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Abstract

This study focuses on heterogeneous services and communication technologies for retrieving and sending information in Malaysian Higher Educational Institutes. It intends to investigate pattern and significant level of various services implementation, convergence of communication technologies, bandwidth capacity for Internet (WAN)/LAN and Quality of Service (QoS). It is designed to determine which communication technologies, services, bandwidth capacity and QoS will achieve the highest level acceptance in Malaysian Higher Educational Institutes. Heterogeneous environment can also generate mobility approaches. A survey method is used to collect data from respondents (System Network Administrator) in Malaysian Higher Educational Institutes. Statistical Analysis using t-test shows that implementation of high speed bandwidth for Internet (WAN) achieved significant level. Frequency test are used to analyze the various services implementation via convergence of communication technologies in heterogeneous environment for retrieving information. The results did not show any significant difference on implementation of various services over convergence of communication technologies and it also shows decreasing of graph in exponential pattern. The most apparent finding of this study is that various services implementation in Higher Educational Institutes can affect convergence of communication technologies usage in accessing information over heterogeneous network environment. From the survey results, it confirms that Malaysia Higher Educational Institutes have not achieved a maximum level of various services implementation via convergence of communication technologies in heterogeneous network environment and QoS implementation. Therefore, low convergence of communication technologies can also produce a low mobility and ubiquitous computing environment in Malaysian Higher Educational Institutes. Recommendation based on the finding for future work is to develop heterogeneous model environment for evaluating convergence of communication technologies and services performance in Higher Educational Institutes.

Keywords: LAN, Heterogeneous Environment, QoS, Ubiquitous, Mobility, WAN

1.0. Introduction

The purpose of this study was to investigate current network infrastructure, implementation of various services and utilization of variety communication technologies for retrieving and sending information to last mile users over heterogeneous environment in Malaysia Higher Educational Institutes. This study discusses details and focuses on (i) types of communication technologies and services have been used for accessing information; (ii) impact of heterogeneous services and utilization of communication technologies over high speed bandwidth for computer network in Malaysia Higher Educational Institutes; and (iii) Quality of Service (QoS). In this study, services refer to service-oriented architecture and communication. The communication can involve either simple data transmission or it could involve two or more services. While, technologies are related to communication technologies media that have been used by last mile users. In addition,

heterogeneous environment is related to implementation of various services such as WWW, Email, VoIP, IP Telephony, IVR, WAP, VoD, Video Conference and Unify Messaging that can be accessed via variety of communication devices such as PC, PDA, fix and mobile phones over wired and wireless network. The study deployed survey methodology to evaluate and measure the implementation of various services and convergence of communication technologies for retrieving and sending information. It intends to investigate pattern of graph and significant level of various services implementation, QoS and convergence of communication technologies.

2.0. Literature Review and Problem Statement

Internet technology has become an important educational technology and tool for developing higher education in accessing information (Jianqiang Li, Zhaohao Sun, 2004). Future users will use more than one device that is capable of gaining access to the Internet. Moreover, in the future, the integration of data and communication services, almost every 'Internet Ready' device will be a communicable device. With the availability of this infrastructure, users are now demanding and expecting more services (Binh Thai, Rachel Wan, Aruna Seneviratne, Thierry Rakotoarivelo, 2003). The convergence of communication technologies and applications is driving demand for new and innovative communications services that supports communication, technology and media (Sibongiseni Tunzelana, 2002). For example, City University of New York, LAN infrastructure on all the campuses has been upgraded from 100 Mbps to a fully redundant and scalable 1 Gbps backbone. Many new services have emerged to realize ubiquitous computing environments, owing to the increasing supply of mobile devices and more widespread Internet and wireless network facilities such as CDMA cellular phones or WiFi smart phones (Melazzi N.B, 2005); (Tack-Don Han, Cheolho Cheong, Jae-Won Ann et al., 2004). Users will use more than one device that is capable of gaining access to the Internet (Paul Reynolds, 2003). Users can get the information content they want, in any media, over any facilities, anytime, anywhere (J.C. Crimi. 2002). Convergence is pushing towards an environment that requires new investment in infrastructure and able to support the delivery of rich services (various services), applications and content. For example, using computers to phone, browsing websites with cellphones or reading emails on TV screens to illustrate idea of convergence (Xianxin Jiang; Fangchun Yang; Hua Zou. 2003), (Podhradsky, P. 2004).

