Brief Study on Thin Client Computing
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1 Overview

The growth of personal computer (PC) technology began with standalone computing in the 70's. Nowadays, desktop computing, as a kind of client-centric computing, is the mainstream computing environment in the society. The PC is becoming more powerful and users can get more control over the data and applications.

Currently most schools are adopting the desktop computing approach in setting up their computing environment. With the advancement of computing technologies, thin client computing is emerging as an alternative computing environment in the offices as well as schools.

What is Thin Client

Thin client computing is a kind of server-centric computing. Application execution and data processing are carried out at large at the server ends. The client performs little or no application execution, data processing and storage. Hardware requirements for thin client are low. It can be simple computing devices, such as PDA (Personal Digital Assistant), low-end computers or some specially designed terminals.

Thin client computing is a software architecture environment. The trimmed down hardware requirement is the benefit, rather than the prerequisite, of the "thin" environment. In general, "fat" client can operate in a thin client network with better performance and flexibility.

Thin Client Technologies

Various approaches can be used in implementing thin client computing. However, in this document, we will focus our discussion on the following two approaches:

1. Windows Terminal (WT) technologies

   It refers to a thin client environment to be built around the Microsoft Terminal Services. The Terminal Server can deliver Windows-based applications or the Windows desktop, to the thin client computers. The clients can run on non-Windows platforms or old versions of Windows, with lower hardware requirements.

2. Browser-based technologies

   The clients use web browser to access the server, just as we use browser to access information in the Internet. The server may use Internet technologies such as HTML, DHTML, JavaScript, Java or Active X for application execution and/or data delivery.

Besides, there are other approaches in implementing thin client computing, such as SunRay1 and Virtual Network Computing (VNC). However, the existing IT resources in schools may not be able to support these approaches. Additional hardware or resources may be required.
The abovementioned two approaches are considered to be suitable in the school environment, because:

- **Familiar user interface:** Both approaches are using familiar user interfaces, Windows or browser. Users would be accustomed to work under the Windows emulation or the browser interface.

- **Better resource utilization:** Schools can make use of the existing hardware and network architecture to deploy either approach.

## 2 Windows Terminal Computing

At present, Windows Terminal (WT) computing is the most popular approach in deploying thin client computing. It is based on the remote presentation computing technology of Microsoft Terminal Services.

### Operation

The server carries out all duties. The resulting user interfaces are transmitted and displayed on the client end. Clients’ input via keyboard and/or mouse actions are transmitted to the server. Users may perceive the computer at the client end as a Windows-based desktop computer.

Two display protocols can be used for Terminal Services: (1) native Microsoft RDP (Remote Desktop Protocol) and (2) Citrix ICA (Independent Computing Architecture). Citrix provides add-on functions on top of Terminal Services, such as load-balancing and Novell protocols (SPX/IPX) support.

![Windows Terminal (WT) operation](image)

### Setup

**Server**

Windows NT Server TSE (Terminal Server Edition) or Windows 2000 Server has to be in place for Terminal Services. There is also a third party add-on application for Terminal Services, such as Citrix MetaFrame, which extends Windows Terminal Services with additional client and server functionality.

**Client**

The client operating system can be any Windows members (Windows for Workgroups 3.11, Windows 9x, NT, 2000, XP or even CE). The Citrix MetaFrame add-on can support more client platform such as Macintosh, UNIX and MS-DOS. Terminal Services Client Access License (TSCAL) and terminal client agent
software, except for Windows 2000 and XP Professional client, are required for each workstation.

More information about WT thin client products is described in Annex A.

### Web-based Windows Terminal

Under Microsoft Windows 2000 Terminal Services, the clients can access Terminal Services by web browser. This is called Terminal Services Advanced Client (TSAC). TSAC only runs on all Windows operating systems (except Windows 3.x). However, there are limitations on using TSAC:

- The browser has to be Microsoft Internet Explorer 4 or later version
- It is not supported on platforms other than Windows
- A server running Microsoft IIS 4.0 or later has to be in place

In fact, third party products such as Citrix Nfuse 1.5 (free with Citrix MetaFrame) and Hob Hoblink JWT provide flexibility in using browser other than Internet Explorer.

