

## To PC or NetPC? Hmmm ...what the heck, let's give it a go!

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Paper Presented to the Australian Library and Information Association 5<sup>th</sup> Biennial Conference, Adelaide, 26<sup>th</sup> October, 1998

### Abstract:

*Some would argue that the time for NCs or NetPCs has either not yet come or has long passed. Flinders has been watching and waiting for some time now. We had planned to try out this "new" approach in a small, controlled way in 1998, perhaps with a small server and up to 10 NetPCs. However, when university funding became available to provide 100 library workstations for student Web access to flexible delivery initiatives being developed in 1998, the Library was faced with a decision. Should we purchase 100 PC workstations with no additional staff to support this significant increase in public equipment, or should we test the theory that significant savings in application and desktop support costs can be realised with a NetPC type solution? Are they really as fast as normal PCs and are they in fact, easier to manage and support?*

*This paper reports the reasons why the Flinders University Library chose the thin client NC solution in preference to standard fat client PCs, why we thought it particularly appropriate for student applications, how we implemented the new system, what problems we encountered and how close to reality we found the promised benefits, to both end users and system managers.*

### Introduction

There is currently a great deal of interest in network computers and despite early claims to the contrary, the NC is not yet dead. Indeed, many now believe there is a bright future for NCs competing against PCs in the right niches. Most systems administrators are tempted by the promise of lower costs, reduced support and easier maintenance, but are unsure if this relatively new technology is mature enough to risk substantial investments in valuable resources. In this paper we attempt to clarify some of the jargon surrounding network computers; consider some of the advantages and problems associated with an NC installation; and report on our experiences at Flinders running WinDD<sup>TM</sup> application software based on Windows NT 3.51 servers with Citrix WinFrame 1.7. We conclude with a brief look at the future of network computing and summarise our view of the NC world as we see it through the eyes of experience.

### Definitions

Thin client, NC, NetC, NetPC, netstation, Windows Terminal, network computer: what do all these terms mean? There is much conflicting information circulating adding to the confusion in the average person's mind of what exactly is a network computer, making the term almost useless (Austin, 1997). Of course, the picture keeps changing as manufacturers add extra features to basic specifications in an effort to attract more prospective customers. Did

Flinders install NetPCs, true NCs or Windows Terminals? As you can probably tell from the title of this paper that we agreed to write before installation, we were not entirely sure at the time and tended to use the terms interchangeably.

### **THIN CLIENTS**

The term “thin client” describes a number of networked devices that have one thing in common: they let a server do much, if not all, of the work. The thin client itself can be anything from a dumb terminal up to a fat PC running NC client software.

The idea of the thin client arises from concerns of the total cost of ownership (TCO) of PCs. Traditionally, a PC user has quite a lot of freedom to control - and foul up - their PC. They are in effect a systems administrator. The thin client is an attempt to integrate the advantages of the desktop PC era with the simplicity of the days of dumb terminals and mainframe servers. A “back to the future” of sorts.

The thin client has the ease of use of a Windows PC and the manageability of a dumb terminal. It may have limited horsepower to run applications that it downloads from a server, but has no stand-alone computing capabilities. The user has no control (in our case) over the look of the screen or applications available.

### **NETPC VS NC**

The Network Computer Reference Profile (NC-1) specification jointly developed by Apple, IBM, Netscape, Oracle and Sun, defines a required central core of functions, plus a series of optional extras. These players believe the NC is basically a terminal with a CPU and memory. The NC downloads its operating system when it boots and then downloads applications on demand and runs them locally. Once the OS is downloaded the true NC is independent of any particular server.

Another group led by Microsoft, Hewlett-Packard, etc, believe in the NetPC. “The NetPC will reduce the cost of business computing by optimizing the design for users who do not require the flexibility and expandability of the traditional PC, and by allowing organizations to centrally manage their information technology” (<http://www.microsoft.com/hwdev/>). The NetPC is essentially an 'each way bet', a sealed desktop PC with a hard drive that offers a “choice of 100% local, 100% server-based processing, or client/server as appropriate for the application” (<http://www.microsoft.com/windows/platform/downloads/netpcmb2.exe>).

