Conceptual Architecture Design and Configuration of Thin Client System For Schools in Malaysia: A Pilot Project

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Abstract— **Thin client systems have advanced recently with new innovative design extensions such as virtualisation and cloud computing. Client-server architecture is the basis for thin client system to connect remote multi-workstations to administrative servers located in headquarters or data center. This paper first presents a literature review on thin client concept and virtualization. In the next section, we describe the Wyse Technology and Linux thin client for windows-based and open source solution respectively. We then proceed with description of proposed conceptual architecture design and implementation for primary and secondary schools in Malaysia taking into account International Telecommunication Union and other International standards or benchmarks for high quality of service (QoS) delivery. Finally, our recommendation is that each system design and implementation is unique and thus requires different sets of decision-making criteria before designing an architecture. Networked-schools across a country like Malaysia with heavy users requirements pose high specification in architecture and system design planning to IT divisions.**

Keywords- Thin clients, virtualization, schools, Malaysia, quality of service

I. INTRODUCTION

Thin client is becoming an attractive alternative for business as well as community users to capitalize on its apparent advantages compared to traditional thick client system. 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.

Malaysia aims to connect all schools with computer facilities by 2010. Urban and top schools have firstly enjoyed the ICT advantages before it is implemented to other rural schools. Smart schools are the pilot project started in 1990s [6].

The remainder of the paper is organized as follows. Firstly, the key features of thin clients and the main concepts related to the available products in the market are reported in the first two sections, respectively. Then, we describe the proposed thin client systems design and network architecture. Finally, conclusion and final remarks for future works conclude the paper.

II. LITERATURE REVIEW

With thin client technology, desktop computers are replaced with "thin clients" – devices that have no hard drive, but instead rely on a network connection to a remote server, where application processing and storage of information takes place. Recently, more and more innovative ideas have been brought to the market from many well-known proprietary as well as open source providers. Despite varied choices, customers often face problems with selection of quality of service either at application or network.

Quality of service is a main concern in a client-server architecture such as thin client system connecting through internet. Reference [9] performed a comparison of the performance of the most popular on the market thin-client remote desktop systems. Their results show that remote desktop protocols cannot operate efficiently in networks having significant latency and with quickly changing network characteristics typical for the best effort network such as the Internet. In contemporary remote desktop systems there is clearly an existing gap between applications performance requirements and that what the underlying network can provide. This results in particularly low performance for the network-sensitive applications such as multimedia which significantly decreases total end-user's satisfaction. Internet

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Telecommunication Union (ITU), for example, emphasizes on high quality of service provided by its members [4].

A. Thin client systems

Using a thin client, the user accesses a rack of blades that sits in the data center, resulting in a dedicated PC experience. With user data located in the data center, thin clients can slash break-fix costs at the client device, greatly enhance security, and eliminate the need for individual software updates and troubleshooting on desktop computers. On the server side, Virtual Desktop Infrastructure (VDI) and Server-Based Computing virtualization takes advantage of a concept long used in mainframe computing – partitioning a server so that it acts and appears as a number of independent computer devices [5, 8].

1) Thin client concept

Basically, thin clients can be explained in three ways. In two of the three, the architecture harks back to the early days of centralized mainframes and minicomputers. In the 1970s and 1980s, a user's machine was a terminal that processed only input and output. All data processing was performed in a centralized server.

a) Shared Services - Input/Output

Using shared terminal services software such as Windows Terminal Services and Citrix XenApp, users 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.

b) Desktop Virtualization - Input/Output

Using products such as VMware Desktop Manager (VDM) and Citrix XenDesktop, 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. They can modify the desktop and add applications like they could with their own PC (a "fat client"). This concept is explained in detailed below.

c) Browser-Based Applications - HTML Pages

This approach differs from the previous two in that 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.

Web-based e-mail is an example of this scenario as well as Web-based productivity applications such as Google Applications. In some cases, copies of the data can be stored locally, but the software scripts are always downloaded into the user's browser for each session. Years ago, this was the approach of the "network computer," which was developed to compete with Windows PCs [5].

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 [8].

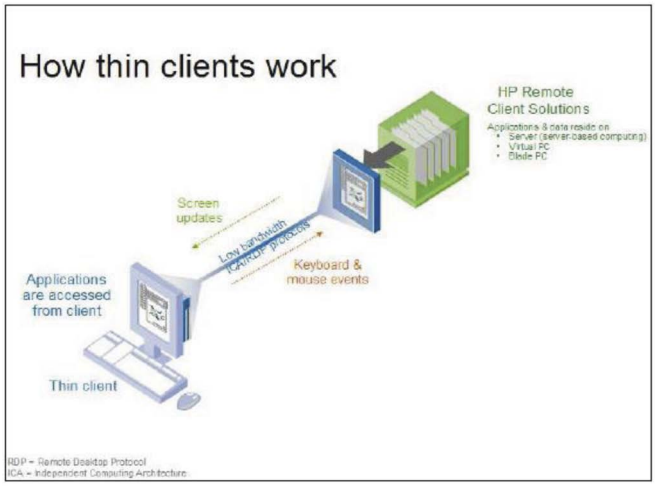

Figure 1: A thin client typically appears to the user as simply a display unit, keyboard and mouse. It is connected to a remote server for its processing power. Keyboard and mouse events are sent upstream to the server; screen updates are sent back to the client. Users can be unaware that they are using a thin client rather than a desktop system [8].

