Integrating thin client solution in human-computer interaction study

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Abstract: - Over the past decades the field of education has witnessed the introduction of Internet, a new and revolutionary technology that seems to radically alter the way humans teach and learn. Offering thin client solution for Orang Asli provides opportunities for the team to undertake human-computer interaction related studies. Thin client is an effective and efficient ways to provide least computer computers and internet facilities and infrastructure for organizations or communities. Orang Asli community is continuously given attention by the government for their development so as not to widen digital gap with other advanced races in Malaysia. IT education and access to computers and internets seem to be one of the noble viable options for the young generations to nurture the knowledge society values. This is due to many adverse reports related to Orang Asli attitudes and behaviours in the media as well as research publications. Thus, our IT social inclusion project is timely and hoped to contribute to their development for better lives. This paper describes the proposed thin client configuration for Orang Asli community in Gombak area. It begins with literature reviews on previous studies, concepts and products available and description of Orang Asli schoolchildren in the area as well as introduction to human-computer interaction and usability testing and evaluation. Based on risk management assessment, thin client system is chosen for the community and the proposed architecture configuration is described and illustrated. The HCI is described and proposed for future researches.

Key-Words: - human-computer interaction, thin client, schools, Malaysia, Orang Asli, information technology

1 Introduction

One of the increasing areas of research nowadays is human-computer interaction (HCI). HCI is a study that involved interaction among users, computer and tasks [13]. It is also related to the understanding how users use computer system to perform specific task in specific environment until the best system can be built to satisfy users requirements. Interaction between human who performed the task on the computer in specific environment consists of four elements, (i) User, (ii) Specific tasks, (iii) Specific environment and (iv) Computer System [20]. With the advances in information technology such as thin client technology, this further enables many HCI-related researches be undertaken. Literature section will elaborate on areas of studies under HCI.

Thin clients are seen as promising innovative alternatives to fat clients for users. One of the main benefits for thin client is the improved maintenance and security due to central administration of the servers in the datacenter. Thin client is where a client machine relies on the server to perform the data processing. It can be either a dedicated terminal or a regular PC with thin client software. In recent years, more thin client products are developed by manufacturers and providers including the virtualization or even Linux platform.

Thin client technology and server virtualization are technologies that have been in use for several years or longer, both in the corporate world and in some institutional data centers. Client-server architecture is predominant in this circumstance connecting multi-workstations through internet. As issues such as management costs and security concerns rise, IT departments have looked for solutions that specifically address device and network manageability. Organizations are turning to two technologies – thin clients and virtualization – to bring device management under control.

In education, the possibility to easily reach an extremely large number of users with significantly low costs has motivated the development of an increasing number of Web applications for educational purposes [6]. The application of thin client technology in education significantly achieves many benefits as promised such as cost savings and mass reach. Hence, in the case of Orang Asli community in Malaysia, providing internet access through thin client is made possible given the low implementations costs.

The provision of computers and internet enable researches on HCI. Usability testing and evaluation researches in the field of HCI have also received a lot of attention from researchers. HCI) studies in management of information system (MIS) are "concerned with the ways humans interact with information, technologies, and tasks, especially in business, managerial, organizational, and cultural contexts" [32].

The remainder of the paper is organized as follows. Firstly, the literature review section discusses on thin clients technologies and several previous studies found in the literature. Then, we bring into the scene the Orang Asli schoolchildren and their community in Gombak, Selangor and then we introduce further on human-computer interaction concept and related studies such as usability testing and evaluation to relate to thin client solution. The main aim of this paper is to describe the proposed thin client systems design and network configuration for the Orang Asli community library. Finally, discussion and conclusion for future works wrap up the paper.

2 Literature

This section reviews and discusses on thin client, Orang Asli schoolchildren and HCI concepts and applications. With thin client technology, desktop computers are replaced with "thin clients" which are devices that have no hard drive but instead rely on a network connection to a remote server in datacenter, for example, where application processing and storage of information takes place.