The third faction are proponents of the Windows Terminal and Application server. The Windows Terminal has a minimal processor, uses Windows NT as an interface and all processing is done on the server, either using Citrix WinFrame or Windows NT 4.0 Terminal Server edition (Hydra) to talk to clients. Flinders has chosen this type of WinFrame solution utilising WinDD™ (Windows Distributed Desktop).

### **NETWORK COMPUTERS**

The Network Computer Reference Profile ([http://www.nc.ihost.com/nc\\_ref\\_profile.html](http://www.nc.ihost.com/nc_ref_profile.html)) defines network computers as follows:

“NCs are expected to be highly scalable and to span a product range from the palmtop to the desk-top. They attach to the network and inter-operate with other network nodes and network content in an IP-based network. They are end-user devices. NCs adhering to the NC Reference Profile support a

common Java-based programming environment enabling network-resident applications, as well as stand-alone applications, to execute on them. They are typically dependent on the network but may offer stand-alone functionality.”

### **NC REFERENCE PROFILE**

The NC Reference Profile consists of a set of open standards and guidelines that form the basis of an NC. The initial NC Reference Profile released in 1996 includes:

#### **Required**

- Minimum screen resolution of 640 x 480 (VGA) or equivalent
- Mouse (or other pointing device)
- Keyboard (or other text input capability)
- Sound
- Network support, including TCP/IP, User Datagram Protocol (UDP) and Simple Network Management Protocol (SNMP)
- Web browser support, including HTTP and HTML protocols
- Standard Internet e-mail support, including SMTP, IMAP4 and POP3 protocols
- Common multimedia formats, including JPEG, GIF, WAV and AU
- Java VM, runtime environment and class libraries

#### **Not Required**

- Persistent local storage (hard drive or flash RAM)

#### **Optional**

- Legacy network support for ftp, telnet and Network File System (NFS) protocols
- Remote boot and simplified administration via Dynamic Host Configuration Protocol (DHCP) and Boot Protocol (BOOTP).
- Secure communications via Secure Sockets Layer (SSL) emerging security
- APIs, ISO 7816 (SmartCards) and Europay/MasterCard/Visa specifications (Ruley, 1997)

In essence, a “not so dumb” terminal with enough horsepower to make a network connection to a server, download and run Java VM. The true NC adheres to the above specification. The Near NC adds Java and a Web browser to an existing X terminal or Diskless workstation. The NetPC, or anti NC, promoted by Microsoft adds a hard disk for caching and Windows OS. By this definition, Flinders has installed something between a Windows Terminal and a Near NC, or a NetPC with a floppy disk drive instead of a hard disk.

### **WHAT CAN AN NC DO?**

The true NC uses a standard Web browser to access Java applications from servers. Once an NC has booted it can roam the network to download applications from any server, but has a strong reliance on Java applications and applets. Support for legacy and Office type applications is not good as the technology is quite new. However, Java based office applications, like “Corel's Office for Java” (<http://www.corel.com>) are now beginning to become available. NCs do not have persistent RAM or a hard disk for storing information (browser cache, etc.) or virtual memory management. They are an ideal replacement for a dumb terminal where a GUI interface is required or desirable.

## **OVERCOMING THE LIMITS OF THE TRUE NC.**

A raft of middleware has emerged to fill the gap between the true NC and a PC. This “middleware” takes the form of Citrix WinFrame or Microsoft Terminal server (Hydra). This “middleware” is designed to overcome the “Windows and legacy” weaknesses of the NC. These solutions turn the simple desktop device into a “smart terminal” display device where applications run on an application server and display on the device.

### **Advantages**

The advantages of thin client solutions depend to a large extent on what type of thin client is implemented. The true NC specification does not require Windows or legacy application support and the NetPC with local hard disk complicates support issues. Here we list the advantages of the WinDD™ Citrix WinFrame solution implemented at Flinders.