2) Thin client 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. Fig. 2 shows the architecture of virtualized client.

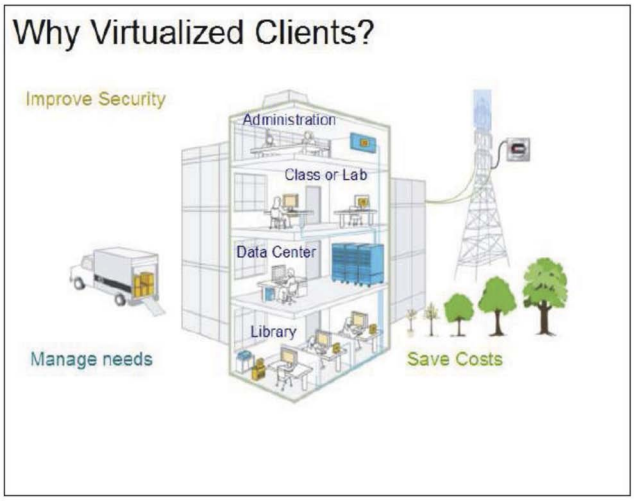

Figure 2: Virtualized clients can be used throughout the school areas such as libraries, data centers, classrooms, laboratories and administrative areas [8].

It is also far more efficient because it makes the best use of existing resources, ensuring high availability and lower equipment expenses. It can also save on energy costs, since fewer servers are needed to do that same job.

From the IT manager's point of view, having all operating systems, data and applications remain in a central location, typically the data center, is a huge bonus. With the sort of centralized computing that thin client technology offers, IT regains control of many of the factors that have historically driven up the time, expertise and cost of managing the network.

There are a number of benefits to thin client virtualization, but the technology's ability to reduce costs and enhance control is central, especially for networked-schools. In particular, support expenses and total cost of ownership per computing device can drop dramatically. In short, summaries of key benefits of virtual clients include [2]:

- Improved security – With no data saved on the end-user device, virtualized clients secure sensitive student and institutional data behind the institution's firewall.
- Cost-effective management – Costs such as operating system upgrades and maintaining virus and malware software are greatly reduced.
- Better management – The IT department can efficiently scale to the diverse needs of users by giving students, faculty and staff access to data and applications where and when they need them
- Cost savings – Total cost of ownership (TCO) is dramatically reduced because there are far fewer support and service calls, greater energy savings, and far longer equipment lifecycles.
- Increased reliability – Only a central server must be managed and maintained, rather than hundreds of desktop machines.
- Backup and continuity control – Backing up data and systems means backing up the server, not every computer on the network.
- Compliance – Schools face legal risks with the need for tighter data security. Privacy regulations are often difficult or impossible to enforce over distributed desktop machines.

B. Conceptual Design and Architecture

Installing thin client system for networked-schools across Malaysia requires careful thought compared to a single corporate organization with branches. Teachers, administration and students require high capability or quality of service to the system since they tend to use all available features of technology such as audio and video which require higher bandwidth and network availability.

Hence, adopting same model as in [2], we propose our design to be basically a 3-tier client server architecture. We require a network-enabled architecture because of the user requirement for access by multiple users simultaneously from distributed locations. Due to the amount of data and its interrelationships, we require a separate relational database. Since there is complex business logic, we decide on a 3-tier architecture where the schools and authorities business rules are isolated into their own separate module. In addition, a virtualized environment as in Fig. 2 is added where appropriately depending on suitable needs. A peer-to-peer architecture is also another option but the requirement for user backups and data updates make a central server solution a preferred choice.

Business rules change frequently whereby they require access to rapidly changing data. Thus, an option to use a thin client user interface (UI) on the client side of the application looks promising. Since there are significant differences in functionality between an administrator and a user, it is better to separate the UI's into two different modules.

- User UI: This module contains primarily the UI screens for user interaction with the system. It also contains network support for user authentication and network services.

- Administrator UI: This module contains primarily the UI screens for administrator interaction with the system. It also contains network support for admin authentication and network services for administrator services.

- Web Server: This module is a standard web server that accepts secure https requests and handles them.

- Business Logic Module: This module contains all the business logic for the application.

- Database Server: This module is a standard Relational Database System (RDBS).

Since the system architecture affects all aspects of system design and implementation, the choice of an appropriate system architecture is critical. A typical web-based information system development can be designed as a thick client or a thin client architecture. Both thin and thick client architectures have advantages and disadvantages of their own. The choice between thick client architecture and thin client architecture depends on specific application requirements [2].

There are more thin client designs and architectures available such as linux thin client, Wyse and HP among others. We describe below some of the thin client products offered in the market:

1) Wyse Technology (Low cost, high performance thin client with legacy and USB ports for a pure network-based computing environment).