## 3 Browser-based Computing

User who is familiar with Internet surfing would be accustomed to using browser-based applications. It is as intuitive as navigating a Web site. Some web applications even provide interfaces similar to the Windows environment.

### Operation

This approach is similar to the operation of Internet web. Hypertext Markup Language (HTML) formatted web pages would be stored or generated in a web server and be delivered to the client. HyperText Transfer Protocol (HTTP) would be used as the transfer protocol for the pages.

![Diagram: Browser-based operation (by HTTP protocol)]

For generation of dynamic web pages, technologies such as Active Server Page (ASP), Java Server page (JSP) or Common Gateway Interface (CGI) may be used in the servers. Also, scripting language (e.g. JavaScript, VBscript and Active X
control) can be run on the client side. In fact, most available web technologies, which are not listed here, can be adopted in the operation. As most of the common browsers support Java, Java application is also considered as browser-based technology here.

**Setup**

The heart of this approach comes from the applications. Unlike the off-the-shelf applications such as Microsoft Office, the browser-based applications (HTML or Java-based) require user to design and maintain the applications on his/her own. More effort would be required in its development and maintenance.

**Server**

A web server has to be in place for delivery of web pages. An application server and a back-end database server may be required for handling business logic and data storage respectively to achieve better performance.

**Client**

Certainly, the client needs to have a web browser. Plug-in like Flash, Real Player or Java Virtual Machine (JVM) may also be required on the client side, depending on the application requirements.

### 4 Benefits of using thin client computing

Thin client computing offers a different computing environment from the traditional desktop computing. The followings outline the strengths of adopting either WT or browser-based approach, with reference to desktop computing.

**Simplified management**

As most applications are executed at the server end, the client management tasks can be simplified. Examples include:

- Less technical support for users
- Centralized data backup at client end
- Simplified software installation, distribution and maintenance (e.g. service patches update)
- Better desktop management (e.g. desktop lock-down and configuration)

**Lower cost for client hardware acquisition**

The acquisition cost of client hardware can be lowered, because:

- the requirement of upgrade or replacement of client computers would be reduced
- acquisition costs for thin terminals are lowered

**Better security at client end**

With fewer functions at the client end, security breaches from clients may be minimized. Examples include:
• Virus infection from client end (e.g. floppyless clients)
• User tampering (e.g. copy or delete files or directories of other users)
• Installation of malicious code to computers

**Roaming-user capability**

Users, including those accessing via the Internet, will work in the same desktop environment whenever they access the school network. This would work better than the roaming profile of Windows network environment.

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**Desktop Computing or Thin Client Computing?**

Desktop computing may be suitable for schools when:

- there is an extensive use of multimedia applications such as voice, graphics or video, etc.
- there is a frequent use of highly technical applications (e.g. CAD/CAM, graphical/video editing)
- local computer peripherals (e.g. Chinese handwriting device) are important in the operation of client computers
- there is a greater demand in the freedom of choice of software applications

Thin client computing may be suitable for environments with the following characteristics:

- standard and structured user environment (e.g. kiosk)
- high level of security requirement (e.g. limit the use of removable storage media)
- large number of user base with frequent upgrade, addition or removal of software applications

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5 **Using the thin client approaches in schools**

The features and characteristics of the thin approaches are summarized below for comparisons.

<table>
<thead>
<tr>
<th></th>
<th>Windows Terminal</th>
<th>Browser-based</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Client platform</strong></td>
<td>● Natively support clients with Microsoft operating systems. <em>(Third party client software is required for other client platforms)</em></td>
<td>● Platform independent</td>
</tr>
<tr>
<td><strong>Requirements on client computing power</strong></td>
<td>● Lower</td>
<td>● Higher computing power is required in processing such as: - handling browser plug-in - maintaining user settings, bookmark and cache</td>
</tr>
</tbody>
</table>
### Client agent required
- Yes
- No (just browser is required)

### Client licensing
- Terminal client access licenses are required
- No client access licensing

### Off-the-Shelf Applications
- Can use off-the-shelf applications which are certified for terminal environment.
- Less off-the-shelf applications available, mostly customized web applications are used.