### **LOW COST OF OWNERSHIP**

The costs of updating and maintaining PCs on the desktop are growing each year as we acquire more hardware that needs constant upgrading to cope with the latest software. The average useful life of a PC is 2 to 3 years with a new operating system needed every couple of years. New software upgrades such as Netscape come out every 6 months or so and require constant support to ensure all users in a large network are kept up-to-date with the same versions. Inevitably, PC users in the same organisation end up on different versions with resultant compatibility issues. The Gartner Group estimates the TCO (total cost of ownership) of a Windows95 PC to be \$9,476 pa (Kirwin, 1997). It is claimed that savings of 30% can be made with NCs because server centricity and relatively dumb clients significantly reduce complexity at the desktop that in turn reduces support costs. Depending on the type of installation, Zastrocky & Cappuccio (1997) estimate savings ranging from 26% for the NetPC to 39% for the true NC running Java applets within browsers or Java applications within the Java Virtual Machine.

NCs are expected to last up to 7 years with occasional firmware upgrades before they need replacing. During this period, servers will require memory and possibly processor upgrades as applications grow. As client numbers increase there will be a need for more servers and possibly a faster network.

Despite the promise of reduced costs, network computing technology is not ready to replace existing systems en masse (Austin, 1998b) but instead “is emerging as a viable way to implement new front ends to existing systems”. Austin asserts the “primary benefits of network computing pertain to reducing the incremental cost of delivering more services for more users more quickly”. However, when assessing true costs, due consideration should be given to high server costs, increased network bandwidth, developing new skills and the hiring or retraining of suitable staff capable of maintaining and supporting the new network computer environment. There is also a risk that small NC applications may not scale successfully to support high volume production applications and indeed, we did encounter several new problems described below as we increased the size of our installation.

In our experience, the initial setup costs are not cheap. With the advantage of a bulk purchase of 100 NCs, the average unit cost was still higher than a standard PC of comparable power as shown below. Note the extremely high price of the non-standard external floppy disk drive.

Tektronix NC200H	1,500	Tektronix NC200E	1,200
FD144 floppy drive	400	Monitor	240
Monitor	240		
	-----		-----
Client Total	2,140	Client Total	1,440
Server cost/NC	710	Server cost/NC	710
	-----		-----
NC200H Total	2,850	NC200E Total	2,150
<b>Average unit cost</b>	<b>\$2,500</b>		

The same price today (9 months later) can purchase a much more powerful dual processor Pentium PC with a large hard disk. There are in fact no real up front savings, but hopefully costs will fall as NCs become more popular and more units are sold. The savings are expected to be realised in lower maintenance, reduced desktop support and lower upgrade costs.

As user needs grow in terms of storage and processor requirements, it is much cheaper and easier to upgrade central servers with more hard disk and memory than each PC desktop in the organisation. Not all users have equal demands and the unused resources of many “light” or occasional users can be pooled in an NC environment making more resources available to the “heavy” user.

#### **DESKTOP MANAGEMENT**

In the traditional PC network of a large organisation, data and software (usually in multiple versions) are spread over the entire network. This makes it difficult and expensive to ensure that all desktops are backed up adequately. Often, only data is backed up as backing up the entire hard disk of every user including all software is not only redundant in many cases, but also time consuming and expensive in terms of backup media. The cost to the user of a partial backup regime is that they inevitably lose something when they have a software or hardware problem. This may be some important data that happened to be saved in an application folder instead of a documents folder, or they may have to wait while a hard disk is replaced. They then usually lose some of the software preferences or Netscape bookmarks they had painstakingly created.

In the NC environment, many of these problems are minimised. All data and application software are stored on the central server (only one copy of each application), requiring much less disk space and making backups much simpler and quicker. Software management is simplified too since only 1 copy per server needs to be managed. Keeping track of multiple licences is much easier and it may even be possible to purchase fewer licences as it is unlikely that all users will need simultaneous access to the same set of software.

In a student environment it is important that users cannot tamper with the software to make it unusable for the next user, something that happens quite frequently in student labs of PCs or Macs. Although it is possible for users to customise their view of the software that can be saved between logins in a WinDD environment, we have elected not to allow this feature because there are many users sharing the same login account. This decision may be reviewed when individual login accounts are provided. Students can therefore tailor the appearance of software during their session, but when they logout, all preferences are lost and the next user loads the default settings again.

