Educational Multimedia Taskforce

SCHEMA

Initial Evaluation of System

Report on the Implementation of Network Computers

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More information about the Schema project can be found under http://www.stir.ac.uk/schema/

The publication of this package has been supported by the european commission (TEN-telecom, TSER and Leonardo da Vinci) under the Joint Call orchestrated by the Educational Multimedia Taskforce

Centre For Research and Development in Learning Technology

Project Number:	1024
Project Title:	SCHEMA; Social cohesion through Higher Education in Marginal Areas
Document Type: (PU/LI/X)*	PU

Deliverable Number:	D 2.2
Contractual Date of Delivery:	30.8.98
Title of Document:	WP2: Initial Evaluation of System
Internal Document Number:	1/98 (Stirling)
Nature of the Deliverable:	RE
Author(s):	Simon Booth
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*Type: PU–public, LI–limited, X–internal
**Nature: PR–Prototype, RE–Report, SP-Specification, TO–Tool, OT-Other

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The publication of this package has been supported by European Commission (TEN-Telecom, TSER and Leonardo da Vinci) under the Joint Call orchestrated by the Educational Multimedia Taskforce

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Executive Summary

This report details SCHEMA's trial installation of Network Computers NC™ . It reports on experiences using three different types of network connection for the Acorn NC: modem, ISDN and 10Mb Ethernet.

It also discusses the various support options for the NC server: UNIX and Microsoft NT.

Also included is a discussion of the merits of the NCs native operating environment (with built-in Browser and Word compatible word processor) against the MetaFrame approach.

The NC Reference Profile and NetPC specifications are also given.

Contents

1. Introduction

It should be clarified at the beginning of this report that it discusses both NCs in general and Acorn NCs in particular. When any NC is meant, NC will be used and when the Acorn NC is meant, Acorn NC will be used.

NCs are just like "normal" desktop PCs except that they have no local hard disk storage or local configuration. Disk store is provided on the server to which the NC connects over a network. The NC reference profile specifies that the network is TCP/IP. Configuration information (e.g. what applications this user can run or whether this user has access to the administrative functions of the NC) is controlled at the server end. Thus NCs offer two significant related benefits over traditional PCs:

- The complexities of managing the NC are entirely hidden from the user. Additional applications are mounted at the server end and made available to users (on a per user basis, if required)
- If an NC fails a replacement could be posted out to the user. There would be no requirement to install "their" configuration as it is held centrally and would be accessed by the replacement NC.

There are various mechanisms for the Acorn NC to connect to the server: modem over a POTS phone line, Integrated Digital Service Network (ISDN) or Ethernet. The main difference from the users prospective is the speed that the network technology provides.

The biggest user benefit is that the NC really is a "plug-n-play" device. For the modem/ISDN variants, all the user has to do is:

- Plug the modem lead into a suitable telephone socket
- Provide electrical power
- Connect a television set to the NC via a SCART cable (or a standard computer monitor via the VGA connector)
- Connect keyboard and mouse
- Insert smartcard and, when requested, enter a Personal Identification Number (PIN). The smartcard holds all the information required to establish the connection.

The Internet Service Provider (ISP), in this instance, does the remainder. That is, they ensure that the NC can browse the web and, optionally, access private file store. The ISP can also provide additional applications, mounted on their server, for the user to access and run. The application provided can easily be controlled on a per-user basis.

The Acorn NC comes with two applications built into ROM: a Web browser and a simple Microsoft Word compatible word processor. The browser is HTML 3.2 compliant but does not support JavaScript– this lack of JavaScript support is a problem from SCHEMA's perspective as one of the learning environments (Proto–Project Tools for Learning) we propose to use requires JavaScript. Some solutions to this problem are presented in the text.

One way that SCHEMA is planning to deploy NCs is to provide access to Windows (and Windows applications) via the MetaFrame client available for NCs. MetaFrame

from Citrix (www.citrix.com) is a software client that allows windows application run on a remote server to appear to be running on the machine running the MetaFrame client. MetaFrame clients are available for a range of architectures including the ARM 7500FE based NC. The Acorn NC is such a device. A longer discussion of the various “interface” options appears in the conclusions to this report.

The structure of this report is as follows: firstly, the various types of Acorn NC are discussed (Ethernet, ISDN, modem). This is followed by the details of the server options for the Acorn NC– UNIX or NT. Next details of the MetaFrame technology are presented. Lastly, some conclusions drawn.

2. NC Connectivity

Ethernet

Most NCs support 10base-T networking. To boot the NC uses either the bootp or DHCP protocol, broadcasting its MAC address and being allocated its IP by a suitably configured bootp or DHCP server.

