The Exploitation of Instant Messaging to Monitor Computer Networks Using XMPP: A Study Focuses on School Computer Labs

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***Abstract*—Network management in school computer labs is important in order to ensure that all computers are working properly and reliably and can be used effectively. There are various network management systems available in the market, yet none of these systems meet the requirements of users who want a simple, easy to use and fun network management system. Through this study, an instant messaging system is specifically designed to be used and implemented to monitor computer networks in schools. The system uses the Jabber/XMPP due to its ability to provide better security, openness, flexibility and cross-platforms support. Extended function and plugins are added to meet the monitoring requirements in school labs. A network monitoring test was conducted to verify the system readiness and its ability to perform tasks. The results showed that the system managed to transmit all the necessary data and information accurately.**

***Index Terms*—network management, instant messaging, context awareness, presence awareness, FCAPS model, Jabber/XMPP, plugins, client-server**

I. Introduction

The Malaysian Government has launched several initiatives to promote the adoption and diffusion of ICT in education. According to the Malaysian Education Blueprint 2013-2025 [1], the Ministry of Education has spent more than RM6 billion (USD 1.9 billion) from year 1999 to 2010 for ICT purposes and most of the funds are allocated for the construction and development of the computer labs. However, to date, the use of ICT in schools has not reached a satisfactory level. One of the major problems faced by the ministry is that computer labs are not properly managed. Hence, the development of an effective network management system to manage the computers in computer labs should be seriously considered.

Network management is important to ensure networks are in good condition, efficient and reliable. According to Pavlou [1], network management has always been a key aspect of communication networks.

Instant messaging (IM) has become a widely used application for communicating in real-time over the internet. The capability of IM to provide synchronicity and presence awareness makes it attractive to users. Synchronicity relates to the transaction speed of the technology. Presence awareness notifies users about the availability of other users, that is, whether or not they are online.

Previous studies have shown that IM technology is useful, fun and easy to use [2] [3]. For example, the results from a survey of 300 global organizations conducted by META Group showed that IM provides three benefits: efficiency, presence and cost savings [4].

The use of IM in network management has not yet been studied in detail compared to other fields [5]. In the present research, a network management system incorporating presence awareness and IM techniques is developed for the management of computer networks in school computer labs. It is hoped that the system will overcome the problems faced by ICT teachers in managing their computer networks and help them perform their duties. This support is particularly necessary because studies have shown that most teachers are not highly adept at using technology [6] [7] [8].

II. Related Work

A. Network Management

Network management refers to methods, activities and procedures related to the operation, administration, maintenance and provision of a system [9] [10] that assists user to monitor and maintain a computer networks. According to Pavlou [1], with today's network speeds and complexities, network management tasks such as monitoring services and equipment and directing the necessary alerts to the relevant person are urgently required.

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There are many standards and functionalities in the area of network management [11] [12] [13]. One of these standards is the Open Systems Interconnection (OSI) FCAPS model which is used as a framework for network management. The model comprises the following five areas [12]:

- Fault management–The main task of fault management is to detect, isolate, notify and correct malfunctions encountered in the network.
- Configuration management–The management of network device configuration includes configuration file management, inventory management and software management.
- Accounting management–Accounting management deals with information on the use of network resources.
- Performance management–Various aspects of performance are monitored and measured so that the overall performance can be maintained at an acceptable level.
- Security management–The main focus of security management is controlling access to network devices and corporate resources to authorised users.

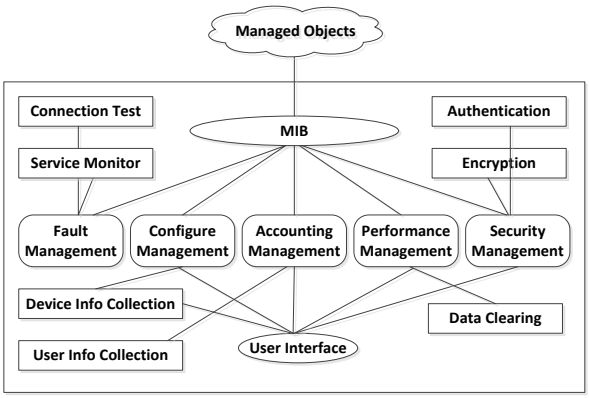

Figure 1. Network management structure of mobile IM system (Source: [5])

Gao, Xiao, Gao and Chen [5] developed the network management structure of a mobile IM system which includes the OSI FCAPS model. Fig. 1 presents the network management structure of the mobile IM system.