2.1 Thin client concepts

Generally, three methods of thin client configurations are available for adoption. Firstly, shared services thin client enables users to share the operating system and applications in the server with all other users at thin client stations. Although presented with their own desktop, users do not have the same flexibility as they do with their own PC and are limited to running prescribed applications and simple tasks such as creating folders and shortcuts. Secondly, a more innovative approach using virtualization concept also seems practical. In this desktop virtualization, each user's desktop (OS and applications) resides in a separate partition in the server called a "virtual machine." Users are essentially presented with their own PC, except that it physically resides in a remote server in the datacenter. Users can modify the desktop and add applications like they could with their own PC (a "fat client"). Thirdly, the user's machine does the processing; however, the applications and data come from the server. The thin client contains a Web browser, and the programs come in the form of scripts on Web pages (HTML pages) from a Web server on the Internet or from the company's intranet. This is known as Browser-Based Applications - HTML Pages. One of its drawbacks is that the software scripts are always downloaded into the user's browser for each session.

As Fig. 1 illustrates, under a thin client setup, applications run on a remote server. They can also run on a virtual PC – essentially a space on the server that has been set aside for that user – or a blade PC. Brokers are used to allocate an available virtual PC or blade PC to a thin client, but are not needed in a server-based setup. On the server end (or the virtual PC or blade PC), the graphic is captured, compressed, encrypted and sent back to the thin client. At the client, keyboard and mouse events are captured and transmitted to the server [4, 10].

A recent innovative thin client product is the virtualization. Thin client virtualization goes beyond the power of thin clients and server virtualization, building on their potential to address some of the biggest challenges IT faces today.

With virtualization technology, a single server can act like multiple computers, sharing its resources via the network with many clients and applications. The ability to virtualize servers is an extremely powerful concept because each virtual "instance" created on the server can run different applications and even different operating systems, all transparent to the user. That frees administrators from the typical physical and geographic limitations imposed by server locations and capacities. Virtualization allows servers to be located anywhere and set up for any purpose. The servers can run virtualization software

on the backend server to create multiple "virtual desktops" on a single server. Each virtual client, while resident on the server, is in essence a user's desktop. It can consist of an operating system, applications and data as well as information specific to a particular user such as personal system settings. Each virtual client session is then "mapped" back to a thin client. The end result is that each user has a computing experience identical to running his own desktop personal computer [4].

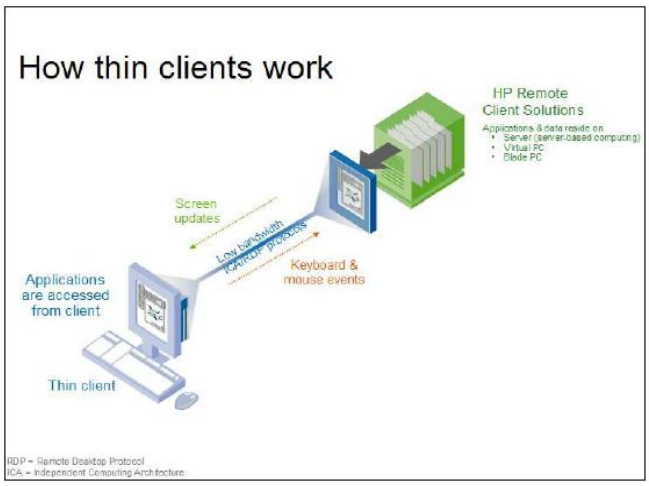

Fig 1: A thin client typically appears to the user as simply a display unit, keyboard and mouse. It is connected to a remote server for its processing power. Keyboard and mouse events are sent upstream to the server and screen updates are sent back to the client. Users can be unaware that they are actually using a thin client rather than a desktop system [4, 10].

There are many thin client products available in the market such as Hewlett Packard and Wyse. On the other hand, Linux thin client is also a viable option to be considered but requires knowledge on Linux open source technical setting up, installation, configuration, maintenance and also troubleshooting.

2.2 Thin-client architecture

As described in Section 2.1 above, thin client can operate in three environments namely shred services, virtualization and browser-based applications. Users can develop their own thin client system architecture depending on system requirements. For instance, Casella et al. [6] proposed architecture of e-learning systems characterized by the use of Web services and a suitable middleware component. These technical infrastructures allow extending the system with new services as well as to integrate and reuse heterogeneous software e-learning components. Moreover, they let users better support the "anytime and anywhere" learning paradigm. Their proposed architecture is an example of an implementation for the run-time environment in a sharable content object reference model (SCORM) to trace learning processes which is also suitable for mobile learning.