For the Acorn NC, the boot files themselves are provided via the Network File System (NFS) under UNIX or shares under NT (if the Acorn NC supports NetBEUI). One restriction is that the boot files themselves must be on the same server as the bootp (in NT this is the DHCP) server. Under NT and TopCat only the boot files have this restriction, under UNIX all the files (applications, plug-ins for the browser and user's file store) must be on the bootp server. With NT, once the NC has booted the applications and user file store can be allocated on different servers– as they usually are in many organisations.

Configuration of the Ethernet Acorn NCs under UNIX and NT is discussed in the appropriate sections: "3. UNIX Server support" and "4. NT Server support".

Alternatively, the Acorn NC can be configured with a static IP address. In this instance, netmask, DNS server, gateway and NFS mount / NT share are also specified and stored in the NCs CMOS.

The Acorn Ethernet NC supports three types of login: a smartcard containing the user's details (the user enters a PIN to identify themselves to the smartcard), a traditional login where the NC requests a username and password, or "hardwired" where the NC simply starts and presents some pre-defined configuration– this could be a particular program or just the browser.

As the Ethernet NC automatically mounts NFS volumes it is straightforward to provide user file store and additional NC compliant applications from the NFS server. Providing user file store has a number of advantages. Not only does the user have the ability to save personal files, but the Web browser can use this file space to store lists of favourite web sites and cache all the recently visited sites. The biggest advantage, though, is the ability to run applications. Most applications that run on Acorn's RISC OS operating system will run on NCs if they are based on the ARM7500FE processor as Acorn's NC is– the NC reference profile does not specify a particular processor. This means that a wide range of programs are already available for the Acorn NC including DTP, word processors, spreadsheets, drawing programs and a wealth of educational software– reflecting Acorn's success in the UK education market over the last fifteen years.

ISDN

The Acorn ISDN NC supports dial-up using the standard point-to-point protocol (PPP) for a dial-up session. In this instance, the ISP provides the IP address for the NC in the normal way over PPP.

The Acorn ISDN NC supports using a smartcard to access it. The smartcard contains all the information required to establish the PPP connection and user's configuration:

- Dial-up number
- Domain Name Server(s)
- Domain Name
- Username/Password
- Welcome URL
- Personal URL
- NFS volume

The user simply identifies themselves via a PIN. The smartcard can be used in two ways:

- Establish a PPP connection and allow web browsing and access to applications in the NCs ROM (along with the browser there is also a Microsoft Word compliant word processor).
- Establish a PPP connection and mount an NFS volume. This allows access to applications held on the server along with, optionally, personal file store. Using this access mechanism, additional Acorn NC compliant applications can be provided to the user from the server.

The main advantage with ISDN from the home or remote user prospective is the performance available: 128kbps (ISDN 2) is roughly three times the performance of a 56K modem (usually these provide 42-44kbps in an asymmetric fashion, the upload speed is a maximum of 33.6Kbps). The level of performance is particularly important for SCHEMA as support for a reasonable level of video conferencing will be required in some courses. Hardware and software are already available to support video conferencing on Acorn's RISC OS and this also runs on the Acorn NC.

Modem

Like the ISDN based Acorn NC, the modem version supports smartcard access and supports exactly the same range of features. The only difference is the performance available to the end user. In the UK this is likely to be the popular choice for home users due to the high cost of ISDN telephony. In December 1998, the rental for home ISDN connectivity is three times that of a standard telephone line and as two calls are made call costs double.

At present, the fastest modem available for use with Acorn NC is 33.6 kbps. This is insufficient for full screen video conferencing applications, but more then sufficient for MetaFrame based Windows sessions or the use of applications specifically written for the NC or RISC OS– RISC OS applications tend to be reasonably small (<1M) and so can be relatively quickly downloaded to the NC. Once downloaded they can be left running on the NC to avoid downloading again. The only time these applications are lost from the OS on the NC is when they are closed down or the NC is powered-down. Normally when ending a session on the NC the machine is placed in standby mode and is not powered down.

The modem-based solution is probably sufficient for SCHEMA's needs.

Summary

Of the Acorn NC types discussed so far only the Ethernet variant could not easily be deployed in the domestic environment– with Ethernet, the whole set up assumes familiarity with IP networking and the Ethernet machine makes no sense in the domestic environment. Both the ISDN and modem variants are suitable for home use. Both have the same requirements:

- Suitable telephone connection
- Power
- Display device (TV or computer monitor)

There is no configuartion on the users part as the user is supplied with a suitably configured smartcard. To connect to the network, the user simply inserts the smartcard and enters (when requested) their PIN.

Once the network connection is established all three types of Acorn NC behave pretty much the same except for access speeds. There are some exceptions to this rule with the Ethernet NC– see “4. NT Server support”.