In the 21 century, a network infrastructure is based on multi-service implementation over convergence of network medium such as ISP, PSTN and GSM (Qigang. Z, Xuming F., Qunzhan L., Zhengyou H., 2005). Availability of multi-service has produced multi-traffic in network infrastructure. Therefore, multi-traffic in the network infrastructure has become more complex to observe and analyze (Kyung-Hyu L, Kyu-Ok L, Kwon-Chul P, Jong-Ok L, Yoon-Hal B, 2003); (Xianxin Jiang, Fangchun Yang, Hua Zou, 2003). Today, retrieving and sending information can be done using a variety of communication technologies such as PC, PDA, fix and mobile phones that are more prone to hetergenous environment, but unfortunately the optimal capability of communication technologies are not fully realized. Percentage of PC technology usage for accessing information has achieved 96% but utilization of using other communication technology devices still not fully utilized in retrieving and sending information (Assistant Sectary Cecilia V. Reyes. 2003), (Binh Thai, Rachel Wan, Aruna Seneviratne, Thierry Rakotoarivelo.2003). The main factors of network congestion in Higher Education are related to network design and bandwidth capacity (David R. Gerhan & Stephen M. Mutula, 2005). Nevertheless, few studies have been conducted to evaluate the application of computer network technologies and services over heterogeneous environment in Higher Education Institutes. Therefore, retrieving and sending information over heterogeneous environment using convergence of communication technologies in Malaysian Higher Educational Institutes should be analyzed and evaluated. This study posits several research questions such as (i) how does the implementation of various services using variety of communication technologies percentage; (ii) what are the level of network utilization and

bandwidth capacity for LAN/Internet connectivity and (iii) how is the level of QoS implementation for retrieving and sending information in Higher Education Institutes.

3.0. Methodology

The study deployed survey methodology to evaluate and measure the implementation of various services of communication technologies for retrieving and sending information. Malaysian Higher Educational Institutes were selected because, to investigate the pattern of network infrastructure that has build based on multi-service implementation over convergence of network medium such as ISP, PSTN and GSM in the 21 century. This survey was conducted in January 2006 in several Malaysian Higher Educational Institutes. Public and private universities including college universities were selected to participate in this study (refer to Table 1).   Research procedures in Higher Educational Institutes consist of (i) identify research questions; (ii) construct research instrument; (iii) identify sample frame; (iv) collect data from the respondents; (v) evaluate and measure the data and; (vi) validate and analyze the data. The questionnaire comprises four categories: (i) general information; (ii) network infrastructure; (iii) communication technologies and services; and (iv) Quality of Service (QoS). Figure 1, shows the data collection process, validate and analysis in this study.

Table 1: Sampel of Malaysia Higher Educational Institutes

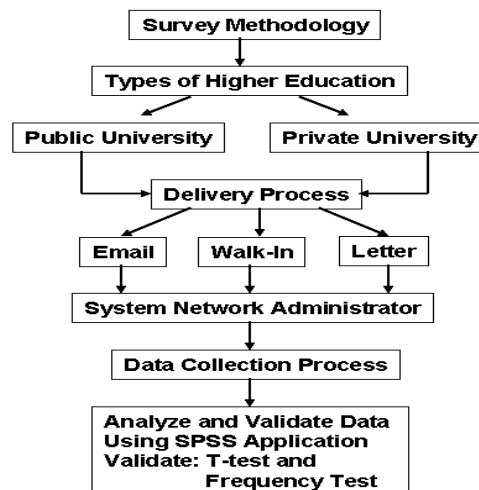| Malaysia Higher Educational Institutes Population		
Types of Higher Education	Public	Private
Total	17 Universities	19 Universities 9 College Universities
Sample of Population (Response rate)	10 Public Universities 60%	16 Private Universities 60%

Figure 1: Data Collection and Analysis

4.0. Analysis of Heterogeneous Environment Implementation Performance

Impact and performance analysis of heterogeneous environment implementation will be divided and discussed in three areas: (i) analyze availability of bandwidth for network infrastructure; (ii) analyze implementation of various services and communication technologies over heterogeneous environment; and (iii) analyze implementation of QoS for heterogeneous environment.

