# Fat or Thin?

# Is the Verdict In?

John Banbury
Networks Librarian
Flinders University Library
John.Banbury@flinders.edu.au

Ian Brown
Information Technology Librarian
Flinders University Library
Ian.Brown@flinders.edu.au

***Abstract:***
*Thin client or network computing is a hot topic. The hype claims lower total cost of ownership, faster applications deployment and reduced management pain, compared to traditional computing architectures. Early in 1998 the Flinders University Library installed network computers in the Central and branch libraries for student access to the Internet. This paper is a review of network computers in the light of our experience over the past two years. Do network computers offer all that is claimed in the hype? Are there hidden costs? What are the issues of configuration, server scaling, network performance and fault diagnosis? Do they have a future in the Library arena?*

# Introduction

Although thin client technology has been around for several years, the jury is still out on whether thin clients represent the next wave of computer technology. While some members of the jury have already written them off as an unlikely contender to the PC juggernaut, others are cautiously optimistic that an alternative to the never-ending upgrade cycle may be possible. Thin clients promise a reliable, secure and predictable environment in contrast to the system instability experienced by many frustrated PC users, but are they mature enough yet to deliver on the promise? As the evidence grows, we hope the jury will eventually reach a just and reasonable verdict; one not swayed unduly by the vested interests of mega corporations seeking ever increasing profits from enforced PC redundancy, or the fears of technical support gurus whose job security is intimately tied to traditional PC technology.

# Definitions

The subject of thin client technology can be confusing, especially when the industry uses the same terms to describe different things. To add to the confusion, a network computer can operate as a Windows Terminal and a normal PC can simulate both. Although McNaught (1999) claims that thin clients are display only devices and that Windows Terminals are the only true thin clients, we have assumed a slightly wider interpretation to include network computers and Javastations.

## Thin Client

A thin client is a kind of minimalist computer. There are 2 basic types: the Network computer (NC) and the Windows Terminal (WT). The NetPC is no longer a player in the marketplace (Sheehan, 1998) and will not be discussed in this paper.

## Network Computer

NCs are little more than a processor chip, some memory, a screen, a mouse and a keyboard which connects via a network to a server computer. The server houses the thin client's operating system and application software as well as the user's files. When the NC is switched on it sends a boot request to the server, which in turn sends the operating system over the network to the client. Once booted the user selects available applications from a GUI desktop and runs them locally.

The Sun Javastation comes closest to the original concept of a network computer with all local processing based on Java applets downloaded from the server. While applications were limited initially, Citrix now supports a Java-based ICA client that provides Windows compatibility.

## Windows Terminal

Windows Terminals are a different model. A proprietary operating system is downloaded from a server at boot. Once booted the Windows Terminal runs software on the application server and the WT device does no local processing. All processing is performed on and by the server. The WT is really just an input/display device.

Windows Terminals must support either Microsoft’s Remote Desktop Protocol (RDP) or the Independent Computer Architecture (ICA) protocol (Sheehan, 1998). This thin client software can either reside permanently on a terminal chip, be downloaded to the terminal from the server for local execution at boot time, or even loaded permanently to a PC, Macintosh or Unix workstation to be used as required. Microsoft Windows NT 4.0, Terminal Server Edition supports RDP under NT 4 while Citrix WinFrame is used for earlier versions of NT. An add-on product from Citrix called MetaFrame supports ICA access on NT 4, Mac and Unix machines. Since Windows Terminals only run Windows applications, the servers must use Intel-like processors.

One fact that blurs the distinction of NCs and WTs is that WTs are named by what they do, not what they are. A network computer is defined by a hardware specification (Network Computer Reference Profile http://www.sun.com/smi/Press/sunflash/mncrs-profile.html) whereas a WT can be anything from a UNIX workstation to a desktop PC or Macintosh computer. A Windows Terminal just displays Windows programs that are running on a server. It can be a "fat" Pentium III with oodles of memory and disk running a Citrix client, or a "thin" Network Computer.

# Advantages

Many advantages have been claimed for thin clients. In the next two sections we will consider the claims and concerns and then report our actual experiences.

## Total Cost of Ownership

Although many proponents of thin client technology claim that thin devices are cheaper to purchase initially than equivalent fully configured PCs, we have not found this to be true. While thin devices contain fewer parts that should translate into a cheaper price, they have not yet reached sufficient market penetration to reduce their price proportional to their reduced PC content. When the cost of high end servers to handle the increased processing and disk storage is added, the unit cost of a thin device works out to be about the same or more than an entry level PC. With the recent trend in very cheap PCs becoming available, they are likely to cost comparably more, despite some entry-level devices now costing less than US$500.