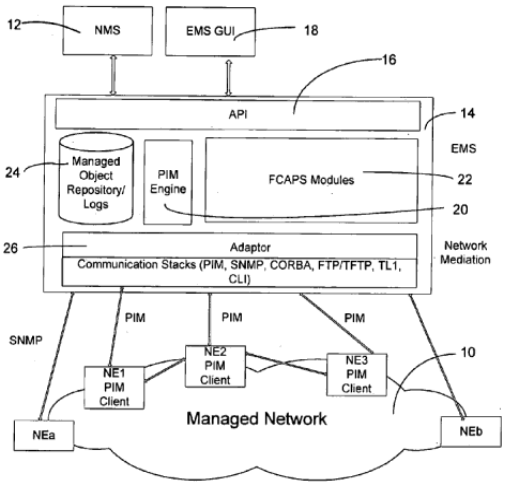

Figure 2. Architecture for network management system using presence awareness and IM technique (Source: [14])

The FCAPS model was also used in the architecture of a network management system using presence awareness and IM techniques patented by Li, Huang, Gao and Li [14], as presented in Fig. 2. The architecture follows the Internet Engineering Task Force (IETF) recommendations RFC2778 [15] and RFC2779 [16]. In the present study, the OSI FCAPS model is also incorporated in the system framework for our network management system.

B. Instant Messaging

As a social networking tool, IM has been among the fastest-growing technologies used for the purpose of connecting people and maintaining interpersonal relationships. IM was described as a "sleeping giant" in the workplace by Gartner Research [17] due to its mostly untapped and unrecognised benefits. Its usefulness underlies its rapid growth and it is widely used in the corporate world [18]. In 2007, Gartner Research predicted that IM would be the de-facto tool for most knowledge workers by 2011 [19].

IM is an important tool in ensuring effective network relationships, which in turn are a prerequisite for smooth, seamless collaboration in network communication [20]. For example, one form of IM is computer-mediated communication, which can generate proactive notifications via a pop-up message dialogue window, forming a bilateral and near-synchronous form of communication that closely resembles face-to-face interaction.

The IM literature includes many studies that focused on users' acceptance of IM as a communication tool [2] [3] [21]. However, few studies have addressed the exploitation of IM for other purposes [5] [22] [23] [24]. According to Shen *et al.* [25], IM user experience involves two basic dimensions: i) functional experience related to controllability, ease of use and involvement; and ii) emotional experience related to a sense of fun, enjoyment and reciprocity. Hence, a review of the literature concluded that there was a need to conduct a study to investigate the use of IM in a network management system, as IM has been widely adopted and is considered fun and easy to use

A survey conducted by the AOL media corporation indicated that IM is useful for communicating with colleagues and delivering quick responses in making decisions [26]. Many studies have also shown that IM is widely used in the workplace [27] [28] [29] [30] [31]; however, research on the use of IM in the workplace in Malaysia is still lacking [32].

C. Presence Awareness in Instant Messaging Systems

IM systems typically provide a function that monitors the availability status (online/offline and active/idle) of every person in the user's contact list, which is called presence awareness. Presence awareness is a part of context awareness. According to Dey [33], "a system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task". Schilit and Theimer [34] described context awareness as software "that adapts

according to its location of use, the collection of nearby people and objects, as well as changes to those object over time".

Context can be defined as information that is used to explain the situation of an entity (people, places or objects) and that is relevant to the interaction between the user and the application, including the user and applications themselves. Context-aware applications use context information (location, situation, date and time etc.) and react based on changes in the context [2].

Context awareness also incorporates information about the user and the condition of IT devices such as the environment, situation and location [35], identity [36], time and activity [37] which form the primary context in explaining the situation of an entity. IM applications normally implement basic context-awareness functions by displaying online/offline status and the current activity performed by the user's contacts ("available", "busy", "away" etc.).

