the application permissions. "Android users should pay close attention to the services that an application seeks permission to access," said Denis Maslennikov, Mobile Research Group Manager at Kaspersky Lab. "Automatically permitting a new application to access every service that it says it needs to means you could end up with malicious or unwanted applications doing all sorts of things without requesting any additional information." The other way is disable applications installation from any source other than Android Market. Update the mobile operating system and install the mobile antivirus also are the way to protect the devices for example, Lookout Mobile Security which is the most frequently downloaded security application in Android Market [28].

2.4.5 Android Applications

Android is using Android Market to support its distribution application. Android Market is not just only allows the user to browse, and download apps, but also hosted his application in Android Market as developers. It needs a $25 registration fee through Google Checkout [29].Android Market divides into two categories which are games and applications. Top Free section also supports to let the user know what top free applications are Based on Robin Wauters on May 2011, there are approximately 294,000 paid and free applications, while on September 2009, there are 10,000 applications.