Reduction in total cost of ownership (TCO) is expected to be realised from lower maintenance costs over the long term and the extended life cycle of the client device. TCO savings have been reported variously at 57% for Wyse Windows Terminals by Zona Research (http://www.wyse.com/solution/tco/intro.htm), 46% for Windows Terminals by Microsoft and 22% for NCs by the Gartner Group (Sheehan, 1998). A study by Forrester Research reported "desktop computers cost about eight times as much to support and maintain as 'simple screens' and cause 12 times more downtime" (Correia & Forman, 1998). A Datapro survey concluded "deploying thin-client devices cut support costs by more than 80 percent" (Molta, 1999a).

## Maintenance

Since thin devices have no disk drives and virtually no moving parts (excluding the mouse) there is very little that can go wrong at the client end – they are basically "idiot proof" which is good news for system administrators providing support. Almost all maintenance is done at the server end, which greatly reduces the time spent fixing hardware failures and software conflicts at user workstations, especially those in remote locations.

## Life Cycle

The expected useful life cycle of fat PCs is expected to be 2 or at most 3 years. While they may be technically obsolete within a few months of purchase, limited funding dictates that many low end users must suffer with antiquated equipment for many years beyond their accepted use by date. Thin devices offer some hope to this dilemma because they are not easily made obsolete by ongoing demand for bigger, better and faster applications that offer a multitude of features we really don't need, but must have.

Although the intimate nature of current networking prevents us from ignoring this trend, thin client technology can limit its impact to the server device. When new software demands more memory and faster processors, only the server needs upgrading. It is expected that each of the thin desktops will happily continue to use the server's extended resources for maybe 7 to 10 years. Windows Terminals are safer in this respect since they run all software on the server. NCs are more exposed to redundancy risk because they download applications to run locally. As the downloads (usually Java applications) grow in size, on-board memory and processor speed may need to increase accordingly. However, they can always revert to run as a Windows Terminal.

## Rapid Deployment

Once applications have been installed on the server(s) and user accounts have been established, it is very quick and easy to deploy a thin device and give staff access to a full range of up to date software. It is no longer necessary to install copies of software on every desktop. Rapid rollouts in a matter of hours instead of weeks or even months is claimed (Schwartz, 1999).

## Upgrade Ease & Version Skew

Upgrading software is very efficient. It only needs to be done once on the server(s) and all users have instant access to the new version. This in turn avoids the problem of version skew that many organisations experience when some staff cannot read documents produced by colleagues with later versions of software.

## Security

Experienced administrators can ensure that only authorised software can be run from choices made available on the server. The absence of hard disks prevents employees loading their own software from home or downloading software from the Internet. Valuable time is therefore saved while system conflicts and viruses are kept to a minimum.

## Common Desktops

Standardised desktops for all users simplify training and support issues and facilitate user mobility. Wherever they go on a temporary or permanent basis they always have access to their familiar desktop with its common applications.

## Capacity Planning

Where all processing and data storage is done on a central server, it is easier for managers to measure current activity and plan for future needs as resource usage increases. Statistics on application use patterns should allow license rationalisation.

### Backup
Backup is a critical issue that is often compounded when widely distributed desktops are backed up over the network each night. According to the Gartner Group, backup together with client administration and support accounts for two-thirds of the total cost of ownership (Correia & Forman, 1998). With the recent glut of very large hard disks to cope with bloated application size, it is often difficult to justify backing up the entire hard disk of every employee. When the inevitable hard disk crash occurs, it often takes a significant amount of time to reinstall all software and recover documents from the latest backup.

In the thin client environment, all applications and data are stored on the server. If the client device fails for any reason (an unlikely event compared to a PC) the user simply moves to another client device and picks up where they left off. No data is lost and their desktop looks exactly the same when they login again from any location. If the server fails, that's quite a different story and will be addressed under our concerns below.

## Concerns
While the benefits of thin client technology seem appealing at first sight, there are a number of concerns that need to be addressed before embracing this new approach to client server computing. The impact of these factors will vary depending on the enterprise environment and the type of applications and services being delivered.

### Initial Costs
As mentioned under TCO, the initial costs of implementing thin client technology can be quite high, especially if the network infrastructure needs upgrading to cope with the greater dependency on the network for speed, capacity and reliability. According to Golick (1999) hardware savings is "one of the great myths of thin-client networking." Decision-makers should not expect up-front savings, rather a containment of maintenance costs over time.