## **TECHNICAL SUPPORT**

NCs are designed for fast display performance, not for storage or intensive data processing. With no hard disk, fewer moving parts mean fewer breakdowns. There is so little that can go wrong with an NC that client failures are very infrequent. In the past 8 months we have had only three NC failures, two with power supplies in the first week (one out of the box) and the other with an intermittent motherboard problem. This 3% failure rate compares quite favourably with the very high (around 50%) failure rate experienced with recent batches of Digital and Compaq PC hard drives. Client support levels are similar to those we have enjoyed for so long with dumb terminals.

Software installations are a one off job - simple, quick and easy. There is no need to go around to each PC for a personalised installation. When someone gets a new NC, they have instant access to all software on the server - no need to wait for installation and setup. Upgrades and maintenance can be handled quickly and easily. A single upgrade on the server gives all users instant access to the latest software or additional hardware resources. There are no 2<sup>nd</sup> class users who must wait for technical staff to get around to their machine. They need not wait for more funding to give them a more powerful PC capable of handling the latest software from Microsoft.

## **EQUIPMENT LONGEVITY**

Disk, memory, and processor upgrades for large numbers of client PCs are expensive and often hard to justify on old machines. NCs on the other hand claim to have a much longer useful life of around 6 or 7 years because it is not necessary to upgrade the client NCs to use the latest software. Only the server needs to be upgraded to add more users or to give the client more power to run bigger programs.

WinFrame includes Citrix's ICA (Independent Computing Architecture) thin-client software. ICA is a general-purpose presentation services protocol for Microsoft Windows that allows an application's user interface to execute with minimal resource consumption on a client PC (<http://www.citrix.com/prodback.htm>). For example, it is possible to run ICA client software on old 386 PCs. Even old 286 machines can be pressed back into service using the ICA client software (Turner, 1997). The reason is that the client simply acts as an input output device (ie. keyboard and monitor) and runs all the power hungry software on the server that is configured accordingly.

## **LOCAL APPLICATIONS**

With the Tektronix NC purchased by Flinders, it is possible to run some software locally which reduces network traffic and the host workload, eg. a native Web browser called Navio. Likewise, it is possible to run local legacy emulators such as IBM 3270 or DEC vt220 if required.

## **Disadvantages**

Potential difficulties of the thin client approach include high dependence on both the server and the network in terms of load and reliability. If the server or the network goes down, all the clients go down too, unlike traditional PC users who can still work independently of the network to some extent. Load problems can be addressed with appropriate configuration of the servers, adding more memory or processors or even extra servers as load increases. Server reliability is important for critical services and may require varying levels of server redundancy. These may range from mirrored disks to full RAID redundancy, hot swappable

disks and power supplies, and complete backup servers that can automatically assume the load when a server fails. The level of redundancy employed obviously affects the total cost of ownership.

Highly fault-tolerant, highly available, high speed switched networks are an essential ingredient for a successful network computer installation. As part of the University's plan to deliver high quality teaching material via the campus network, the NC installation included a new 100Mb switched network to every NC in each library. This was the first of its kind to be deployed on campus. Apfel et al. (1997) predict that by 2002, caching technology will be built into network switches to simplify network design and limit network peak loads caused by network computers.

The Citrix Systems' ICA approach employed at Flinders helps to minimise network load. Apart from the initial operating system load at boot time (once per day) no files or executables are transmitted across the network. Only screen image updates, keystrokes, mouse clicks and co-ordinates are transmitted. This allows a reasonable dial-up connection to be made for after hours administration purposes using one of the ICA clients available for PCs or Macs.

For some configurations an NC application may run faster than local PC versions, but this of course depends on the local PC and the power of the server. Of particular interest is the fact that old 386 PCs and old Macs can be used with ICA client software to run applications on the NT Server which they could never run locally, eg. imagine running Office 98 on old equipment - impossible on a 386 PC, but quite acceptable via an ICA client. This strategy we have begun to implement with older database searching workstations (486 SX20 and 386 machines) accessing our Ovid Web subscriptions with the latest Netscape, via the training server. Performance declines of course with more simultaneous users, but the cost of upgrading the server is substantially less than upgrading each users' PC.