One of Wyse's products is Desktop Manager 2 which 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. 3), with thin clients providing the user interface. This approach results in thin clients that work more like full desktop PCs, the theory goes, 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 [7].

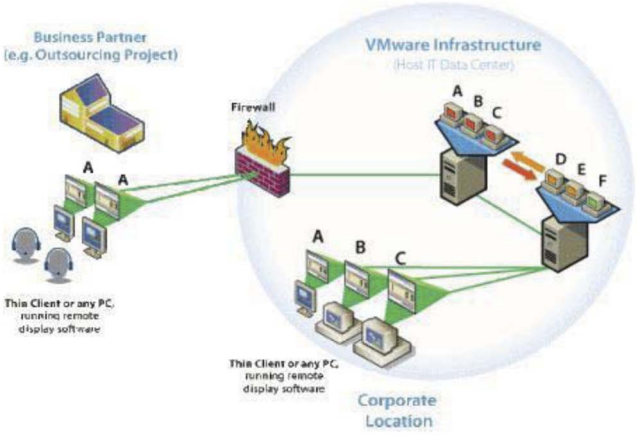

Figure 3. Wyse's VMWare VDI typical use (Source VMWare)

2) Linux thin client

The Linux Terminal Server Project (LTSP) adds thin-client support to Linux servers. LTSP is a flexible, cost effective solution that is empowering schools, businesses, and organizations all over the world to easily install and deploy desktop workstations. A growing number of Linux distributions include LTSP out-of-the-box.

Shiny new thin-clients and legacy PCs alike can be used to browse the Web, send e-mail, create documents, and run other desktop applications. LTSP not only improves Total Cost of Ownership (TCO), but more importantly, provides increased value over traditional computing solutions. LTSP workstations can run applications from Linux and Windows servers.

Linux thin-clients have proven to be extremely reliable because tampering and viruses are virtually non-existent. It's distributed under the GNU General Public License, meaning that it is free and always will be.

Using Linux Terminal Server can provide incredible power and the sheer simplicity. The server, upon boot-up, automatically maps 254 virtual nodes and alias IP addresses to a network card. When any PC is connected to the network on the Terminal Server's subnet, the PC can become a thin-client within seconds. It then operates as if it is a full fledged login to the terminal server [5].

III. CONCLUSION AND FUTURE WORKS

In this paper, we have described thin client systems and virtualization and the available products in the market. To implement thin client systems in Malaysian schools requires diligent and careful planning and management. Understanding the holistic paradigm will give the optimum approach. The issues of quality of service and cost efficacy are two main considerations. Based on the literature review, we proposed an architecture of a thin client system aiming to address several important issues. First of all, it is worth noting that current advances in computing and the development of pervasive applications intensify the diversity problem, giving rise to many variations in terms of performance, environments, and device characteristics. The availabilty of a Middleware provides us with an integration framework for multiple and potentially diverse computing platforms. Moreover, the synergistic use of a Middleware component and Web Services turns out to be a suitable solution to integrate different software components, to easily extend, for example, the e-learning system with new features, and to improve interoperability among different systems.

Another important issue considered in the proposed architecture is the effective support of student learning process traceability. As a matter of fact, the architecture integrates components, which have been specifically conceived to trace the student learning process, to deploy e-learning courses, and to manage the knowledge sequence to be presented to a student. Finally, the system architecture has been also conceived to effectively realize the learning anytime and anywhere. To this aim our efforts were addressed to let a student enjoys knowledge contents via pure HTML browsers.

In the future, we aim to expand the proposed system with new components, by exploiting the extensibility feature of the proposed architecture. In particular, we intend to integrate with current eduwebTV and other coursewares developed by education ministries. We also aim to manage adaptive contents and to support synchronous and asynchronous learning activities. This will allow us to personalize the knowledge enjoyed by each student on one hand and groups of students will be able to work together to solve problems while keeping their diversities on the other. As a result, the learning environments will encourage individual accountability, prompt feedback, high self expectations, and students' welfare.

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REFERENCES

[1] Amor, D. (2002), The E-business (R)evolution, Prentice-Hall, Englewood Cliffs, NJ.

[2] Casella, G., Costagliola G., Filomena Ferrucci, Giuseppe Polese, Giuseppe Scanniello (2007), A SCORM Thin Client Architecture for E-Learning Systems Based on Web Services, International Journal of Distance Education Technologies, 5, 1, Idea Group Inc.

[3] Conallen, J., (1999), Modeling Web Application Architectures with UML. Commun. ACM 42, 10, pp. 63-70.

[4] http://www.itu.int/net/home/index.aspx accessed 10th June 2009.

[5] http://www.ltsp.org/ accessed 15th June 2009.

[6] http://www.moe.gov.my/ accessed 10th June 2009.

[7] http://www.wyse.com/ accessed 15th June 2009.

[8] http://www.hp.com/ accessed 15th June 2009.

[9] Nieh, J., Yang, J., Selsky, M., Tiwari, N., (2002), The Performance of Remote Display Mechanisms for Thin-Client Computing. by In Proceedings of the 2002 USENIX Annual Technical Conference.