### Fat Servers
While the thin device itself may appear comparatively cheap (although the plummeting price of PCs makes this less so) the cost of the server must be factored in. NCs are less demanding on the server as they download software to run locally, but Windows Terminals demand server attention constantly since all applications run on the server. To support 20 or 30 devices, these servers must be quite fat and contrary to some vendor claims, over configuration is almost a necessity. As a rule of thumb, take the vendor recommendations and at least double them in terms of memory and processor requirements.

### Fat Networks
Lewis (1999) claims that "architectures that ignore the capabilities built into intelligent desktops in favor of servers at the wrong end of a WAN link … are fat-network architectures … because they require faster (read more expensive) WAN connections and bigger (read more expensive) servers to achieve a user experience that's a fraction as satisfying as the one you can achieve through a local GUI." While this may be true more so for network computers that download applications and applets to run locally, the network bandwidth required for Windows Terminals using ICA or RDP is fairly modest since only keystrokes, mouse movements and screen changes are passed between the client and the server.

## Downtime

Potential downtime is a major concern. With all applications and data stored centrally, the server represents a single point of failure that can affect many users. When a server or network goes down, traditional PCs can continue to operate independently, at least when it comes to word processing or similar work not involving interaction with a networked database. While NCs can continue to operate with software already downloaded, Windows Terminals are completely at the mercy of the network and server. When either fail, the user may as well go home. To minimise these problems it is essential to build robust networks with highly redundant servers, which substantially adds to the total cost of ownership.

## Specialised Support

In our experience, thin client servers are not particularly easy to set up and maintain. Although the total maintenance load is considerably less than a comparable PC environment, a new set of skills is required to successfully install and maintain a thin server environment. Staff with the necessary skills may not be easily found until the market matures. Managers may find a significant amount of administrator time is spent coming to grips with the peculiarities of thin client technology. While this technology promises a stable and reliable environment, "in the end, reliability will be a product less of the technology and more of the people who implement and support it" (Molta, 1999b).

## Immature Technology

One of the reasons for the problems faced by new administrators is the technology's immaturity. Regular patches are released to solve problems as they are discovered in the field but it is not uncommon for a patch to cause a new and unexpected problem. As the technology matures, we expect this type of problem to become less common.

## Software Limitations

Licensing of thin client software can be a minefield requiring a legal degree to interpret the implications of per seat versus per server and client access licenses. Applications are also limited to those that are multi-user aware.

## After Hours Maintenance

One minor but annoying problem with having so many clients absolutely dependent on the server is the very small window of opportunity for server maintenance which normally needs to be done out of business hours. While this is not new or unique to thin servers, as Libraries aim for 24 hour access to their electronic resources, the opportunity to provide pain-free maintenance gets ever more difficult.

## User Resistance

Some PC users may resist the move to thin clients because they think they are losing power and control of their desktop environment. In fact, many low end users who traditionally suffer with the oldest and slowest machines may actually benefit significantly. There is a very good chance that a new thin client will be a much faster machine than the one they are used to, with a full range of up to date and compatible software. Even high end users benefit from compatibility and a more stable desktop that is less prone to system crashes (Schwartz, 1999). If they are truly power users, they are probably not suitable candidates for thin client migration.

## Flinders Experience

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 (Brown & Banbury, 1998).

Knowing the constant problems associated with supporting public workstations the prospect of installing and supporting 100 PCs was daunting. Chris Hannan (1998) from the State Library of Victoria, concluded at the VALA 98 conference 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 with minimal risk of failure.

### Installation

The basic hardware chosen was from the Tektronix NC200 range of Network computers. The Tektronix NC consists of a small box about 6 or 7 cm 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 a server, via tftp in our installation, each time the NC is booted. The NC is based on open network standards using a standard PC monitor, keyboard and mouse.

In our installation we have configured the Tektronix NCs as Windows Terminals (WTs), using Tektronix' WinDD (Windows Distributed Desktop) application software based on Microsoft Windows NT Server 3.51 and Citrix WinFrame 1.7. It operates in a Windows environment, in our case, Windows NT 3.51. This environment was selected in response to observation of "average" computer users in recent years. Most users spend minimal time and effort learning to use a system. Installing a familiar, Windows based, system makes support simpler for library staff. The Windows environment, supporting standard DOS floppy disks, facilitates the portability of downloaded information.