A book chapter by Grundy and Zou [8] describe a new approach to providing adaptable thin client interfaces for web-based information systems. Developers specify web-based interfaces using a high-level mark-up language based on the logical structure of the user interface. At run-time this single interface description is used to automatically provide an interface for multiple web devices such as desk-top HTML and mobile WML-based systems as well as highlight, hide or disable interface elements depending on the current user and user task. Their approach allows developers to more easily construct and maintain adaptable web-based user interfaces than other current approaches.

An architecture can be designed over low-quality LAN links and they do not provide satisfactory end-user performance in enterprise environment for more and more popular graphical and multimedia applications. To overcome this, Lubonski et al. [17] designed architecture of server-side quality of service (QoS) management component responsible for mapping application QoS requirements into network QoS. In their architecture, flexible adaptation mechanisms can dynamically map user-perceived QoS defined for each application and terminal device to the current network state in order to maximize user experience. Additionally, by combining perception information with traffic management techniques they are able to prioritize the multimedia flows (such as video streaming) in a single thin-client connection as well as provide fair resource allocation among multiple user connections to the same server. The component architecture provides a set of QoS management mechanisms for remote desktop protocols and is a solid basis for further enhancements.

2.3 Orang Asli community

Orang Asli, also known as the original people or the indigenous people, make up 0.5% of the total population of Malaysia [31]. They are divided into three main tribal groups, namely Semang (negrito), Senoi and Proto-Malay (Aboriginal Malay). Orang Asli has 18 ethnic subgroups and are not a homogeneous race, which indicates their diversity in terms of cultures, traditions and their lifestyles. The Orang Asli people have different beliefs and

languages which all depend on the ethnicity and their location. Thus, their relationship, life dependency and identity make them very much related to their land and nature.

Orang Asli is commonly perceived and reported in some researches and publication, as community with different problems such as population, education, attitudes and is regarded as barbaric and too lazy to work hard to develop themselves and their race [31]. From the study, Tijah et al. [31] found that developing and creating awareness among Orang Asli had not yielded a tangible result but rather complicated matters further. Thus, suitable methods or programmes that give them sense of belonging or ownership and excitement from the programmes are warranted. For instance, the implementation of different programmes at their childhood stage are very noble way of developing and creating awareness among Orang Asli children. Common public perception is that Orang Asli are said to be introverts [19], but these set of people are said to be intelligent and spend most of their time thinking and using their brain for activities that will benefit them rather than talking [1].

2.3.1 Internet usage among Orang Asli schoolchildren

The research team survey to Orang Asli schoolchildren in three schools, two secondary and one primary, in Gombak area shows that these students are familiar with computers and internets because they can access their schools resources centre. Nevertheless, the computer facilities are insufficient to cater for all students in the schools and hence, their usage is limited. This hinders their computer and internet proficiency level predominantly due to limited accessibility to computers and internets either at schools or homes. Demographic shows that most respondents cannot afford to own a personal computer at homes let alone subscription to internet. Most respondents have to go to cybercafés in order to access computers and internets.

In short, this study proposes installation of thin client system for the Orang Asli community in Gombak to use internet facilities for all kinds of purposes. Thus, the team must assess the environment such as infrastructure, economic, social and technology that is most suitable in order to maximize the project benefits.

The team started the groundwork in April to November 2009 to obtain computer and internet education and usage among Orang Asli schoolchildren in three schools near the Gombak Orang Asli community area. In addition, several discussions were also held between research team and authorities such as Jabatan Hal Ehwal Orang Asli (JHEOA) and staff in the library. The following section will discuss and illustrate the proposed thin client architecture configuration selected by the research team as the most suitable approach for the project.

2.4 Human-computer interaction (HCI)

Over the past decade the field of education has experienced the introduction of the Internet, which has radically altered the way humans teach and learn. And one of the most important areas in usability of internet-based interfaces is HCI. HCI research in the management of information system (MIS) discipline has a long and an extensive history and is becoming more and more important. Many different disciplines contribute to the development and enrichment of HCI research within the MIS discipline.