4.1. Availability of bandwidth for network infrastructure

Frequency test was used to analyze and measure availability of bandwidth speed for network infrastructure in Higher Educational Institutes. Figure 2 shows that implementation of 2 Mbps (low speed bandwidth) has achieved higher percentage than 20 Mbps and above (high speed bandwidth) in Higher Educational Institutes. While, it also shows that LAN speed bandwidth more focusing to 100 Mbps implementation compared to 1 Gbps (see Table 2). Frequency test has show decreasing of graph in exponential pattern for Internet bandwidth implementation from low speed bandwidth to high-speed bandwidth.
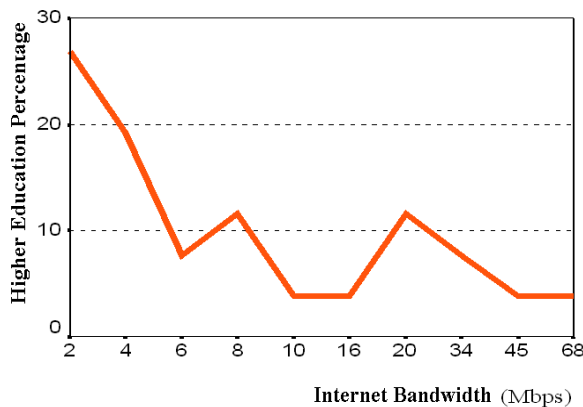

Figure 2: Internet Bandwidth speed availability in Higher Educational Institutes

TABLE 2: LAN Bandwidth speed in Higher Educational Institutes

Types of Bandwidth (LAN)	Implementation Percentage	Public Universities	Private Universities	Total Implementation
10 Mbps	Implementation	3	0	3
	Percentage	11.5%	0%	11.5%
100 Mbps	Implementation	3	14	17
	Percentage	11.5%	53.8%	65.4%
1000 Mbps	Implementation	2	1	3
	Percentage	7.7%	3.8%	11.5%
10000 Mbps	Implementation	2	1	3

T-test was used to test hypothesis for implementation of bandwidth capacity. By using t-test, the result shows that implementation of high-speed bandwidth for Internet (WAN) achieved significant level as compares to LAN. From the result, it shows that there is significant difference regarding the implementation of high-speed bandwidth for Internet (WAN) in Malaysian Higher Educational Institutes. However, implementation of high-speed bandwidth for LAN among public and private Higher Educational Institutes did not show any significant difference and it has a similarity and focusing of high-speed bandwidth implementation 100 Mbps (see Table 3).

TABLE 3: T-test for Types of Bandwidth between Public and Private Institutes

Types of Bandwidth	Higher Education	Sample	Significant Value	T Value
Internet (WAN)	Public	10	0.03	2.308
	Private	16		
LAN	Public	10	0.268	1.135
	Private	16		

4.2. Implementation of Various Services and Technologies

Frequency test was also used to analyze the implementation of various services and technologies in Higher Educational Institutes. Figure 3, shows the result of various services implementation such as Web and Email services achieve higher percentage (100%) as compared to other services such as Video Conference, Voice Mail, WebCT, VoD, IP Telephony, VoIP, Unify Messaging, WAP and IVR (20% and below). Therefore, retrieving and sending information in Malaysian Higher Educational Institutes used mainly Web and Email services.
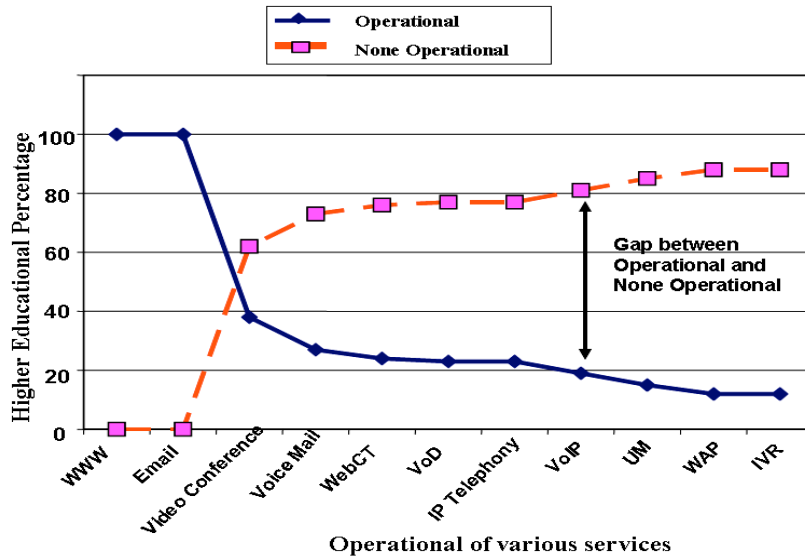
Figure 3: Implementation of Various Services in Higher Educational Institutes