3. UNIX Server support

Acorn's NC support pack is not a commercial product and has some rough edges. Nevertheless it does work and provides an excellent environment to support NCs. The pack is intended to support the Acorn Ethernet NC, but can be used with both dial-in variants.

Configuration is simple. The steps are given below:

- Unpack distribution
- Set correct access permissions for NC support files
- Configure bootp
- Configure NFS
- Configure PCNFS
- Define NC username(s) and password
- Connect up and switch on NC

When familiar with the process it takes about twenty minutes from start to finish. The UNIX support pack is UNIX generic and should work with any flavour of UNIX as long as the UNIX can support all the necessary services listed above. The support pack is UNIX generic because the UNIX server does not actually run any code on behalf on the NC, it simply makes the code available to the NC over NFS.

The UNIX selected at Stirling was Linux as this can be downloaded freely from the Internet or purchased for approximately 60ECU (which obtains a CD, installation manual and thirty days support). In Oulu, Solaris was employed with few problems. A second reason Linux was selected is that it runs on quite lightweight hardware– sometimes referred to "trailing" edge. The initial installation at Stirling was achieved using a 486DX2/66 with a 325Mb hard disk and 32Mb RAM plus 10Mbps network card. A second hard disk has been added as the initial installation virtual fills 325Mb (leaving out X-Windows would make this installation considerably smaller). The processor has also been upgraded to facilitate Linux kernel re-builds– certain additional hardware support in Linux requires complete kernel re-builds and this is time-consuming process. A good basic configuration to support Acorn NCs under Linux is 486DX2/66, >500Mb hard disk and 32Mb RAM plus 10Mbps network card. Such machines can be sourced in the UK for as little as 200ECU.

The UNIX support pack provides for three types of start up for Ethernet connected Acorn NCs: login, hardware and smartcard. We have employed the "normal" login method where the NC, once it has finished booting, presents a login screen. A user with a suitable username and password can then logon and use the NC's browser. From this browser interface, web access is available. Additional applications can also be accessed, if configured.

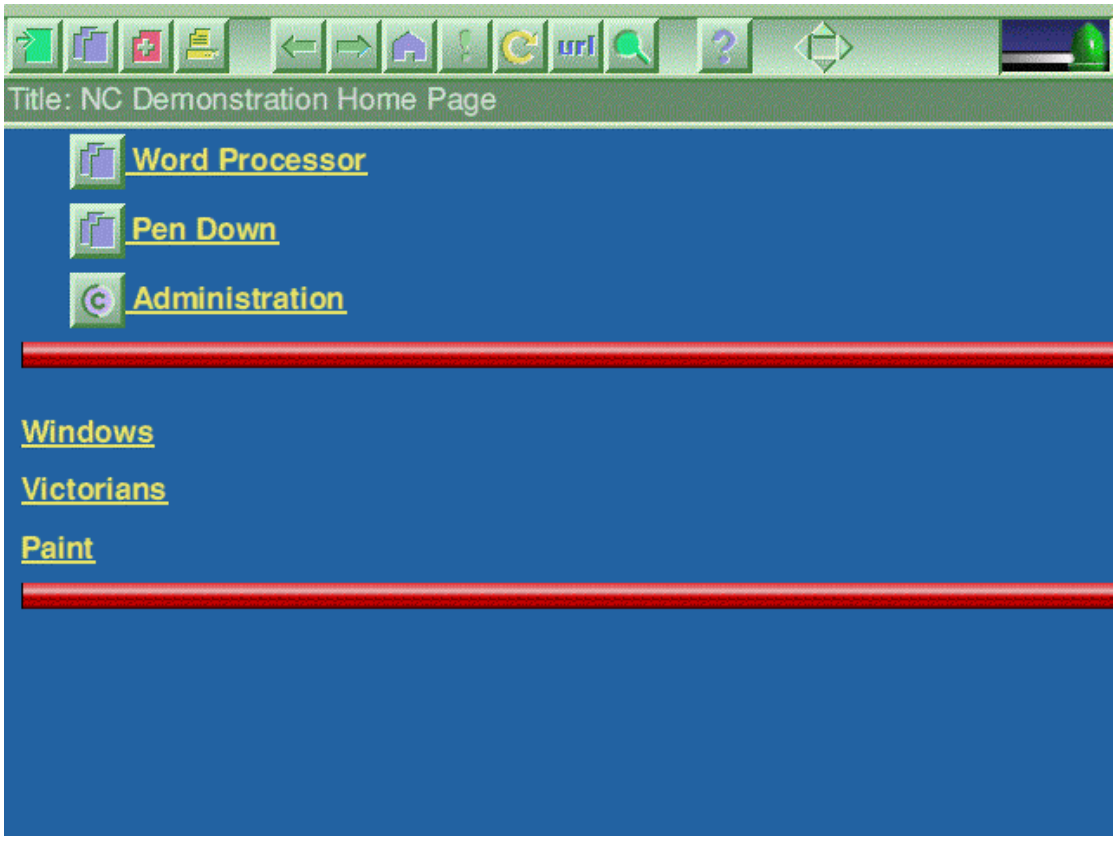

Figure 1: Standard NC Interface

Note the links to the additional applications. These can easily be controlled on a per-user basis.