Zastrocky & Cappuccio (1997) claim that the main weakness of this type of NC is scalability. They found that "20 users seem to be the apex of the performance curve and adding additional users lead to performance problems". However, they also acknowledge that the NC prevents inquisitive users from doing anything destructive on their desktops - "good news for managers, and bad news for many users."

## **The Flinders Experience**

### **WHY NCs?**

Historically, Flinders has shown a marked preference for Macs over PCs. We have approximately 90 Macs to 30 PCs in our public areas and the ratio is 65 to 30 in favour of Macs for staff use. In our experience Macs have proved much easier to install, maintain and support than their PC counterparts. Demand for Internet access has been steadily growing with the 20 public Internet Macs in constant use. As a result of the University's decision to invest heavily in flexible course delivery via the Internet, the Library successfully lobbied for funds to ensure that any Web based products developed through flexible delivery funding would be equally available to on campus students as well as targeted remote students. The Library's commitment as an information provider, its extended opening hours and distributed branches make it an ideal location for students from all faculties to utilise Internet resources. As a result, funding was made available to purchase 100 student workstations with associated high speed networking.

Knowing the constant problems associated with supporting public workstations (even the Macs used with Netscape needed regular cache cleaning) the prospect of installing and supporting 100 PCs was daunting. We had planned to spend maybe \$25,000 or so on a small trial NC installation of up to 10 workstations in a well-defined project. However, when funding for 100 workstations became available at short notice, we needed to make a very quick decision. Chris Hannan (1998) from the State Library of Victoria, concluded at the VALA 98 conference held in January that network computers were not yet mature enough to support the multitude of staff applications that they provided on library staff PCs. We had heard of some performance problems experienced in the University's Information Science & Technology department where they were providing NC access to Microsoft applications. However, their installation was still considered successful and we knew that our installation would be limited to a small range of software that did not include any power hungry applications. With generous server configuration, we believed we could provide a good level of service in a well-defined application environment and with minimal risk of failure.

### **INSTALLATION**

As we did not have sufficient time for an extensive review of the literature and market place, we decided to purchase the same equipment set already in use on campus in the Information Science & Technology department. In this way, we were not breaking entirely new ground and we had access to local expertise during the implementation phase. The University also had a site licence for the NC Bridge software that helped to reduce costs. NC Bridge provides local terminal emulation and printing as well as remote system administration.

The basic NC hardware chosen was from Tektronix running Tektronix' WinDD™ (Windows Distributed Desktop) application software based on Microsoft Windows NT Server 3.51 and Citrix WinFrame 1.7. The NC client hardware and NT servers were supplied by a local Tektronix reseller called Logi~Tech.

The Tektronix NC consists of a small box about 6 or 7 cms high with a footprint smaller than a standard 14 inch monitor. There is no hard disk or internal floppy drive, although an expensive external floppy drive can be attached via an optional parallel port. It has a proprietary kernel operating system that is downloaded from the server via tftp each time the NC is booted. The NC is based on open network standards using a standard PC monitor, keyboard and mouse. It operates in a Windows environment, in our case, Windows NT 3.51 that looks like Windows 3.11 to the user. Our installation will eventually be available under Windows NT 4 with a Windows95 flavour.

As there are no moving parts, they are also much quieter than a normal PC with no fans and no noisy hard disks. Because there is no hard disk, there is no software on board. Only the operating system is downloaded from the server and application software is run directly on the server. Even if there are up to 100 users running Netscape, only 1 copy of the program is actually running on the server and each client is able to run their version of Netscape with their own preferences and bookmarks, etc.

### **SERVER SETUP**

Basic recommendations allow 4Mb of RAM per user for light users with 10Mb for power users, 15 users per CPU and 16Mb for the operating system. We decided to treat all users as power users and allowed 50Mb for the operating system. In total, five dual Pentium 266 Mhz servers with mirrored 4Gb hard disks were purchased, three for student applications, one for



training and one NFS file server running Sun Solaris to handle user authentication. Four servers came with 384Mb RAM while the training server had 128Mb. Load balancing software was purchased to allow under-utilised server capacity to be drawn on by heavily used servers. The WinDD™ (pronounced windy) servers were named appropriately as “Monsoon”, the primary domain controller, “Hurricane”, the backup domain controller, “Typhoon”, an application only server, “Zephyr”, the training server, and “Sirocco” the authentication server. The three student servers were configured with 30, 35 and 35 users respectively with the primary domain controller looking after the two branch libraries and having the fewest numbers of users. The training server has 15 user licences.