Figure 4 show the impact of various services operational on convergence of communication technologies utilization for retrieving and sending information. The result also shows decreasing use of communication technologies such as PC, PDA, Mobile Phone and Fix Phone in accessing information which is less than 10%.
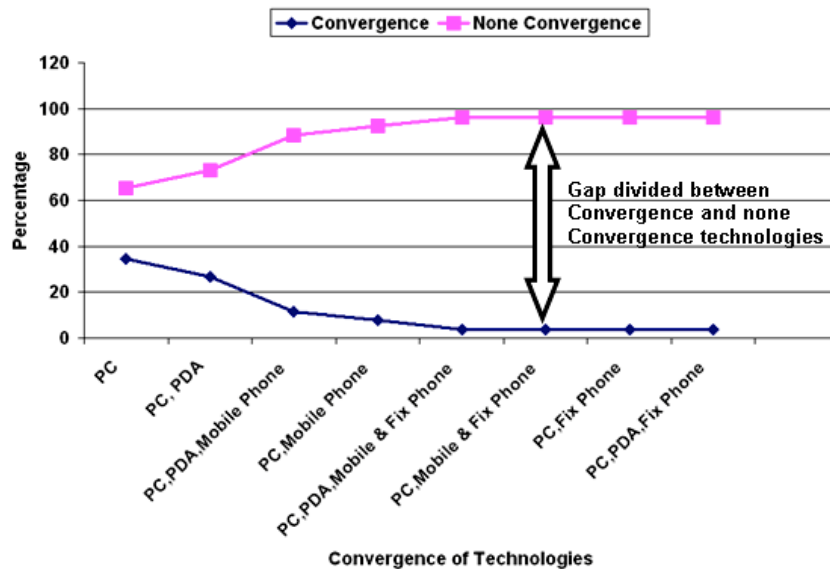

Figure 4: Convergence Variety of Communication Technologies

Figure 5 shows communication flow of devices that communicate with each other for accessing information in Malaysian Higher Educational Institutes. It indicates that Malaysian Higher Educational Institutes did not achieve optimal performance in heterogeneous environment.

Low speed bandwidth implementation for Internet connectivity (refer to Figure 2) can contribute higher bandwidth utilization. Figure 6 shows that the majority of the Higher Educational Institutes have obtained higher bandwidth utilization (80% to 90%). A few of Higher Educational Institutes (10%) has not fully utilized the bandwidth utilization (20%-30%).
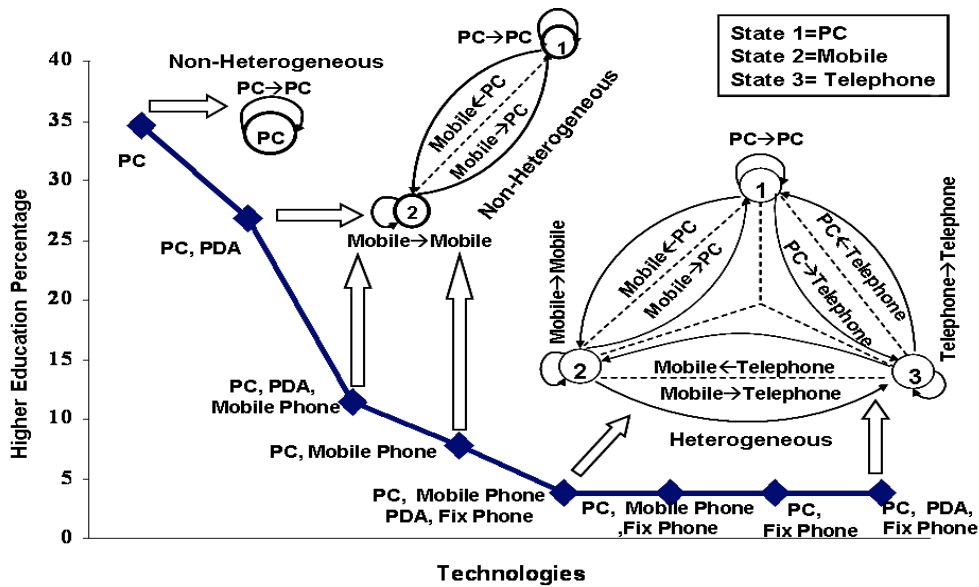