#### Server Setup

When configuring WinDD, basic vendor 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 II 266 Mhz servers with mirrored 4Gb fast wide SCSI hard disks were purchased, three for student applications, one for training and one NIS 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 configured as a Windows NT domain with 1 PDC one BDC and one Windows server. The student servers were configured with 30, 35 and 35 users. The training server has 15 user licenses.

With this configuration we stepped beyond the users/processor recommendations of the vendors on two of the servers. It was felt that it would be unlikely that all terminals would be in use concurrently so there would be some spare overhead on the servers.

## 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 the future. 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.

Since our installation, the Tektronix Video and Networking division has merged with NCD and the Tektronix range of network computers is no longer available.

## Purchase Cost

The purchase cost of thin clients is a complex issue. They are network devices that cannot exist without networks and network resources. The network resources will differ substantially between NC and WT installations.

The following table compares the costs of the installation at Flinders Library with the purchase costs of PCs at the same time. In both cases network costs are not included, they are ubiquitous with each type of installation.

Table 1: Purchase cost comparison: PCs versus thin clients

| Desktop | Cost | Monitors | Servers | Licenses | Total Cost |
|---|---|---|---|---|---|
| 100 PCs | $191,900 | Included | None | Included | **$191,900** |
| 50 x NC200E<br>50 x NC200H<br>50 x Floppy drive | $56,750<br>$68,650<br>$20,250 | | | | |
| Total | $145,650 | $24,000 | $47,236 | $46,359 | **$263,245** |

As this table shows, the initial setup costs are quite high. With the advantage of a bulk purchase of 100 NCs, the average unit cost was still higher than a standard PC of comparable power. Note the extremely high price of the non-standard external floppy disk drive. Much of the purchase cost was influenced by our decision to deploy Windows Terminals. Windows Terminals require bigger and/or more servers and include greater licensing costs. A Pure NC environment would dramatically reduce the server and license costs.

The same price today can purchase a much more powerful dual processor Pentium PC with a large hard disk. There is in fact no real up front saving, but hopefully costs will fall as NCs become more popular and more units are sold.  Savings are expected from lower maintenance, reduced desktop support and lower upgrade costs.

## 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 could be upgraded with more memory and load sharing software and added to the pool of student servers. If necessary, the fifth server reserved for user authentication and logins could be coopted to share the load. An additional 4Mb of memory can be added to some of the NCs to allow them to run as a NC with a native Netscape browser, native Telnet and TN3270 applications. This would remove the application load of these terminals from the servers. So, we believed that we minimised the risk of poor performance, and apart from some early problems mentioned below, performance has proved to be quite satisfactory.

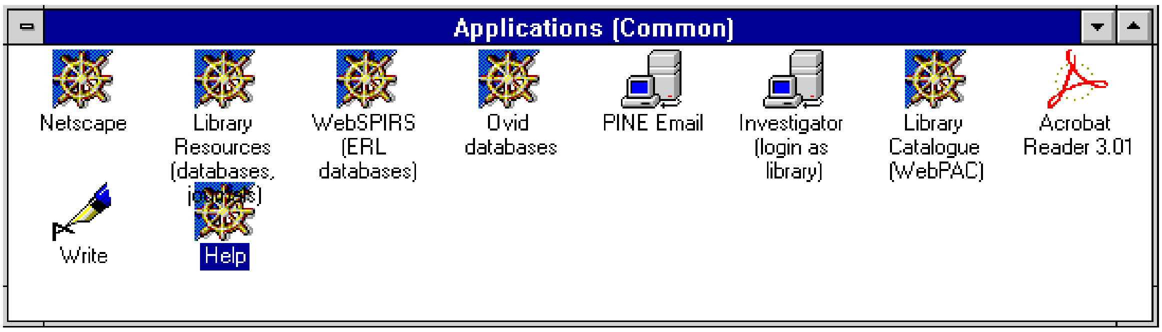
## User Authentication

The original plan was to implement user authentication on the 5th server following the model used by the IST department.  Information for each enrolled student would be downloaded from the ILMS system nightly to create individual user accounts, and students would login using Unix NIS for authentication to the pool of WinDD servers.  This has not yet been implemented because plans were announced to establish a campus wide authentication system that would fulfil this function.

Instead, we set up a manageable number of shared user accounts.  Students obtained their user name and password from a customised option on the Library OPAC.  Students enter their library barcode and phone number and a user name and password are given to authorised users.  Passwords are changed on the 1st of each month to restrict use to currently enrolled students.