#### **CLIENT SETUP**

Of the 100 Tektronix NCs installed, fifty NC200H and fifty NC200E models were purchased, each with 16Mb on board. The more expensive NC200H machines were chosen because they can be upgraded with an optional digital video card. This will allow 30 frames per second MPEG-1 video to be delivered in a proposed video on demand service to be implemented in 1998. Half of the NCs were fitted with external floppy disk drives via an optional parallel port and the two models were distributed so that alternate workstations had access to a local floppy disk drive. Temporary hard disk storage on the server is available for users without access to floppy disks or drives. Specifications for the NC200 models are available at [http://www.tek.com/VND/Products/Network\\_Computers/nc200ds.html](http://www.tek.com/VND/Products/Network_Computers/nc200ds.html).

#### **RISK MANAGEMENT**

As this was a large installation in relatively unknown territory, we built in some contingency planning in case performance was not all we had hoped. The training server can be upgraded with more memory and load sharing software and added to the pool of student servers. If necessary, the 5<sup>th</sup> server reserved for user authentication and logins can be co-opted to share the load. An additional 4Mb of memory can be added to some of the NCs to allow them to run a native version of Netscape called Navio. This would ease the load on the servers and reduce network traffic. So, we believe that we have minimised the risk of poor performance and apart from a temporary problem mentioned below, performance has proved to be quite satisfactory.

#### **USER AUTHENTICATION**

The original plan was to implement user authentication on the 5<sup>th</sup> server following the model used by the IST department. Information for each enrolled student would be downloaded each night to create individual user accounts, and students would login via the unix server which would then authorise them to access the pool of WinDD™ servers. This has not yet been implemented because the University's Information Services Division announced plans to establish a campus wide authentication system in 1998 that would fulfil this function and we did not see the need to duplicate their effort - we had enough to do!

Instead, we set up a simple system of 13 shared user accounts. Students obtained their user name and password from an option on the Library OPAC. A custom program that gives telnet access to a variety of database services was amended to include password administration. The same logic that only allows authorised users to access restricted services was utilised to deliver passwords for NC access. Students enter their library barcode and phone number and if not currently suspended, a user name and password are given. Passwords are changed on the 1<sup>st</sup> of each month to restrict use to currently enrolled students and to minimise the effect of passwords becoming know to unauthorised users.

## APPLICATIONS

The primary applications available to students are Netscape for Web browsing and Telnet used to check e-mail via the University's Pine e-mail system. Telnet access to Investigator, the Library's OPAC, is also available as well as Adobe Acrobat for viewing PDF files and a simple word processing package called Write. The Help file gives online instructions on how to use the NCs, eg. printing and saving to disk (<http://www.lib.flinders.edu.au/resources/nc-faq>).



This initial suite of applications was chosen because none are particularly processor intensive. They were therefore not expected to cause any performance problems on the servers. If performance continues to be good, additional software may be added in future. In particular, we are interested in how well the servers will handle Microsoft Office applications.

Printing facilities are initially limited to downloading to floppy disk and printing at a stand-alone print workstation. A network printing solution will be implemented when further funding is released which will ease pressure on demand for NCs with attached floppy disk drives.

## USE

So far, the NCs have proved enormously popular with almost all machines in use during peak periods, which tend to be early morning, lunchtime and late afternoon when many students check their e-mail. Login sessions are limited to 60 minutes to encourage equitable use, but there is nothing to stop users from immediately logging in again. In September, the average number of login sessions was over 5,000 per week with more than 800 logins per weekday. Even during the mid-semester break, almost 4,000 logins per week were made.

