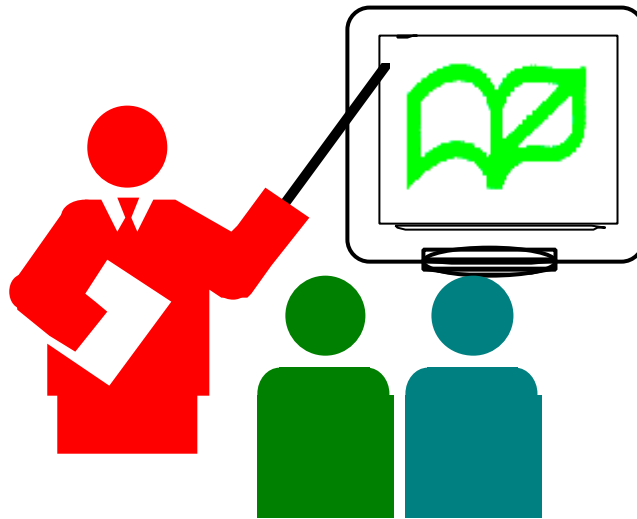


Information Technology in Education Project

Brief Study on Thin Client Computing

(RM05/2002)



Infrastructure Division
Education Department
The Government of the HKSAR

www.ited.ed.gov.hk

May 2002

For enquiry, please direct to inspector of Regional Support Section, Infrastructure Division, Education Department at (852) 3123 8103 or write to Principal Inspector, Regional Support Section, Infrastructure Division, 5th Floor, Kai Tak Government Building, 5 Arrivals Road, Kowloon City, Hong Kong.

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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.

About this Document

The document introduces the idea of thin client computing technologies. The adoption of thin client computing in school environment as well as the deployment considerations are also discussed.

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.

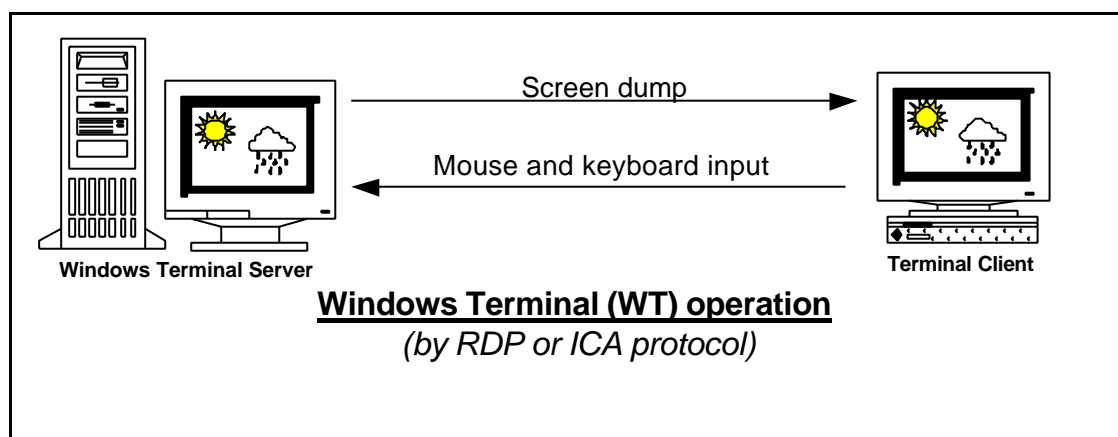
2 Windows Terminal Computing

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.



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

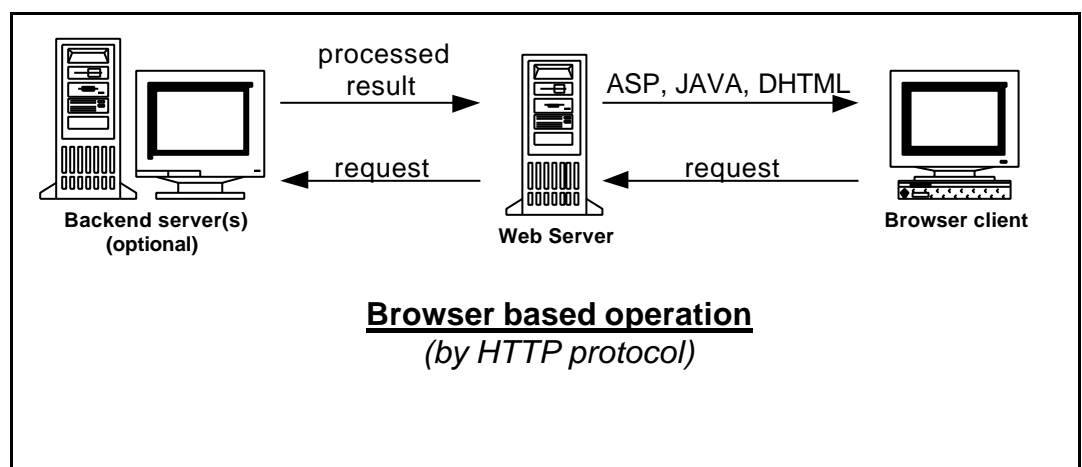
In fact, third party products such as Citrix Nfuse 1.5 (free with Citrix MetaFrame) and Hob Hoblink JWT provide flexibility in using browser other than Internet Explorer.

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.



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.