## Applications Deployed

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 system, eg. printing and saving to disk.
(http://www.lib.flinders.edu.au/resources/nc-faq)

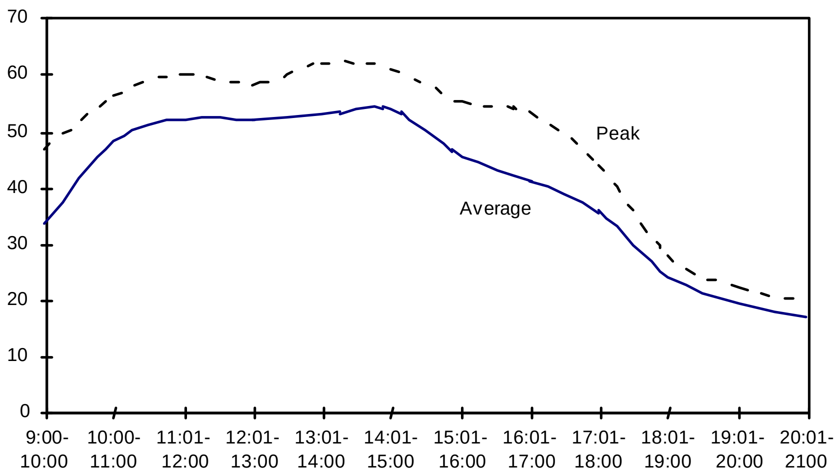



This initial suite of applications was chosen because none are particularly processor intensive. They were not expected to cause performance problems on the servers.

Printing facilities were initially limited to downloading to floppy disk and printing at a stand-alone print workstation.  A network printing solution was implemented when further funding became available.

## Use

So far, the WTs have proved enormously popular with almost all machines in use during peak periods, which tends to span early morning to early evening.  The graph below shows average and peak concurrent users within the Central Library (2 servers, 66  WTs).




*Number of concurrent users - Central Library*
*Data averaged 17 - 25/8/1999*

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 98, the average number of login sessions was over 5,000 per week with more than 800 logins per weekday.  One year later demand for services has increased to an average of over 9,000 login sessions per week, with more than 1,500 logins per weekday.

## 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, let alone Citrix WinFrame or WinDD.  We have experienced several problems which prospective implementers might like to note.

Initially, all users' home directories were stored on one of the WinDD servers.  No matter what server you logged in to, your user directory was available.  With this configuration we experienced licensing problems.  The licensing was initially installed in per server mode (concurrent users on each server).  In this mode each login consumed two NT licenses, one for the login and one for the sharing of the user directory.  Changing to a per seat license system solved this problem.

With the licensing problems rectified the next issue was one of performance.  With more than 40 users connected, the home directory server 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 on the affected server 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 in the same location. The file sharing between the servers was disabled and an H: drive was configured on each server for home directories. 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.

The next problem we experienced was again related to licensing, every 4 - 8 hours the server would stop allowing users to log in. The license manager indicated that there were no available licenses. This was clearly not the case. This was a persistent problem that took quite a while to solve. It appeared that the Microsoft logging software was incrementing license counts as people logged in but not always releasing licenses when a user logged out. A hotfix to the software was applied which corrected a console login and logout from consuming a license. When an administrator logged in on a console, a license was used; however, this license was never released on logout. If an administrator logged in five times during a day, then 5 licenses would become unavailable. The hotfix corrected that issue but the problem continued.

Disabling the Microsoft license logging service, suggested by the vendor, had no affect. A Windows service pack was installed to correct licensing issues, among other problems. The NC Bridge software also needed an update to work with the new service pack. These changes improved the reliability of the administration tools, however, they had no affect on our licensing issues. 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 licenses."

The solution in this installation was to remove license pooling. So this we did, although pooling is quite an advantage, but the removal of license pooling had no appreciable affect on our problem. 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 100 or so logins per day. We experience a much higher rate of logins, 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, as discussed above.

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 hotfix was released;

> "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 pro-active regime to check and reset hung WinStations. We average 10-20 hung WinStations per day. By rebooting the servers overnight and checking three of four times per day, we can run a quite stable system. This situation continues to the current day.