### Special application development
- Not required
- Web application development is required

### Access via Internet
- Yes, by Microsoft Internet Explorer browser only
- Yes

### Deployment
- Relatively easier to be deployed
- May require more complex architecture

As most of the schools are adopting Windows platform, deployment of WT approach is relatively easier. Terminal services are already bundled in Windows 2000 Server and Professional. Also, most applications, which are familiar in schools (e.g. Microsoft Office), can be run on the thin client computers. For example, with PDA running Pocket PC 2002 and wireless network, users can use MS Office or other desktop applications in the PDA with high mobility.

Browser-based approach requires web applications, which may be provided by software companies or ASP (Application Service Provider). ASP can develop, manage or host the applications and charge the services on a subscription basis. By using thin client technologies, ASP can deliver their services. The web applications can be easily accessed within the school LAN or via the Internet.

For example, an ASP provides a web-based scheduling and calendaring program to school. Students can check the updated schedules or notices through the school kiosks, which are running browser-based applications. Also, users can access and use the scheduling program at home via the Internet.

Though there are considerable differences between the two thin client approaches, schools are advised to examine their requirements and budgets in order to have the most appropriate choice.
Considerations

In adopting thin client computing in school environment, school should consider and review the following issues before deployment.

6.1 Cost

Extra server capacity

In a server-centric environment, higher computing power and storage at the server end is required. In most cases, additional and dedicated servers as well as higher server backup capacity have to be taken into account.

Higher system availability

When there is no offline backup support for the thin client computing, school will be suffered when server or network failure occurs. Hence, extra cost and effort may be required to enhance the reliability and availability of the server and the network.

Licensing cost

In WT approach, the cost for Terminal Server Client Access License (TSCAL) for each client machine should be considered. In browser-based approach, the existing application license in schools (e.g. MS Office, PhotoShop, etc.) would have no further upgrade value when the versions are found to be outdated.
6.2 Support and training

Different support requirements

In thin client environment, more hardware support tasks would be demanded at the server end. For example, more effort may be required at server load-balancing and resilience. For browser-based approach, support on web applications would be different from that on desktop applications. In some cases, the ASP may provide the support services. Hence, a higher cost may be incurred.

User training

When users have to work in the new computing environment, extra user training is required. This is especially important for browser-based applications which may have different interfaces and operations from desktop applications.

6.3 Hardware issues

Maintenance of old workstations

As the replacement cycle of thin client computers is relatively long, it may be difficult to arrange related maintenance services for the equipment. For example, there would be no memory upgrade service for computers which are running on the obsolete EDO memory.

Limited peripherals at client side

Thin client computing may restrict the use of local computer peripherals such as Chinese Handwriting Input devices, scanners and infrared devices. The current "Plug-and-Play" features in Windows 2000/XP may not be fully enjoyed.

6.4 Software issues

Application Availability

Most of the software applications in the market, as well as those legacy applications in schools, are designed for the desktop computers. Hence, the choice of thin client applications in schools would be limited.

Windows Terminal computing

Not all the applications can be run smoothly in the WT environment. There is a list of Terminal Services Certified Software (see the links on the right box), which highlights the application’s compatibility. However, the list does not cover all the applications in schools, especially on multimedia applications in WT environment.

Browser-based computing

Besides, up to the present, there is no web version for most of the applications in schools (as depicted in Annex B). Whether web version applications would be
available or not is relied on the business decision of the software vendors. It is anticipated that in the near future, most vendors would continue to only offer their non web-based interfaces for some time.

**Software support**

In using thin client computing, especially in WT approach, software such as operating system and web browser in the client computers may not be required to be upgraded frequently. Hence, problems may arise in supporting the use of the old version software.