HCI can be described as the point of communication between the human user and the computer [11]. A broader definition by The Association for Computing Machinery defines HCI as "a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them" [2]. HCI started as an interdisciplinary field, has stayed interdisciplinary, and can be predicted to continue to be interdisciplinary. This is because no single discipline can completely cover the complex, extensive issues involved; as Dillon states: “There is no one field that can cover all the issues worthy of study” [7].

HCI is in most parts deals with technology and human. More people are creating computer applications that affect many more people than ever before. User interfaces and human factors become the bottlenecks of acceptance and deployment of many promising technologies. On human side, the interaction between human who performed the task on the computer in specific environment consists of four elements, (i) User, (ii) Specific tasks, (iii) Specific environment and (iv) Computer System. The main element of the computer system is interface. The interface works as a medium that enables users to communicate physically and cognitively with the computer system [20]. Even though the interactions between human and

computer through the system interface involve user's physical actions towards input devices in order to produce output, but the interactions are influenced by a lot of factors that could not been seen by the users [13].

HCI studies in MIS are "concerned with the ways humans interact with information, technologies, and tasks, especially in business, managerial, organizational, and cultural contexts" [32]. A key aspect of these studies is the concern about humans, not issues related to humans that would interest a pure psychologist, but in the ways that humans interact with technologies for various purposes.

2.4.1 Usability testing and evaluation

User interface evaluation or usability testing and evaluation studies in HCI field, for example, received many attentions from researchers nowadays. It generally refers to instrumental usability (e.g. ease of use, error rate, ease of learning, retention rate, satisfaction), accessibility and information presentation evaluation. Tanja et al., [30], for example, studied on usability evaluation which was based on SUMI (Software Usability Measurement Inventory) questionnaires. The software application tested was a multilingual educational portal EducaNext. They adopt definition of usability from [16] which is based on the implicit assumption that users are rational agents, interacting with a system by using their knowledge and deriving information from the system's reactions to achieve their specific goals.

Usability is a term that could usually be found in the discussions of User Centered Design (UCD) or in rules and principle of design. Usability and Usability Engineering (UE) have taken place in software engineering discipline started end of this decade. Initially, usability was based on user friendliness concept. This concept is very popular and it had been used to explain either a system is easy or difficult to be used. This definition is given by Oxford dictionary and had been argued by HCI experts [2]. Norman [22] specifically mentioned that they do not want this concept being used in User-Center Design concept that has been introduced by them.

Methodologies for building usable and functional computer systems have been introduced and refined over the past twenty years within the discipline of HCI. In usability testing, which is one of the mostly applied methods for identifying usability problems of a system, test participants are usually required to perform specific tasks with the system for which they have incomplete or even erroneous concepts. In order to achieve a system's almost transparency and enable users to fully concentrate on the work, HCI principles include an early and consistent focus on end users and their tasks, empirical measurements of system usage, as well as iterative development. Studies show that redesigning a system's user interface on the basis of user testing (i.e. interaction measurement between users and computer systems) and iterating can substantially improve usability, because usability can only be meaningfully measured during task execution. Hence, the most promising approach to the generation of usable systems is to iterate design and usability evaluation until a satisfactory solution is achieved [21].

Usability evaluation has been accepted as a tool that can provide answers regarding whether the system is designed and developed according to the user's requirements [26]. The evaluation process consists of several task activities being implemented in order to support design [20]. Usability is viewed as an evaluation method and a design process, which is aimed at promoting learnability, efficiency of use, memorability, few and non-catastrophic errors, and subjective satisfaction of a targeted product [24]. The usability testing is of key importance in HCI. It is one of the basic elements used to verify the user interface quality [21].In usability testing, which is one of the mostly applied methods for identifying usability problems of a system, test participants are usually required to perform specific tasks with the system for which they have incomplete or even erroneous concepts. One of the definitions of usability is based on the implicit assumption that users are rational agents, interacting with a system by using their knowledge and deriving information from the system's reactions to achieve their specific goals [16].

In "Usability for the web" study, [3] indicated that usability engineering for website includes six key processes: requirements analysis, conceptual design, mockups and prototypes, production, launch, and evaluation. The first process covers a full understanding of requirements of the target users, platforms, usage purposes, and necessary techniques. The conceptual design is a process to define the functions of the website. The functions defined are then transformed into a visual and interaction design in the process of mockups and prototypes. At the production phase, a complete website would be produced and assessed under a series of field tests. After all of the quality assurance

tests are executed, the website will be launched, and ready for feedbacks from the target users.