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

5 Using the thin client approaches in schools

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

	Windows Terminal	Browser-based
Client platform	<ul style="list-style-type: none"> ● Natively support clients with Microsoft operating systems. (<i>Third party client software is required for other client platforms</i>) 	<ul style="list-style-type: none"> ● Platform independent
Requirements on client computing power	<ul style="list-style-type: none"> ● Lower 	<ul style="list-style-type: none"> ● Higher computing power is required in processing such as: <ul style="list-style-type: none"> - handling browser plug-in - maintaining user settings, bookmark and cache

Client agent required	<ul style="list-style-type: none"> ● Yes 	<ul style="list-style-type: none"> ● No (just browser is required)
Client licensing	<ul style="list-style-type: none"> ● Terminal client access licenses are required 	<ul style="list-style-type: none"> ● No client access licensing
Off-the-Shelf Applications	<ul style="list-style-type: none"> ● Can use off-the-shelf applications which are certified for terminal environment. 	<ul style="list-style-type: none"> ● Less off-the-shelf applications available, mostly customized web applications are used.
Special application development	<ul style="list-style-type: none"> ● Not required 	<ul style="list-style-type: none"> ● Web application development is required
Access via Internet	<ul style="list-style-type: none"> ● Yes, by Microsoft Internet Explorer browser only 	<ul style="list-style-type: none"> ● Yes
Deployment	<ul style="list-style-type: none"> ● Relatively easier to be deployed 	<ul style="list-style-type: none"> ● 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.

Examples of thin client implementation

Schools may partially deploy Thin Client Computing (TCC) as a pilot project. In some cases, implementing the whole network with thin client computing may be too drastic. Running both thin and fat clients may provide more flexibility to schools.

◆ **Running thin applications on "fat" clients**

Thin applications can be introduced in the desktop computing environment. That is, the client does not necessarily to be "thin". For browser-based applications, there are fewer problems in running desktop applications as well as browser-based applications. For WT, compatible applications on Terminal server can appear as icons on users' desktop. Users can enjoy the flexibility of fat client as well as having thin applications. In both cases, the software compatibility as well as performance can be evaluated.

◆ **Deploying both thin and fat terminals**

Some thin client machines can be introduced in the network, such as running thin clients in the kiosks or Internet stations in the library. If the result is satisfactory, thin client computing can be extended to other areas. After all, school is advised to install a separate server for the thin client services.

◆ **Coexistence of Windows Terminal and Browser-based approaches**

The WT and browser-based applications are not mutually exclusive. For instance, if there is a browser-based application already in school, school can deploy the WT for ease of management.

6 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

Compatibility on Windows Terminal Services

For Windows 2000 Terminal Services:

<http://www.microsoft.com/windows2000/techinfo/administration/terminal/tsapcompat.asp>

For Windows NT Server 4.0, Terminal Server Edition:

<http://www.microsoft.com/ntserver/partners/findoffering/serversolutions/showcase/showcasesearch.asp>

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)

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:

	Microsoft		Citrix
Product	Windows NT Terminal Server Edition (TSE)	Windows 2000 Terminal services	Citrix MetaFrame
Server OS supported	Windows NT 4.0 Terminal Server Edition	Windows 2000 Server, Advanced Server, DataCenter Server	All servers on left
Client OS supported	Windows for Workgroup (16-bit), Windows 95/98/Me/NT/2000 (32-bit), Windows CE, Windows based terminals, IE browser		All clients on left, and DOS, Windows 3.1, Linux/UNIX, MacOS, Java, Netscape browser
Multi-users multi-sessions	Yes		Yes
Display Protocol / Technology	Remote Desktop Protocol (RDP) Client-caching & vector-based remote presentation approach which requires relatively low bandwidth		Independent Computing Architecture (ICA) Client-caching & vector-based remote presentation approach which requires relatively low bandwidth
Network Protocol / Architecture	TCP/IP Allows access over slow speed links such as dial-up and WAN that eliminates the need for a dedicated network		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
Load balancing	No	Win2K Server: No Win2K Advanced and DataCenter Server: Limited	Yes
System sounds	Yes (System beep) No (stereo Windows audio)	Yes (System beep) Yes (stereo Windows audio)	Yes
Local disk mapping to server	Manual mapping		Automatic mapping
Local printing in the client	No	Yes	Yes
Data comm. Encryption	Yes		Yes
Smart card support	Hardware dependent		Hardware dependent
Shared clipboard	No	Yes	Yes
Native Chinese processing	No	Yes (Windows 2000 is Unicode-based)	Subject to the products on left

	Microsoft		Citrix
support			
Network appliance availability	Windows based terminals, Windows CE / Pocket PC		Windows based terminals,
Minimum system requirements : Server	Pentium or of equivalence or higher; 32MB RAM, plus 4-8MB for each concurrent connections		
Minimum system requirements : Workstation	Depends on the client's system requirements		
Licensing: Server	The Windows NT TSE Server itself	The Windows 2000 Terminal services itself	The Windows 2000 Terminal Services itself (No Citrix MetaFrame license is required on servers)
Licensing: Workstation		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)	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
Vendor support	Broad 3 rd party support		The product itself acts as an optional add-on on top of Microsoft's
Remarks		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);	

Annex B

Equipment in schools that support Thin Client Computing

Software

- Operating System

<i>Server</i>	Microsoft Windows NT 4.0 Server/Windows 2000 Server
<i>Client</i>	Microsoft Windows NT 4.0 Workstation/Windows 2000 Professional (Chinese or English)

- Application software

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

- Other Applications

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

Hardware

- Client

Workstation	Up to Pentium 4 1.6GHz 128MB RAM 20GB Harddisk
Notebook	Pentium 233MHz – Celeron 800MHz 128M RAM 10GB Harddisk

- 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