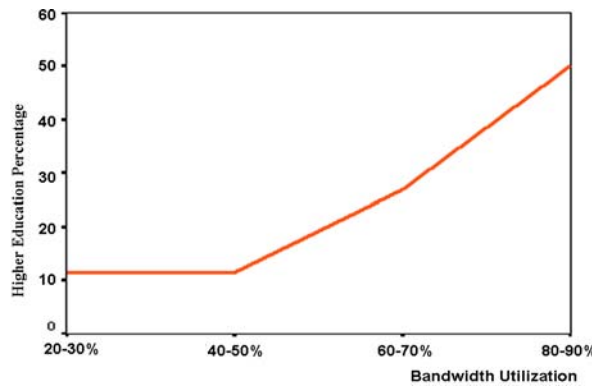**Figure 5: Communication flow of devices in accessing each other**

Figure 6: Bandwidth Utilization in Higher Educational Institutes

Due to high bandwidth utilization, it can degrade the network performance on operational services such as Web and Email traffic congestion (see Table 4). Web and Email services contribute to 66.4% of the network traffic congestion. Today, higher bandwidth utilization in Higher Educational Institutes can impact the heterogeneous network environment performance.

Table 4: Types of Services Congestion

Types of Services	Frequency	Percentage
WWW	12	46.2
Video Conference	3	11.5
WWW, Video Conference	1	3.8
WWW, Email	5	19.2
Email, Video Conference	1	3.8
WWW, WebCT	1	3.8
No Congestion	3	11.5
Total	**26**	**100.0**

From the data analysis, it shows accessing information in Higher Educational Institutes is under utilized based on the implementation of various services and convergence of communication technologies. If Malaysian Higher Educational Institutes want to develop heterogeneous environment, it needs to ensure that capacity, utilization and service of network is well managed. Therefore, it needs a mechanism or model to evaluate and measure network performance in early stage.

4.3. QoS Implementation

Impact of low service operations in Higher Educational Institutes also affects the implementation of QoS (see Figure 7). The result also shows decreasing exponent pattern for QoS implementation.
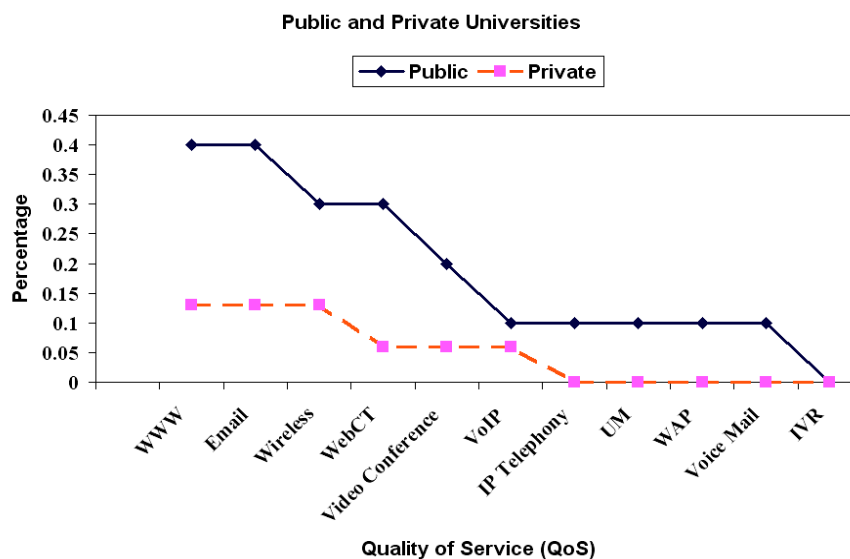