A user-centered design values the feedback from users' experiences that could be described in terms of being useful, usable, desirable, findable, accessible, credible, and/or valuable. Pearrow [23] also confirms that a user-centered design is the central issue of web usability, which is based upon the user information. The user information should include: (1) finding the user's real needs; (2) revealing factors affecting the user's accessibility; (3) understanding which information the user wants to get from the web; (4) discovering the user's preference for the web design; (5) recognizing the user's preference for the system tools; and (6) comparing the relevant websites to understand things the user dislikes.

There are many evaluation methods [9; 2] used in usability evaluations. However, they are different mainly in terms of: (i) Based on users or experts (ii) Numbers of training needed before the evaluation process and (iii) Emphasis given to the user's task and usability problems and many more. To ensure a software project has the essential usability characteristics, [30] divides the usability methods into inspection methods (without end users) and test methods (with end users). Inspection methods are methods for identifying usability problems and improving the usability of an interface design by checking it against established standards. These methods include heuristic evaluation, cognitive walkthroughs, and action analysis. Heuristic evaluation (HE) is the most common informal method. It involves having usability specialists' judge whether each dialogue or other interactive element follows established usability principles [27]. Meanwhile, [29] have developed HCI evaluation framework and suggested that time to complete the specific task as one of the usability evaluation indicator.

On the other hand, a cognitive walkthrough (CW) is a task-oriented method by which the analyst explores the system's functionalities; that is, CW simulates step-by-step user behaviour for a given task [28]. The action analysis method is divided into formal and back-of-the-envelope action analysis; in both, the emphasis is more on what the practitioners do than on what they say they do. The formal method requires close inspection of the action sequences a user performs to complete a task [5].

There are several methods for testing usability, the most common being thinking aloud, field observation, and questionnaires. Thinking aloud (THA) [ii Nielsen] may be the single most valuable usability engineering method. It involves having an end user continuously thinking out loud while using the system. By verbalizing their thoughts, the test users enable us to understand how they view the system, which makes it easier to identify the end users' major misconceptions. Field observation is the simplest of all methods. It involves visiting one or more users in their workplaces. Notes must be taken as unobtrusively as possible to avoid interfering with their work. Many aspects of usability can best be studied by querying the users.

This is especially true for issues related to the subjective satisfaction of the users and their possible anxieties, which are difficult to measure objectively. Questionnaires are useful for studying how end users use the system and their preferred features, but need some experience to design. Brinck et al. [3] hold that some principles for making effective tradeoffs need to be taken into account in order to achieve the web usability: (1) the 80/20 rule for setting priorities (users usually spend 80% of their time using 20% of the website); (2) design for manufacture needs, such as considerations on the capabilities of the production tools, the skills of the production staff, delivery limitations, and the cost of materials; and (3) design for evolution, that is, design needs to consider the likelihood of the website to evolve over a period of time. It is important to view usability as a pervasive element of the entire design process, Brinck et al. emphasized that, it will save time in the long run.

For example, in an attempt to compare two evaluation techniques for example, [2] carried out to determine the effectiveness of analytical evaluation technique that was designed, developed and named as Jalan Rentasan Kognitif (JRK) evaluation technique. This evaluation technique was conducted on thirty-seven surrogate users that consist of courseware developers, teachers and university students using the Malaysian Smart School Mathematics courseware. The usability result was then compared statistically with the empirical usability evaluation called Task Analysis Exploratory through Observation using video camera (TAEO). The respondents of the empirical method were secondary school students who used the same courseware as one of the learning aids in school. Usability indicators used in the study were usability problems and users' satisfaction. The study

showed that the effectiveness of the two techniques was quite similar if they were used independently during the evaluation process. The usability indicators obtained in the study could be used as references in the usability comparisons of other educational courseware.

A solution for usability problem is user centered design. Preece [24] indicated that a user-centered design is a participant design in which users are invited to participate in the entire design process. Preece formulated four design principles to engage users: (1) focus on users and their needs; (2) focus on the functions to satisfy the needs after completing the analyses of user tasks and task environment; (3) execute a formative evaluation in order to ensure that the system's functions meet the users' needs; and (4) use an iterative redesign cycle.