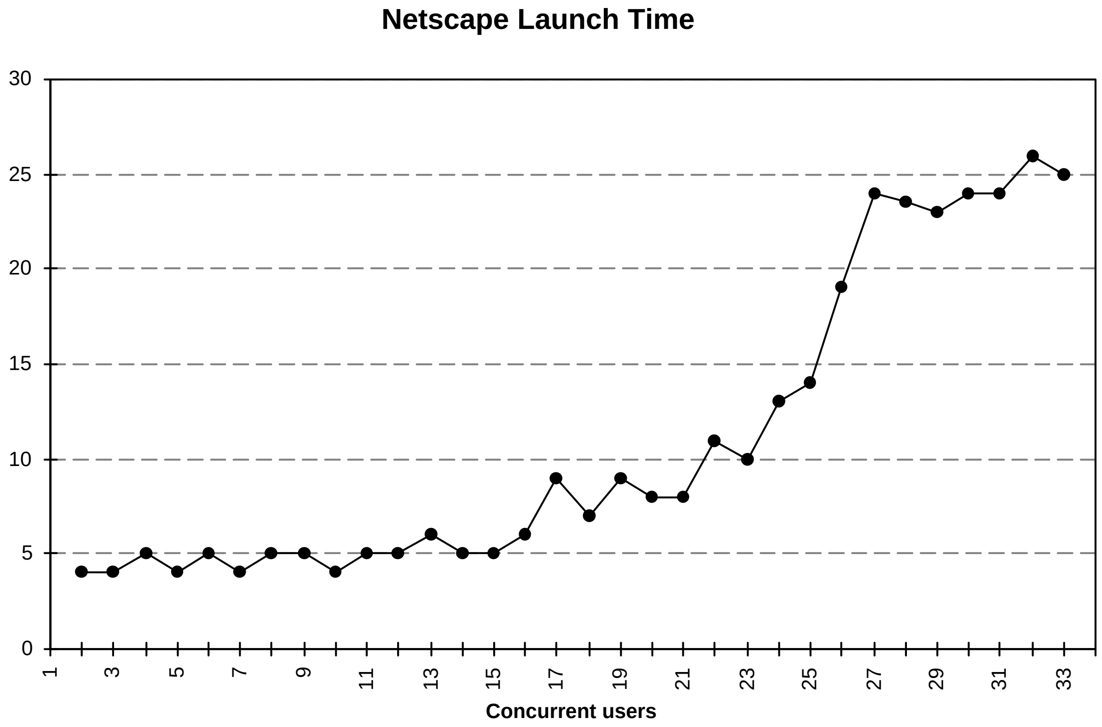
Throughout the last two years there has been a steady flow of hotfixes and Service packs to patch the operating system. Hotfixes have become available for a range of problems from severe, ("This hotfix corrects the problem where all WinFrame licenses were deleted for no apparent reason") to inconvenient in nature ("This hotfix corrects a problem when using the scheduler to shutdown the system").

Other issues we have found include problems with installing some software. For example, Netscape Navigator installs easily. However, if after installation an administrator is the first to visit a Java enabled webpage, no subsequent users can use Java. A curious problem, but easily fixed, now that we have narrowed down the cause.

We have in the timeframe of this project begun to experience upgrade needs. As Information Technology becomes ubiquitous on campus, demand for the service has increased dramatically. The demand is for more sophisticated services, Java WebPages for example.

Initially, we experienced good server performance at levels of up to 32 or 33 concurrent users per server. Now we find substantial decrease in application launch speed as the users on a server increase. When concurrent users per server are below 27 performance is quite good. Above this number of concurrent users, performance declines. The most obvious performance indicator to users is the time it takes to launch an application. At 27+ concurrent users the increase in launch time becomes quite marked. This coupled with students' expectation of "instant gratification" compounds the problem. At moderate user levels a typical Netscape session will take 4 to 6 seconds to launch. This time extends to 19 or more seconds at high usage levels. Such launch delays are unacceptable to our users, who will continually double-click on the Netscape icon until it responds. When it does respond, one finds that you have 5 to 10 instances of Netscape active for that one user. The superfluous processes then compound the application launch speed problem - a "vicious circle".

With the primary users of the system being walk-in library patrons, it is quite difficult to run training for such a non-captive and distributed audience. It is worth noting, however, that the application launch speed is the only appreciable decrease in performance. If a user has an active application, the speed of that application does not appear to differ, no matter the usage level of the server.




Our experience suggests a more conservative users/processor ratio of perhaps 10 users/processor as optimum. Fortunately our initial contingency planning can be called in to alleviate this problem. By adding memory to our training server (256Mb) and redistributing the user licenses we now run 4 servers configured with 25 users apiece. This restores respectable performance to the entire 100 terminals. The extra cost to achieve this 25% increase in capacity was only $650.