The hardwire mechanism can be used to start a particular application (including the web browser in which case it is the same as above but with out authentication). The final access mechanism, smartcard would probably be used in conjunction with the method described above with the smartcard providing authentication. Within SCHEMA we have not evaluated this mechanism.

An ISDN Network

The UNIX support pack used in conjunction with Linux provides an inexpensive way to support small networks of Acorn NCs. SCHEMA has built an exemplar of this type of network for use in either schools or SME's. To test the usability of such a configuration, we plan to deploy such a network in three local primary schools. This is also a mechanism that can employed in the UK or elsewhere to alleviate the high cost of ISDN connectivity by sharing the cost of the single ISDN connection between the network of Acorn NCs.

The ISDN connection is made from the server using one of the many ISDN cards supported under Linux. The Linux server uses the ISDN card to establish an Internet connection using any mechanism that supports IP over the link. The Linux server then acts as a router between the two network interfaces it has: ISDN and Ethernet. As the ISDN line connects almost instantly, this ISDN interface can be configured to connect on demand. Thus when the users request access to the Internet by entering a

URL in the web browser, the ISDN line automatically connects and the data associated with the URL is downloaded.

To minimise the amount of traffic travelling over the ISDN line and thus the costs associated with accessing the Internet, a proxy server can be installed on the Linux server as the Acorn NC can be configured to use a proxy server. The httpd server we have employed for this purpose is Apache. The Apache server is included in the RedHat Linux distribution and is available at no cost for most operating systems.

Having a web server installed on the server has another advantage: certain administrative functions can be exposed to the users via web forms controlling CGI scripts. We have found a mechanism to enable CGI scripts to control "root" level programs using Apache. Consequently basic administration, if required, can be performed by a designed user (such scripts can be username/password protected). Other administration can be performed remotely using telnet or other remote access mechanisms.

We see this type of small NC network, based on an inexpensive but reliable server as a simple way to provide access to the Internet at low-cost over an ISDN or even a modem connection. Additional NC compliant applications can be mounted on the server to provide users with further useful tools. The NC network at Stirling is configured as described above, except that Internet access is provided via the network at the University. It has proved very reliable, requiring only a single reboot since March.

This provides Internet access at much lower cost than purchasing the equivalent number of PCs. It is also easier to manage, especially as the most likely point of failure is the UNIX server and this can, as stated above, be managed remotely.

Even if PC applications are required, it is possible to provide this via MetaFrame– see "5. MetaFrame". The deployment of MetaFrame does alter the economics as an NT server is required and the MetaFrame software must be licensed.

4. NT Server support

At first glance, NT appears ill suited to support the NC. Its method of sharing files is different from NFS and so the NC cannot connect to the file shares to access its boot files. Also, until NT server 4.0 SP2 (service pack 2), NT did not support the bootp protocol natively. Third party bootp support was and remains available. It is also possible to support NFS as a number of third parties provide both NFS servers and clients, notably Intergraph. Microsoft are including the Intergraph client and server in the Services For UNIX (SFU) add on for NT which is currently in Beta. Thus it is possible to use the UNIX support pack with NT but additional software is required.

An early release of an Acorn NT support pack was made available to SCHEMA. This combined with the Intergraph NFS server and NT server 4.0 SP3 provided an environment that almost worked but could not be run reliably. As a result, the NT approach was placed on hold, pending a solution being supplied.

Acorn have been working with a third party to provide a support pack for NT that offers a richer solution than the situation described above. This is now a commercial product called "TopCat" (developed by Microlynx). This product uses native NT protocols for file share access and offers an environment for the NC that is virtually indistinguishable from Acorn's standard desktop operating environment: RISC OS.