Many context-aware IM applications have been developed to ensure the applications display the status information in reliable and useful way. For example, a prototype developed by Begole *et al.* [38] named Lilsys, detects the user's availability from sensor data such as sound, phone usage and computer activity, and provides the status information to other users as "neutral", "possibly unavailable" or "probably unavailable" [39]. Nawi, Haron and Hassan [40] proposed a context-aware IM system with integrated scheduling planner for scheduling appointments with other users in the contact list. Context awareness is an exciting and challenging area in the field of human-computer interaction. The employment of well-designed context awareness can make the IM system become more user-friendly and enjoyable.

Presence information plays a significant role in network management because it allows managers to know the status, activities and situation of a computer at a given time. In the network management system proposed in the present study, the presence information is displayed as follows: i) the icon will be available as an indication of an online machine, ii) the icon will be disabled as an indication of an offline machine, and iii) if the CPU utilisation is more than 80% and no keyboard or mouse input is detected, the machine status will change to "warning" and a notification will be sent to the system administrator.

D. Jabber/XMPP

The design of the network management system in this study is based on the Jabber/Extensible Messaging and Presence Protocol (XMPP). Jabber is the open IM technology introduced by Miller [41] and formalised as the XMPP by the IETF as an internet standard for presence awareness and IM. It uses an Extensible Markup Language (XML) streaming technology to exchange XML elements (stanza) between any two entities in a network. An entity is anything that can be considered a network endpoint including server, clients and so on. Every entity inside an XMPP system has a unique identifier known as the Jabber Identifier (JID) [42]. Normally, a distributed client-server architecture is used in the implementation of XMPP, where the client needs to connect to a server in order to gain access to the network and thus allow the exchange of XML stanzas with other entities. XMPP defines three core stanza, namely, presence, message and iq (info/query):

- The <presence/> stanza is a broadcast notification to advertise its network availability or presence to other entities.
- The <message/> stanza is used to send messages between entities.
- The <iq/> stanza is used when one entity queries another entity with the expectation of a response.

According to Xuefu and Ming [43], XMPP provides features such as security, open standard, flexibility and the ability to integrate with other applications and services. The result from the study conducted by Gao *et al.* [44] indicated that the Jabber/XMPP technology is mature and stable.

An open source real-time collaboration server named Openfire is used as the XMPP server in this study. The Openfire application can run on Windows and Linux/Unix servers and consists of many plugins for function extensions. Plugins provide an easy way to add functions to Openfire without making changes directly to the source.

III. System Architecture

Our network management system uses the client-server XMPP. The network for this system consists of three types of nodes, namely, the system administrator, XMPP server and client computers. The server is responsible for managing the XML streams and delivering the XML stanzas between connected clients. It is also responsible for ensuring that only authorised clients can be granted access to the XMPP network. The client uses the XMPP to communicate with the server, other clients and any other entities on the network. The system administrator needs to connect to the XMPP server, and subscribe the clients to the server in order to create a session with the server and advertise its presence. Fig. 3 illustrates the network management system in our project. The modules for this system are divided into two categories: i) presence status, and ii) instant messages.

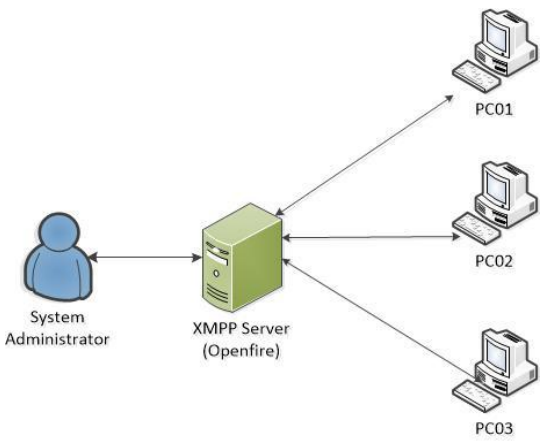

Figure 3. Proposed network management system architecture

IV. System Framework

Fig. 4 illustrates the network management system framework for our project. It shows the relationship between the system administrator, XMPP server and clients.