We will need to begin replacing the servers in 2000 to maintain adequate performance levels. Factors impacting on this are the migration from PINE to a web based email system for student email, and the move from dumb terminal to Java based access to the library catalogue.

## Support

Although the servers need daily intervention, detailed above, we believe that we are making support savings at the desktop. Over the life of the installation we have had no failures of desktop equipment. We have had hard disk failures in two of the servers that affected a large number of terminals at one time, (but if we knew the armoured van was going to drive through that power pole we would have shut down the servers first).

We also experienced a failure of one of the network switches. This was quite dramatic as it disabled all of the library servers, and therefore all of the WTs. However, in a PC installation, a significant number of the desktops would have shared that network switch. Even when one server is down, we do have the option of redirecting terminals to the active servers, albeit with less performance.

The NC operating system has required several upgrades over the past 2 years but each is performed once on the server, and rolled out to the desktop at the next boot. Similarly, application updates are easily accomplished. Just install once on the server and all users have immediate access to the latest version. The only down side is that with extended hours of opening and heavy reliance on the equipment set, it is difficult to find a window of opportunity to do such application installations.

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.

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 a WT environment making more resources available to the “heavy” user.

To contrast with a suite of staff PCs installed at the same time, all of the PCs have had some form of hardware failure in their life. Several have required a complete OS and software rebuild, some twice. All now require upgrades to memory. Across the suite we are already experiencing significant software version skew.

# Conclusion

So, what does it all mean? Most IT managers will agree with Briody’s (1999) claim that they “are growing tired of the complexities of new applications and the expense of the systems needed to run them”. While thin clients will not completely replace the PC, they are quite appropriate for the majority of PC users according to a Gartner Group report by Peter Lowber (Schwartz, 1999). In another Gartner Group report, Zastrocky & Austin (1998) claim “the primary benefits of network computing lie in reducing the incremental cost of delivering more services for more users more quickly - not in reducing the cost of delivering a fixed set of functions to a fixed set of users.”

If all the thin client claims are true, should we all rush out and invest in this new technology? “The ability to leverage existing desktop hardware and software is perhaps the single greatest benefit of thin-client networks. Any desktop computer capable of running a browser can participate in a thin-client network ... thin-client networking expands choices instead of limiting them” (Golick, 1999). This allows managers to experiment with a small installation, plan a phased migration and prolong the useful life of existing desktop hardware.

McNaught (1999) believes we should use the right desktop device for the right application, not necessarily the same device for all applications. Where appropriate, we need a solution that gives the power and performance of PCs without the headaches of PC desktop support. Centralised IT management of thin devices may offer the solution for many users. In judging the merits of conflicting arguments we need to weigh the following evidence in the light of our own unique environment:

| For Thin Clients | | Against Thin Clients |
|---|---|---|
| Lower TCO over time | vs | High initial cost |
| Ease of management | vs | High network dependence |
| Lower maintenance cost | vs | Specialised support staff |
| Ease of centralised backup | vs | Single point of failure |
| Longer life cycle of thin device | vs | High cost of fully redundant servers |
| Rapid deployment | vs | Immature technology |
| Common software and desktops | vs | User resistance |

If we conclude that thin clients are appropriate, we then need to consider what type of client will best meet our needs.

| Windows Terminal | | Network Computer |
|---|---|---|
| Longer life cycle of WT | vs | Lower server demand of NC |
| Low continuous network traffic of WT | vs | High burst network traffic of NC |
| High continuous server demand of WT | vs | Lower overall server demand of NC |
| High network dependence of WT | vs | Independent processing of NC |

## When to Use

Green screen replacement of dumb terminals offers an ideal opportunity to trial thin client technology with minimum risk. Legacy systems can continue to operate while thin clients are phased in. Single routine tasks or jobs with a limited range of functions are also appropriate for thin clients, eg. database maintenance, word processing, e-mail and web surfing.

"In short: if applications must be rolled out quickly, think thin. If network bandwidth is limited, think thin. If employees use a limited number of applications, think thin. If applications must be accessible by users whose desktop environments you cannot manage, think thin" (Molta, 1999a).

## When not to Use

Small enterprises will find it difficult to implement thin client technology without specialised support staff. Power users requiring high end processing for number crunching or graphic intensive applications, eg. CAD, will be better staying with high end PCs. Remote users on slow modems will experience delays downloading applications to NCs but may still benefit from the low bandwidth Windows Terminal approach.