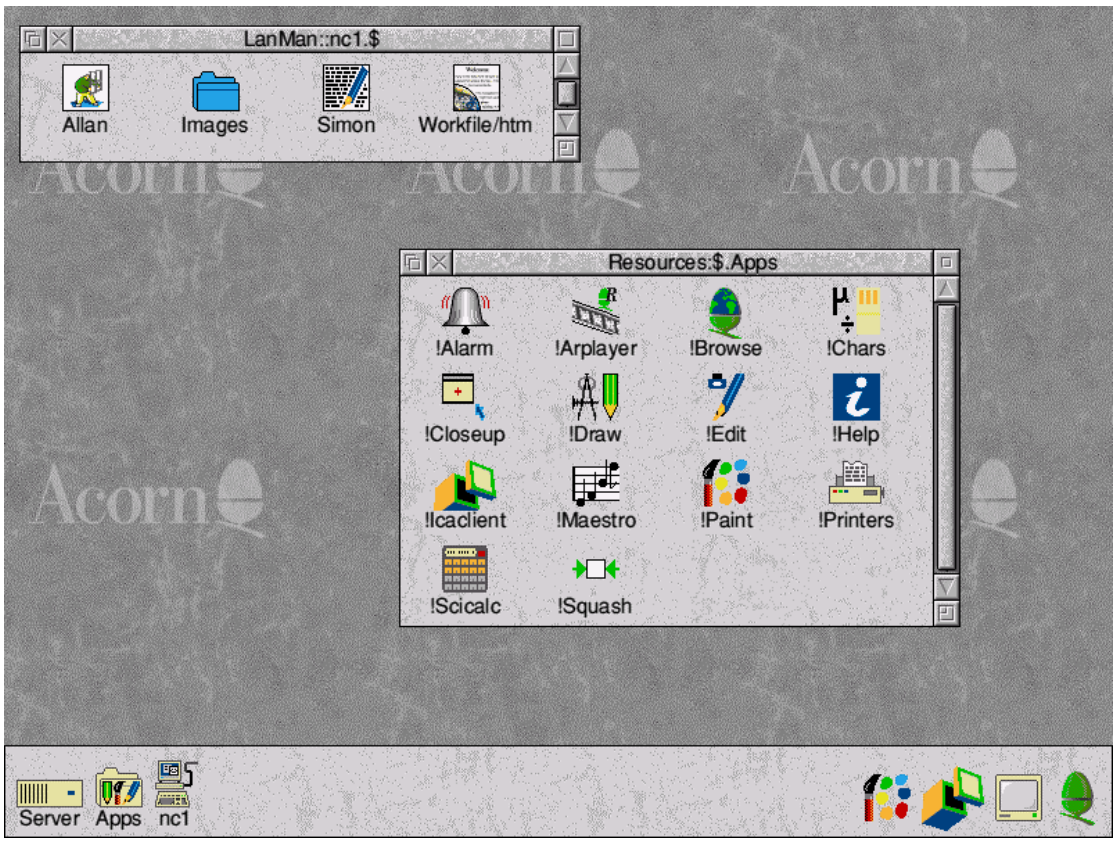

Figure 2: RISC OS Interface

TopCat solution is not based on open standards; it uses propriety network protocols (NetBEUI) and file access mechanism (Server Message Block– SMB) and a propriety operating system (there are many suppliers of UNIX but only Microsoft provide NT).

It nevertheless does have attractions, TopCat provides an environment that supports applications written for Acorn's RISC OS. The UNIX pack supports RISC OS applications but many more will run with TopCat because it provides an environment much closer to RISC OS– for instance, the standard file saving mechanism works with TopCat– it does not with the UNIX package.

RISC OS has been very successful in the UK education market and there is a wealth of software available for this OS– word processors, spreadsheets, Web browsers, Email clients and servers, DTP packages and many others. The main drawback is that at present TopCat only works with the Ethernet variant of the Acorn NC. Neither the modem or ISDN variants of the NC include support for NetBEUI; indeed only recent Ethernet machines include the necessary support.

NT and TopCat does solve the JavaScript problem of the built-in browser as browsers are available for RISC OS that support JavaScript (eg WebSterXL). TopCat does include a different browser itself, Acorn's Fresco (on which t he NC browser is based) but this does not support JavaScript at present. TopCat also includes a number if RISC applications: ICA client, Draw, Edit and several others.

5. MetaFrame

Citrix systems have developed over the past few years a way to run Windows applications on non-PC computers. The technology has been through a number of name changes and is currently referred to as MetaFrame (sometimes also called WinFrame) . Usually Winframe can be taken to relate to NT 3.51 and MetaFrame to NT4.0.

MetaFrame is means of providing a multi-user version of NT. What is meant here by "multi-user" is where the users are all running applications on the NT server itself and not their desktop computer. Their desktop computer acts as a display device for the Windows session running on the NT server– in many respects MetaFrame represents a return to the mainframe/dumb-terminal style of computing. This enables the type of configuration shown below:

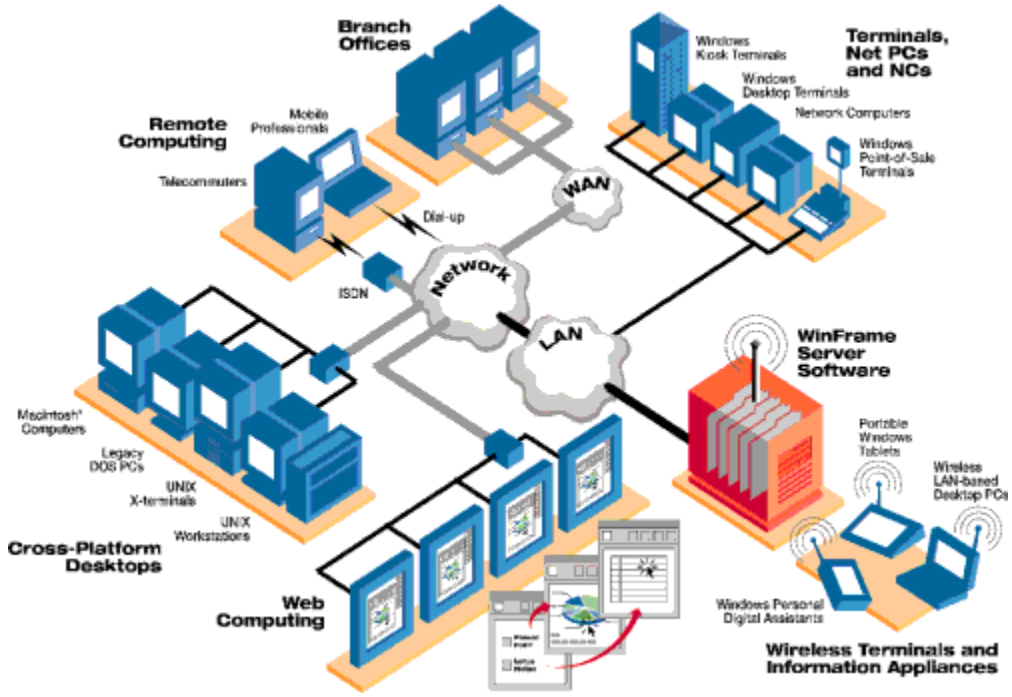

Figure 3: MetaFame Server (Citrix©)

The mechanism that supports this style of working is the Independent Computing Architecture (ICA). This consists of three parts: a server component, a network protocol component, and a client software component. On the server, ICA separates the application logic from the user interface. The user interface information is then transported over whatever standard network protocol is in use (IPX, SPX, NetBEUI, TCP/IP and PPP). Finally the client software presents the user interface (whilst the application itself executes on the server). The figure below shows this:

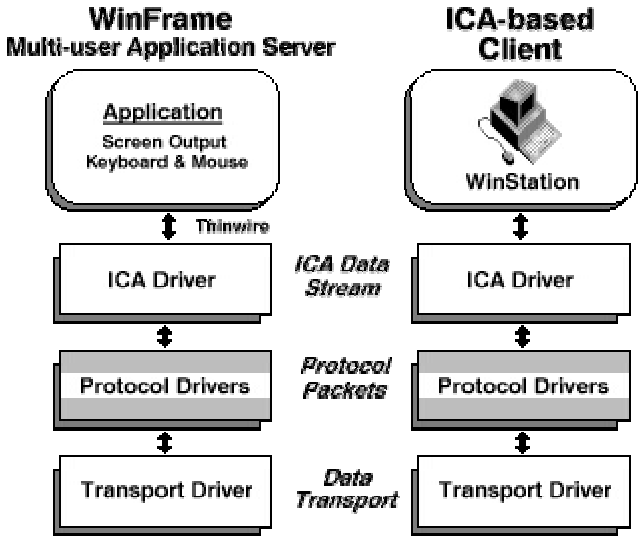

Figure 4: ICA (Citrix©)

The ICA network protocol transports keystrokes, mouse clicks and screen updates (messages) over the network to and from the client computer consuming less than 20kbps. Experiments done within SCHEMA with five devices connected to the MetaFrame server showed that less than 5% of the 10Mbps Ethernet was being used to support the sessions on the different clients. This remained true even under the worst conditions for ICA: when bitmaps updates (the splash screens at the beginning of Microsoft Office applications are examples) are being transported– these require that the whole bitmap be moved over the network and not just the Windows messages describing the screen.

ICA clients are available for DOS PCs, Windows 3-3.11 (allowing Windows 95 applications to be accessed), Windows 95, 98 and NT, Macintosh, Windows CE devices, some flavours of UNIX and, most importantly for SCHEMA, ARM 7500FE based NCs. Acorn have drawn up a specification for an ICA based NC called the "DeskLite". This is a specialised NC with the ICA client built into the ROM. Boca Research currently manufacture a modem based NC to this specification– it is presently only available in the United States.

MetaFrame provides a way to run Windows applications on modem, ISDN or Ethernet connected NCs. This scenario fits with SCHEMA's view that the user should be provided with a simple to use and maintain computing device. This is because users do not have to configure the Windows environment for themselves; this will be done by the network administrator on their behalf.