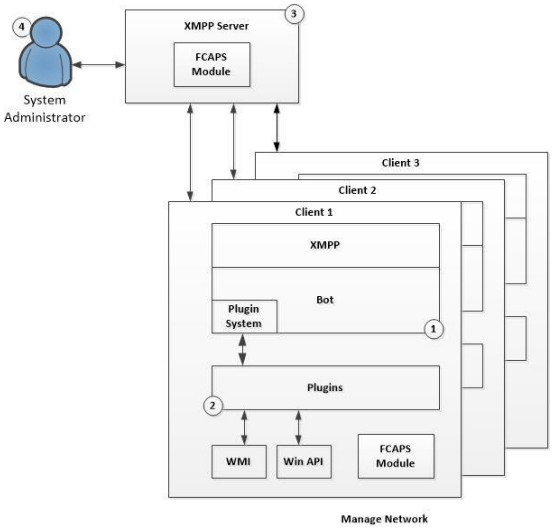

Figure 4. Proposed network management system Framework

As shown above in Fig. 4, the client process is divided into two sections of the program. Firstly, the top half shows the program that will be connected to the XMPP server, which handles the sending and receiving of instant messages, updates the presence status and provides the plugin interface. Each program has its own JID to identify program instances; in this case, the JID will act as PC identifier, to which the system administrator will add the JID in order to get notifications and to query the system status. Each message will be received by the program, interpreted as a command and pattern-matched with a string list in the program, whereby every string is mapped to a function. The string list is developed from the plugin loaded by the program. If a message doesn't match with the list, the message will be ignored. Not all messages will be interpreted as a command – only messages received from the master JID/system administrator will be interpreted as a command. Messages received from sources other than the master JID will be ignored, in order to avoid from access control misuse. Secondly, the lower half shows the plugins that provide bot functionalities to utilise the operating system's application programming interface (API). Plugins are used for monitoring the Windows system using Windows Management Instrumentation (WMI). The plugins added in this project are listed in Table I.

TABLE I. Plugins List

Plugin Name	Description
Free Memory Space	• Returns information on the free memory space
Free Disc Space	• Returns information on the free disc space
Antivirus Status	• Returns antivirus information (antivirus name and expiry date)
Monitoring	• Returns information on computer status and activities
System Notification	• Provides notification services to the program in the system

As summarized in the table above, the available plugins for this project provide information on the free memory space, free disc space, antivirus status and monitoring. The monitoring information describes the status and events associated with a PC or a group of PCs. The main monitoring functions are divided into two categories: i) time-driven monitoring which is based on periodic status information, and ii) event-driven monitoring which is based on information about events of interest [45]. The XMPP server (Fig. 4) relays instant messages between the client computers and system administrator and handles the roster/contact list. On top of that, the system administrator subscribes the JID in order to receive query notifications and system status updates.

V. Conclusion

The investment by the Malaysian Ministry of Education in the construction and development of computer labs in school proves the government's determination to provide world-class education. Thus, it is imperative to ensure the reliability and efficiency of the computer networks in schools to ensure they are well maintained at all times.

The use of IM in a network management system was the focus of this project for several reasons. Previous studies on the factors affecting IM usage, user satisfaction and the adoption of IM in the workplace showed that IM meets the requirements of users who want a simple, easy to use and fun network management system. Hence, an IM-based system is the prominent choice for a network management and monitoring system for school computer labs.

In this paper, a new network management system was proposed to assist network administrators in school computer labs to monitor equipment and services in real time. The system makes full use of the Jabber/XMPP due to the better security, openness, flexibility and support across platforms. On top of that, XMPP software is free and open source which makes it an excellent choice. For the system developed in this project, several extended functions and plugins were added to meet the monitoring requirements of school computer labs. The presence information plays a significant role in network management because it allows the administrator to view the status, activities and situation of a computer at any given time.

A small-scale network monitoring test was conducted to verify the system readiness and its ability to perform the tasks. The results showed that the system was successfully implemented and the system managed to transmit all the necessary information accurately. These useful outputs would be processed and managed by the system administrator. Further study on the usability and user acceptance of the system will also be conducted in several schools in Selangor to gain feedback from the system administrators for system improvement.

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