In short, testing with end users is the most fundamental usability method and is in some sense indispensable. It provides direct information about how people use our systems and their exact problems with a specific interface. There are several methods for testing usability, the most common being thinking aloud, field observation, and questionnaires.

2.4.2 User satisfaction

In usability studies, humans or users, of course, are the main concerns. Therefore, satisfying their needs are top priorities for developers. Studies have shown that satisfaction can be subdivided into five aspects [14]:

• Efficiency: this refers to the user feeling that the software is enabling the taks(s) to be performed in a quick, effective and economical manner or, at the opposite extreme, that the software is getting in the way of performance;
• Affect: this is a psychological term for emotional feeling. In this context it refers to the user feeling mentally stimulated and pleasant or the opposite as a result of interacting with the software;
• Helpfulness: this refers to the user's perceptions that the software communicates in a helpful way and assists in the resolution of operational problems;
• Control: degree to which the user feels that he, and not the product, is setting the pace;
• Learnability: ease with which a user can get started and learn new features of the product.

There are many Web design recommendations, which provide Web developers with useful usability guidelines. Following list contains several commonly used and empirically validated Web usability guidelines. Each of them affects one of the aspects of Web site quality such as readability, understanding the navigation, understanding the content, Web design quality, recency, etc. (See [18])

- The content should represent 50 - 80% of the page.
- Update content often.
- Too many colors in the design reduce their functionality, which affects the readability.
- Minimizing the use of the users' memory is one of the major usability recommendations.
- The font size has a major influence on the legibility of Web page.
- The number of images in the Web pages should be minimized unless they are necessary.
- Minimize animated graphics, which could negatively affect the readability.
- Download speed should be no more than 10 seconds.
- Use consistent navigation elements.

3 Thin client solution

Since the system architecture affects all aspects of software design and implementation, the choice of appropriate system architecture is critical. Basically, two main aspects are considered thoroughly for the proposed architecture as described in the following subsections.

3.1 Risk management

The benefits of thin clients become the main criteria for its adoption in the project. Thin clients also prove that risk management is better performed in thin client environment compared to fat clients.

Firstly, a thin client architecture normally allows instant distribution of updates and revisions if the risk system software is changed as it places the risk applications on the server side. Secondly, the thin client can run directly without browser versioning, installation and environment issues. The users will find it easier to operate the system. Next is that thin client promotes software reuse and facilitates system integration as it can leverage the interface, applications, and database between the client side and the server side.

Fourthly, thin client has better security as it just includes graphical user interface (GUI) while business logic is put onto the server side. And finally, thin client can run on any system that supports a browser. It enables users to access information from any browser without carrying configuration and other files between locations.

The proposed thin client set up involves two separate locations initially which is Orang Asli community library and university administrative datacenter. Besides that, remote server is placed behind a university firewall and thus, extra careful care must be heavily emphasized. Hence, the above risk managements clearly favour virtualized thin client environment.

3.2 Users' knowledge

The Orang Asli community library is managed by librarians and no IT personnel is stationed or servicing the library. Thus, placing the server in the university administrative datacenter allows all the updates and maintenance tasks taken care by existing trained IT staff. The research team is able to monitor the thin client PCs in the library from time to time.

In addition, from earlier findings and observations, the users are expected to have limited knowledge on technical aspects of IT. Therefore, installing fat clients pose higher risks to virus, information and computer security, hard disks overflowed and corrupted and others. Hence, thin client is preferable since the main purpose of the project is to provide internet access to the community.

3.3 Proposed solution

Considering the points in Sections 3.1 and 3.2 and the advantages of virtualization technologies above, thin client virtualization provides significant benefits to the project. However, the team must decide on whether to use open source Linux or proprietary products such as Hewlett Packard or Wyse's technologies. Academic literature does not provide enough evidence on this and therefore, based on reviews of information available on internet the team approaches the products resellers and inquire more about their products and services. In addition, the team also approaches ITD, IIUM to learn from their experiences on the use of thin client system. From these, the team decides to opt for Wyse's Desktop Manager 2 for the pilot project for its distinct advantages and suitability for the project environment.