The benefit of this approach is that SCHEMA can exploit the huge base of Windows based multimedia courseware and solve the problems presented by the lack of JavaScript support in the current NC browser. We can use whichever Windows based browser we feel at the time is best, be it IE 4 or Netscape 4 or later versions of these.

Server Specification

The server specifications to support MetaFrame are quite lightweight considering that the server executes the applications on behalf of the user. The two examples below are taken from Kanter (1998):

Server to support 20 concurrent typical users, 16-bit applications:

200Mhz Pentium Pro
2-GB SCSI Harddisk
128Mb of RAM
256Mb Pagefile

Server to support 80 concurrent power users, 32-bit applications
4x200Mhz Pentium Pro
4-GB RAID-5 Harddisk array
512Mb RAM
1024Mb Pagefile

Typical users run only one or two applications with only one active at any given time. Power users often run three or more active applications at once. There is also a difference between 16/32-bit applications. 16-bit applications require their own memory space whereas 32-bit applications use the same memory space apart from their data– it is much more efficient to run 32-bit applications under MataFrame.

SCHEMA experimented with five typical users running 32-bit applications connected to:

100Mhz Pentium
500Mb Harddisk
64Mb RAM
48Mb Pagefile

The performance was just acceptable from such a server but for real use we plan to use:

2x233Mhz Pentuim II
12Gb Harddisks (2GB SCSI, 10GB EIDE)
192Mb RAM
256Mb Pagefile

We expect no more than fifteen concurrent users and on this basis should be able to offer a end-user performance virtually indistinguishable from that running a reasonably-specified PC (and without the administrative overheads involved)

Problems

The main problem with the MetaFrame approach is that not all Windows applications run under it. To support MetaFrame requires modification of the NT kernel– consequently the version of NT is differentiated from standard NT server by having a different kernel. The name given to the new version of NT server is Windows Terminal Server (WTS). Fortunately, the vast majority of applications do run. Within SCHEMA, all the applications we tested worked (Microsoft Office 95, Netscape 4, IE 4.0).

As mentioned previously, 16-bit (DOS, Windows 3.0-3.11) applications place a larger memory burden on the WTS machine than 32-bit applications. With 5 users running a 16-bit application, 5 copies of that application have to be held in memory as each runs in its own space; with 5 users running a 32-bit application, a single copy of the applications logic is required in the server's memory, with each user having their own data space on the server.

Users are accessing the server itself (just like a traditional mainframe) and so care must be taken when setting up the machine to ensure that the users cannot harm the server– either accidentally or maliciously.

6. Conclusions

The primary reason behind the choice of NC technology within SCHEMA was an agreement with Larry Ellison's view that PCs are too complex to work in a domestic environment. Despite the efforts of Apple, Microsoft and others, personal computers remain difficult to use for many people, and are certainly too difficult to fix when something goes wrong. The NC was designed to solve this problem. It really is a "plug-n-play" device like a television or toaster.

SCHEMA's target market of user's working in the fields of Health, Education and Welfare display a resistance to using computer technology. We believe that by delivering a genuinely simple-to-use and maintain technology we will encourage more of our target users to enjoy what we believe are the benefits technology can bring.

The NC achieves its ease-of-use and maintenance by shifting the responsibility for its management to a third party– usually whoever is running the server that the NC uses for file store. With a traditional PC or Macintosh all the management issues have to handled by the local user– installing new software being the primary example (but backup is also important and most home users solve this by not doing it!) If any thing goes wrong with an installation on a conventional PC then again the local user has to resolve the problem. Whilst the NC user does lose the freedom to install any application they might want, (unless they can get the agreement of the system administrator) they gain the benefits that with a "closed" environment all the applications they require will be provided. Thus SCHEMA will never need to get our users to download and install application "x" or browser plug-in "y". If these are required we will add on the server and give the user access to them; consequently, we can easily add plug-ins or applications halfway through a course, if we wish.

The NC user also gains another benefit if anything does go wrong with their NC. If a traditional PC fails then a full replacement requires not only new hardware but the reinstallation all the software. This may require considerable and in any case the users personal work is likely be lost if the harddisk has failed (assuming that the user had neglected to keep backups in a safe place). With the NC, a replacement device is simply sent out, the user plugs it in and reconnects to the network and gains access to all the applications he or she had access to before as well as to all the material they had created.

Interfaces

SCHEMA can configure the NC in a number of ways.

- Basic Interface– Browser and built-in word processor
- Enhanced Interface– as above but with additional applications
- RISC OS (Ethernet)
- MetaFrame– Windows NT 4.0

Each environment offers benefits and drawbacks

Basic Interface

This consists of the just the browser and word processor built into the NC's ROM. This allows the web to be accessed and documents created and stored. Whilst this is very simple to use– the user either clicks on the link to start the work processor or browses the web in the usual way– as the browser presently offers no JavaScript support it cannot be used with ProTo, the main learning environment adopted in the project. A further problem is that most plug-ins are not available for the Acorn NC.