Vendors would cease their support to some of the old version operating systems or web browser applications. For example, after Dec 31, 2001, Microsoft MS-DOS, Windows 3.x and Windows 95 would enter the non-supported phase. (For details, please check: [www.microsoft.com/windows/lifecycle.asp](http://www.microsoft.com/windows/lifecycle.asp))

**Restriction on multimedia applications**

In WT environment, refresh delays may be found in applications having extensive use of graphics or video (e.g. multimedia, video-conferencing, CAD/CAM). In addition, the possibility of launching new web version of multimedia applications is not high.

### 7 Conclusions

As at today, desktop computing is the prevailing computing environment. However, thin client computing is beginning to emerge as a server-centric alternative to provide easier client management, better client-side security and lower client hardware requirement.

Two major thin client computing approaches, namely Windows Terminal (WT) and Browser-based approaches, are mentioned in this document. WT approach may be easier to be deployed within a school LAN as schools can use the familiar desktop applications like MS Office on WT devices such as Pocket PC PDA. Though user may need to have extra support in developing applications, Browser-based approach may work better across different schools with large user population over WAN connection. For example, a web-based scheduling application can be accessed in school LAN or via Internet for students, teachers or even parents.

Before the deployment of thin client computing, issues such as hardware, software, support, training and cost should be considered and assessed. It should be noted that not every environment is best implemented by thin client computing. Given the many limitations and constraints on thin client computing, it is recommended that only small scale pilot testing or partial deployment should be carried out for the time being.
Annex A

Comparison of Microsoft and Citrix Thin Client Computing Solutions

Microsoft is one of the key players in the market providing thin client computing solution for Windows platforms. Software vendors like Citrix provide additional features on top of Microsoft’s to provide more functionality and broader clients’ support. A summary of key characteristics and features of thin client computing implementations is given below:

<table>
<thead>
<tr>
<th></th>
<th>Microsoft</th>
<th>Citrix</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Server OS supported</strong></td>
<td>Windows NT 4.0 Terminal Server Edition</td>
<td>Windows 2000 Server, Advanced Server, DataCenter Server</td>
</tr>
<tr>
<td><strong>Client OS supported</strong></td>
<td>Windows for Workgroup (16-bit), Windows 95/98/Me/NT/2000 (32-bit), Windows CE, Windows based terminals, IE browser</td>
<td>All clients on left, and DOS, Windows 3.1, Linux/UNIX, MacOS, Java, Netscape browser</td>
</tr>
<tr>
<td><strong>Multi-users multi-sessions</strong></td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Network Protocol / Architecture</strong></td>
<td>TCP/IP Allows access over slow speed links such as dial-up and WAN that eliminates the need for a dedicated network</td>
<td>TCP/IP, IPX/SPX, NetBEUI, Direct Sync Allows access over slow speed links such as dial-up and WAN that eliminates the need for a dedicated network</td>
</tr>
<tr>
<td><strong>Load balancing</strong></td>
<td>No</td>
<td>Win2K Server: No Win2K Advanced and DataCenter Server: Limited</td>
</tr>
<tr>
<td><strong>System sounds</strong></td>
<td>Yes (System beep) No (stereo Windows audio)</td>
<td>Yes (System beep) Yes (stereo Windows audio)</td>
</tr>
<tr>
<td><strong>Local disk mapping to server</strong></td>
<td>Manual mapping</td>
<td>Automatic mapping</td>
</tr>
<tr>
<td><strong>Local printing in the client</strong></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Data comm. Encryption</strong></td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Smart card support</strong></td>
<td>Hardware dependent</td>
<td>Hardware dependent</td>
</tr>
<tr>
<td><strong>Shared clipboard</strong></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Native Chinese processing</strong></td>
<td>No</td>
<td>Yes (Windows 2000 is Unicode-based) Subject to the products on left</td>
</tr>
<tr>
<td></td>
<td><strong>Microsoft</strong></td>
<td><strong>Citrix</strong></td>
</tr>
<tr>
<td>---------------------</td>
<td>-------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Network appliance availability</strong></td>
<td>Windows based terminals, Windows CE / Pocket PC</td>
<td>Windows based terminals,</td>
</tr>
<tr>
<td><strong>Minimum system requirements : Server</strong></td>
<td>Pentium or of equivalence or higher; 32MB RAM, plus 4-8MB for each concurrent connections</td>
<td></td>
</tr>
<tr>
<td><strong>Minimum system requirements : Workstation</strong></td>
<td>Depends on the client’s system requirements</td>
<td></td>
</tr>
<tr>
<td><strong>Licensing: Server</strong></td>
<td>The Windows NT TSE Server itself</td>
<td>The Windows 2000 Terminal services itself (No Citrix MetaFrame license is required on servers)</td>
</tr>
<tr>
<td><strong>Licensing: Workstation</strong></td>
<td>Windows 2000 CAL for each workstation; Terminal Services Client Access License (TSCAL) for each workstation running on Win95 / 98/ ME / NT (Win2K does not require TSCAL)</td>
<td>Windows 2000 CAL for each workstation; Terminal Services Client Access License (TSCAL) for each workstation running on Win95 / 98/ ME / NT (Win2K does not require TSCAL); Citrix MetaFrame license is required on each workstation</td>
</tr>
<tr>
<td><strong>Vendor support</strong></td>
<td>Broad 3rd party support</td>
<td>The product itself acts as an optional add-on on top of Microsoft’s</td>
</tr>
<tr>
<td><strong>Remarks</strong></td>
<td>Other than thin client computing support (in Application Server Mode), it alternatively supports remote management (in Remote Administration Mode) – let administrators (up to 2 concurrent sessions) remotely manage Win2K server(s);</td>
<td></td>
</tr>
</tbody>
</table>
# Annex B