With virtualization technology, a single server can act like multiple computers sharing its resources via the network with many clients and applications. The ability to virtualize servers is an extremely powerful concept because each virtual "instance" created on the server can run different applications and even different operating systems, all transparent to the user. That frees administrators from the typical physical and geographic limitations imposed by server locations and capacities. Virtualization allows servers to be located anywhere, and set up for any purpose. In addition, it is also far more efficient because it makes the best use of existing resources and thus ensuring high availability and lower equipment expenses. It can also save on energy costs, since fewer servers are needed to do that same job.

Wyse's Desktop Manager 2 is based on VMware's Virtual Desktop Infrastructure (VDI). Like other virtualization technologies, VDI divides the host's physical resources - memory, storage, processor cycles, etc - into multiple virtual machines (VMs). With VMWare's VDI technology, the VMs on a server host are remotely accessible via the network (see Fig. 2), with thin clients providing the user interface.

This approach results in thin clients that work more like full desktop personal computers while still offering some of the administrative advantages of thin clients, such as centralized application installation, upgrades, and patches, better support for unattended backups, greater resource utilization, and lower electricity usage. There are many other thin clients, virtualization as well as cloud computing products [12].

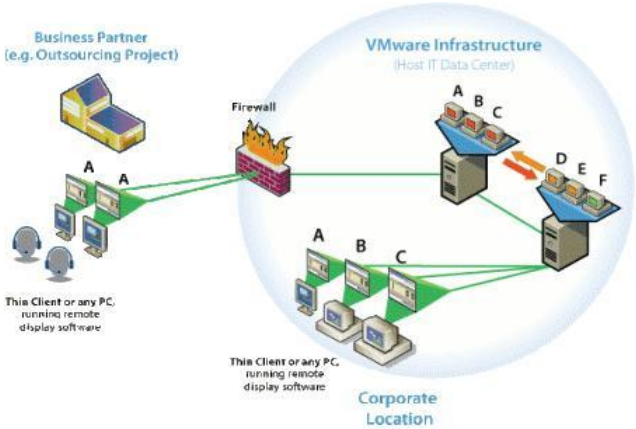

Fig. 2. Wyse's VMWare VDI typical use [12]

The above method seems practical for our study whereby the community especially the Orang Asli schoolchildren will be able to access the internet located in the library and the server is remotely located in IT division, IIUM datacenter.

In addition to that, another option that adds usability to the proposed thin client is via web services. Web Services technology provides a common

infrastructure to integrate heterogeneous software components, thus enhancing interoperability between different components and component reuse, whereas the extendibility feature of e-learning systems is ensured by the use of a specific Middleware component [6]. Web services are modular, self-describing applications universally accessible in a standardized and platform independent way. These applications communicate by standardized XML messages. Web Services are based upon three technologies: Web Services Description Language (WSDL), Universal Description Discovery and Integration (UDDI), and the Simple Object Access Protocol (SOAP).

4 Conclusion

Thin client technology is definitely an alternative viable option for users who look for facilities and characteristics offered by them. One cautious note is that the products must honour the cost savings feature compared to fat clients. Nevertheless, both fat and thin client have their own strengths and weaknesses. Users must therefore think carefully on their requirements and choose the most suitable option wisely.

This proposed solution is based on current environment which may be less favourable when conditions change. We aim, in the future, to expand the thin client system to the whole state of Selangor and this definitely requires a reassessment and reconfiguration of the new architecture which involves a more complex different environment and needs in each user organizations and IT administrative datacenter.

Orang Asli remains one of the development agenda for government. From a survey by team to three schools in Gombak area, Orang Asli schoolchildren are quite familiar with computers and internet. But affordability remains an issue for them to own a personal computer at home. Perhaps the parents can find means to own a personal computer at home since they are relatively affordable ranges of products available in the market. These children, however, live in off-reserve areas and thus their living styles resemble other races. The parents must change their attitudes and give priority to education as one of the main efforts to bring their off-reserve and reserve community a better standard of living. Orang Asli in reserve areas must come out and stress the importance of education and change their attitudes in order for them to stay put with other major races.

As mentioned earlier, HCI studies will be further conducted from this research. The immediate topic is on usability testing and evaluation even though we have interests in other issues identified by [32].

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