Getting users off workstations at the close of business has always been a difficult task for Reader Services staff. One side benefit of using NT user profiles is that they are created to match the library's opening hours. The system is only available to users within the opening hours of the Central Library; they are automatically logged out at closing time. Public workstation numbers have increased from 130 to 200 in the Central Library, with no increase in the time taken for staff to perform the student "round-up" at closing time.

## PROBLEMS

When installing a completely new computing environment it is not unusual to experience a few teething problems, especially when we started with no NT experience at all. We have experienced several problems which prospective implementers might like to note.

Initially all users' home directories were stored on one server (Typhoon). No matter what server you logged in to, your user directory on Typhoon was available. With the initial installation of 17 terminals this worked fine. When the installed terminals reached about 30 we began to experience licensing problems. The licensing was initially installed in per server mode (concurrent users on each server). Then we found that each login consumed two NT licences, one for the login and one for the sharing of the user directory. Changing to a per seat licence system solved this problem.

When we reached approximately 50 installed terminals, performance problems were experienced for the first time. With 40 plus users connected, Typhoon began to slow dramatically. Logins were also very slow. The problem proved to be a shortage of memory. The memory consumed by the shares was far above what we expected. Upgrading the memory in Typhoon (the server that houses the users' directories) by 128Mb alleviated the problem, but the performance was still not satisfactory.

In looking at the way students used the machines we found that the home directories were not used very much. Students tended to be creatures of habit, usually using terminals on the same floor. So we made a couple of changes. Monsoon handles the two branch libraries for Medical and Sturt. In the Central Library, 70 terminals were supported by the other 2 servers (Hurricane and Typhoon). The split of what terminal connects to what server was arbitrarily made on terminal type. NC200E's connected to 1 server and NC200H's connected to another. The two different types of terminal were interspersed at each location within the Central Library building with alternate terminals connecting to each server. If one server failed, 50% of the terminals in each location would not be affected.

The distribution was changed so that the 32 terminals on the entry level plus 3 training terminals now connect to Hurricane. The remaining public terminals scattered over the other three floors of the Central Library connect to Typhoon. By redistributing the terminal connection by location we were able to reconfigure the location of the home directories. A H: drive was configured on each server and file sharing between the servers was disabled. All users now save to a drive on the server to which they are connected. To retrieve a file later one must login on a terminal in the same location. This solution has alleviated the performance problems. Performance is now good at most times and quite acceptable at high levels of usage (70 - 80 simultaneous users).

The next problem we experienced was every 4 - 8 hours the server would stop allowing users to log in. The users would get the following message stating that the server was out of licences even though we have 100 licences for 100 terminals, many of which were not in use.

```
ICA Service
Event ID 1000
Unable to acquire a licence for user 'username', domain 'domain'
```

This was a persistent problem that took quite a while to solve. It appeared that the Microsoft logging software was incrementing licence counts as people logged in but not always releasing licences when a user logged out. A patch to the software was applied which corrected one contributing factor related to console logins. When an administrator logged in on a console, a licence was used, however, this licence was never released on logout. If an administrator logged in five times during a day, then 5 licences would become unavailable. The patch corrected that issue but the problem continued.

The supplier then suggested disabling the Microsoft licence logging service. This had no appreciable affect. The problem always occurred at a time when WinStation Administration (the main administration tool) ceased to function. Without this tool the problem was quite severe and a reboot was the only method of resetting the licences. Subsequently, a Windows service pack was released and installed. The NC Bridge software also needed an update to work with the new service pack. These 2 changes improved the reliability of the administration tools. The problem however continued, though not as bad. We discovered that another WinDD™ user had experienced the same problem a couple of months before, albeit at a much lower prevalence.

“Every so often, (5 times in 4 weeks) the server stops allowing regular users to log in. The users get a message stating that the server is out of licences.”

The solution in this installation was to remove licence pooling. So this we did, although pooling is quite an advantage, but the removal of licence pooling alleviated the problem by only a small degree. The reference to “regular users” proved to be the key. In an enterprise solution, servers tend to receive a much lower number of logins. Each user would tend to login when they arrive at the office and logout when they leave. One would expect a server to get approximately 30 - 40 logins per day. We were getting 50 - 80 logins per hour, with multiple logins per username. Every one of our user accounts would qualify as a regular user. The solution proved to be increasing the number of accounts, and therefore spreading the logins over a larger range of usernames. The ideal solution would be to have individual logins for each potential user.