In the final analysis "end users really do not care where process takes place, or where data is resident, as long as the interface is fast, consistent, seamless and easy to use" (Golick, 1999).

## Future

As always, the future is difficult to predict, but there are a few trends worthy of note. The ubiquitous success of the large telecom networks depends largely on the simplicity of their access device. It is cheap, disposable, easy to operate - and thin. Windows NT Terminal Server Edition will be replaced by a Terminal Services core component of Windows 2000, suggesting that Microsoft are treating the threat of thin client competitors more seriously. The inclusion of smart card readers in recently released thin client devices offers interesting possibilities for patron authentication and charging for service.

The Gartner Group has found that "enterprises that have deployed networks based on thin clients … tend to extend those installations to other parts of the enterprise." The Aberdeen Group predicts that "nearly one-third of all enterprise desktops will be a thin client of some form by the year 2002" (McNaught, 1999). Briody (1999) believes we are entering a post PC era where a variety of smaller, simpler devices are always on, always connected, as easy to use as a telephone and just as dependable. An appliance model is emerging where simple, easy to use devices access the Internet to perform limited well-defined functions.

"Thin-client networking is no longer focused on hardware, but rather on architecture - the architecture of building seamless network applications that maximize the networker's ability to manage the network while at the same time preserving the autonomy of end users to select the most suitable mix of hardware and software to meet their requirements. Networks that have been architected according to thin-client precepts will be easier to scale, offer better security and audit capabilities, and provide smoother migration paths to new technology" (Golick, 1999).

Despite the perceived advantages of thin-client networking the enormous vested interest in fat clients indicates a continuing trend in larger applications needing "larger machines, larger disk drives, larger memory, complexity upon complexity. At some point, though, all of this complexity is bound to collapse under its own weight. Don't wait for this to happen to your organization. Start planning your thin-client migration today. The end result will be an infrastructure that is easier to manage, easier to scale, boosts productivity and costs less to operate. Finally, less is truly more" (Golick, 1999).

# Bibliography


Briody, Dan. Picking the PC's new directions – at a critical juncture, the PC platform is morphing into simplified and specialized devices. *Info World*, June 21 (1999): p 34.

Brown, Ian & Banbury, John. To PC or NetPC? Hmmm ... what the heck, let's give it a go! In *Adelaide 98, pathways to knowledge.* Australian Library and Information Association 5th biennial Conference and Exhibition, October 1998, Adelaide. 99-107.

Correia, Edward J. & Forman, Preston P. Finding wisdom in 'dumb' terminals. *Computer Reseller News*, 815 (1998): 139, 142.

Golick, Jerry. Network computing in the new thin-client age. *NetWorker*, March (1999): 31-40.

Hannan, Chris. Desktop clients: is the network computer an accountant's dream or a system/network manager's nightmare? Unpublished paper presented at the VALA 98 Conference, Melbourne (1998).

Lewis, Bob. While users wait and wait, IS pushes thin clients – or are they fat networks. *Infoworld*, 21.27 (1999): 68.

McNaught, Jeff. Straight talk on thin clients. *Electronic News*, 45.29 (1999): 28.

Molta, Dave. For client/server, think thin. *Network Computing*, June 28 (1999a).

Molta, Dave. Thin-client computers come of age. *Network Computing*, May 3, (1999b): 139.

Schwartz, Jeffrey. Thin clients shed unwanted pounds. *Internet Week*, June 7 (1999): 21.

Sheehan, Mark. Thin clients and network-centric computing. *Online*, 22.6 (1998): 89-98.

Zastrocky, M. & Austin, T. *Higher-education 'cost savings' with network computing*. Online. Gartner IntraWeb Research and Advisory Services, COM-05-8318 (1998). Available: http://www.flinders.edu.au/gartner/research/ras/72200/. 31 August 1999.

## Acronyms

| | |
|---|---|
| BDC | Backup Domain Controller |
| HotFix | Patch to the Citrix WinFrame or WinDD software |
| ICA | Independent Computer Architecture |
| NC | Network Computer |
| NCBridge | NC operating system |
| NIS | Network Information Services |
| PDC | Primary Domain Controller |
| PINE | Terminal based email system, Program for Internet News and Email |
| RDP | Remote Desktop Protocol |
| TFTP | Trivial file transfer protocol |
| WinDD | Windows Distributed Desktop |
| WinFrame | Multiuser Windows-based application server software |
| WinStation | Means of connecting to a WinFrame server |
| WT | Windows Terminal |