## Equipment in schools that support Thin Client Computing

### Software

<p>| | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><strong>Operating System</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Server</strong></td>
<td>Microsoft Windows NT 4.0 Server/Windows 2000 Server</td>
</tr>
<tr>
<td><strong>Client</strong></td>
<td>Microsoft Windows NT 4.0 Workstation/Windows 2000 Professional (Chinese or English)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Application software</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Productivity</strong></td>
<td>MS Office 97/2000/XP</td>
</tr>
<tr>
<td><strong>Utilities</strong></td>
<td>Norton Utilities, Anti-virus, Multi-language enabler</td>
</tr>
<tr>
<td><strong>Internet</strong></td>
<td>Internet Explorer, Outlook Express</td>
</tr>
<tr>
<td><strong>Graphics</strong></td>
<td>CorelDraw, PhotoShop, Flash</td>
</tr>
<tr>
<td><strong>Web-publishing</strong></td>
<td>MS FrontPage, Authorware, Dreamweaver</td>
</tr>
<tr>
<td><strong>Development</strong></td>
<td>MS Visual Studio, C++, BASIC, FoxPro, Turbo Pascal</td>
</tr>
<tr>
<td><strong>Multimedia</strong></td>
<td>Real player, Microsoft Media player</td>
</tr>
<tr>
<td><strong>Special</strong></td>
<td>Computer Aided Learning, CAD/CAM</td>
</tr>
</tbody>
</table>

### Other Applications

- SAMS (School Administration and Management System)
- Multimedia computer based educational CD
- System Monitoring System
- Library System
- School Intranet System

### Hardware

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Client</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Workstation</strong></td>
<td>Up to Pentium 4 1.6GHz</td>
</tr>
<tr>
<td></td>
<td>128MB RAM</td>
</tr>
<tr>
<td></td>
<td>20GB Harddisk</td>
</tr>
<tr>
<td><strong>Notebook</strong></td>
<td>Pentium 233MHz – Celeron 800MHz</td>
</tr>
<tr>
<td></td>
<td>128M RAM</td>
</tr>
<tr>
<td></td>
<td>10GB Harddisk</td>
</tr>
</tbody>
</table>

### Peripherals connected to workstations

- Chinese Handwriting Input Devices
- Scanners
- Printers
- Modem
- Removable Media Drive
- Video Conferencing Kit

### Server

- Up to Pentium III 1.13GHz, 128MB – 512MB, 9G/18G x 5 in RAID

### Peripherals connected to servers

- Backup Tape Drive
- Uninterruptible Power Supply