At about the same time another problem presented itself. Every so often users would experience a “green screen hang” upon login. Currently logged in users were oblivious to any problem but no new users could access the system. There seemed to be no obvious pattern to this error. It would affect any of the servers at any time. Quite frustrating! Then another software patch was released;

“SE305046.EXE This hotfix corrects the problem where a hung WinStation would cause subsequent users to experience a green screen hang upon login.”

This hotfix only alleviated the problem to a small degree, but it at least made us aware of what the possible cause could be. Armed with this information (perception) we were able to instigate a productive regime to check and reset hung WinStations. We average 4 - 6 hung WinStations per day. By rebooting the servers overnight and checking a couple of times per day we can run a quite stable system.

Other issues we have found include problems with installing some software. For example, Flinders has a site licence for anti virus software. When attempting to install Vet NT, Install shield informs us that you cannot install Vet for NT because this is not an NT machine. Attempting to install Vet95 we are informed that this *is* an NT machine - get Vet for NT. Trying to install Vet for Windows 3 we are informed that this is not a Windows 3 machine and that we need Vet for Windows 95. Transferring an installed version of Vet from a Windows NT machine overcomes this problem.

## The Future

The Gartner Group predict that “due to compelling cost/benefit factors, shipments of Windows terminals, Java computers and other thin client devices will total 20 percent of all desktop shipments by 2001 (0.7 probability)” and “by 1999, 40 percent of all enterprises will deploy thin client devices for some uses” rising to 60 percent by 2001 (Apfel, 1998). According to Balmer & Austin (1998) the first complete network computing architectures will be available in 1999 with the four key properties of network computing reaching maturity by 2002. These include 1. Dynamic cached propagation enabling clients to cache applications locally thus cutting bandwidth requirements; 2. Write once, run anywhere cross-platform capability; 3. Automatic platform adjustment that allows clients to download those applications for which it has sufficient resources to run locally while running others on the server; and 4. Network context storage that allows users to see their entire “work space” wherever they use the network, even if their home device fails. Austin (1998a) claims that “network computing is about software architectures and that changes in hardware architectures will largely follow, not drive, the evolution of network computing ... by 2000, network computing architectures will be the primary client-design center for 40 per cent of new internal application development work.”

## Conclusion

Although our version of Citrix WinFrame runs on NT Server 3.5.1 with a Windows 3.1 flavour, we decided the promise of much lower client support in a student environment was well worth the risk of deploying the new technology with a relatively old “look and feel”. Without doubt, there were challenges involved in implementing the new technology and prospective administrators should allow for a reasonably long learning curve. They should understand issues of configuration, server scaling, network performance, fault diagnosis, security, degree of lock-in, and user profile management (Gassman, 1998). NT Server administration skills are an essential pre-requisite to minimise teething problems.

Has the total cost of ownership fallen by 30% compared to PCs? It’s hard to judge this early in the life cycle, but the indications are good. The costs of support, maintenance and upgrades can hopefully be contained at the same time as we provide more services on more equipment. So far, client problems have been minimal and mostly at the level of a loose cable or simple user education. Our remaining 7 or 8 Internet Macs in the Central Library cause us more problems than the 70 NCs. There have been a number of server problems, but we attribute most of these to learning how to manage a new environment and we expect the remaining problems to be resolved when we move to individual logins.

In summary then, what is the potential for libraries. One of the main attractions is for what is called green screen replacement, ie. replacing dumb terminals with GUI desktops. Access to Investigator is a prime example where we can give OPAC users a richer, though somewhat slower, interface to the catalogue through such products as WebPAC that will allow them to follow links to local and remote resources on the Internet. E-mail and Web browsing are ideal candidates for network computers which is the primary use of our 100 NCs. Word processing is something that we plan to look at when further funding is available to upgrade student Mac labs in the libraries. The life of existing PCs can be extended by using them with ICA clients and we hope to look at using more of our older CD-ROM workstations in this way to access a range of database services.

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