Figure 7: Implementation of QoS on Service Operations

5.0. Conclusion and Future Work

From the survey results, it shows that Malaysian Higher Educational Institutes have not achieved maximum level of various services implementation via convergence of communication technologies for retrieving and sending information. Furthermore, Internet bandwidth connectivity implementation is more focusing on low speed bandwidth (2 Mbps) compared to high-speed bandwidth implementation. Low speed bandwidth can affect the bandwidth utilization in network infrastructure. In addition, the survey also indicates a minimum QoS implementation in Higher Educational Institutes. Web and Email services have contributed to higher network congestion due to high utility. To ensure that other services e.g. video conference, video on demand, VoIP and IP telephony can operate without any interruption, the Higher Educational Institutes should have high-speed bandwidth and good QoS implementation. The most significant finding in this study is to show that accessing information over heterogeneous environment in Malaysian Higher Educational Institutes is still under utilized.

Based on the findings of this study, I have conceived a new comprehensive communication flow framework of devices and taxonomy that allows us to categorize of heterogeneous environment (see Figure 8). This framework suggests a low mobility and ubiquitous computing environment in Malaysia Higher Educational Institutes. In addition, convergence of communication technologies aims to enhance various services implementation for accessing information in Higher Educational Institutes. Figure 9 shows how the relationship between network performance, multi-

traffic, bandwidth capacity, utilization and QoS can affect network connectivity such as LAN or Internet (WAN) over heterogeneous environment.
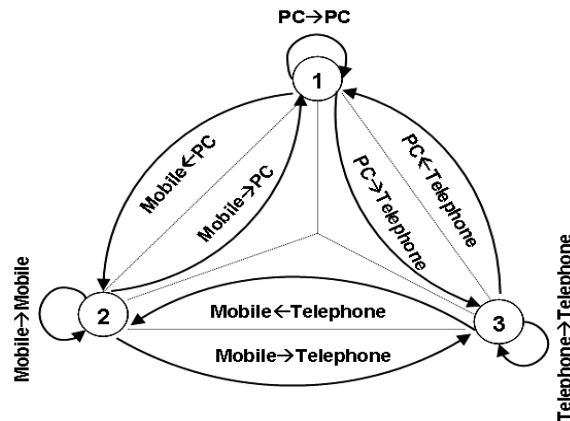

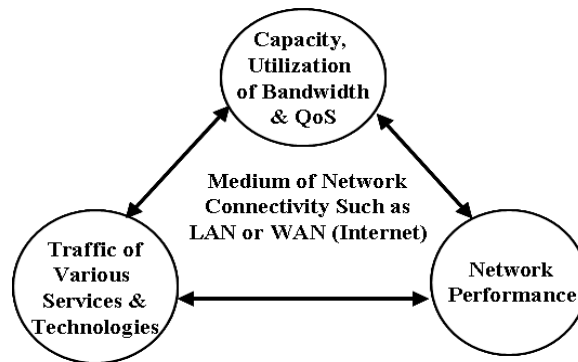**Figure 8: Flow of Heterogeneous Environment Design**

Figure 9: Bandwidth, Performance and Traffic Relationship

If Malaysian Higher Educational Institutes are planning to develop heterogeneous network environment, they need to ensure that bandwidth capacity, bandwidth utilization and QoS of network are well managed for multi-service traffic. Heterogeneous environment can also generate a mobility approaches for accessing information (see Figure 9). By measuring bandwidth utilization and bandwidth capacity performance before deployment of new heterogeneous network environment, can aid in the correct redesign and configuration of traffic prioritisation in network infrastructure, see illustrated in Figure 10. Future work is to develop a conceptual framework for heterogeneous model as a platform to combine various services implementation and convergence of communication technologies. This futuristic model can help system network administrator to evaluate capability of network performance on preparation, planning and designing stage.

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