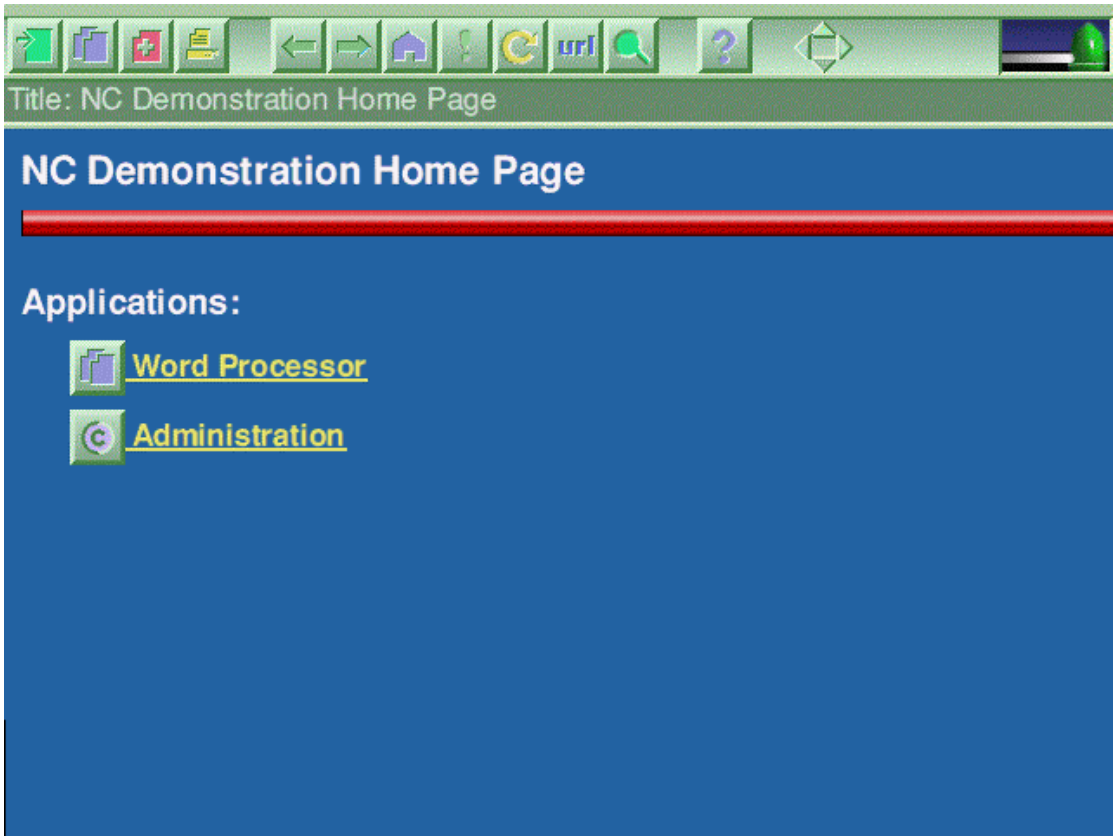

Figure 5: Basic Interface

The browser itself provides the interface presenting the user with their "welcome" page– this page has a link to the word processing application.

Enhanced Interface

The second configuration consists of the basic interface but with additional applications. The additional applications can be a spreadsheet, drawing package, ICAClient (MetaFrame), etc. The extra applications are accessed via links placed on the welcome page. As pointed out earlier in the text the applications are usually reasonable small and can be quickly download over a modem (and once downloaded they will remain resident in the NCs memory). The drawbacks with this interface are the same as for the basic interface: no JavaScript at present and many plug-ins are not available.

RISC OS

The RISC OS configuration is likely to be most attractive to those already familiar with the RISC OS interface. This interface provides access to the largest number of RISC OS applications, including web browsers with JavaScript support. The drawbacks are that many users are not familiar with the RISC OS interface, but even more crucially this interface can at present only be delivered to Ethernet NC connecting to an NT server running the TopCat software.

MetaFrame

This is standard Windows NT4.0 on an NC. Virtually all Windows applications can be run. This access mechanism can be provided as an option in the enhanced interface or alternatively can be booted straight into, giving the users an NC that appears to all intents and purposes is a Windows machine. This solution deals with JavaScript and plug-in problems. It also works with all the NC variants as the ICA protocol is tuned to work with low-bandwidth connections.

This is an attractive configuration as users that already have PCs or Macintosh (or UNIX) machines can join the SCHEMA module on an equal footing– they do have to install the ICA client for their machine, but this is no worse than installing most browser plug-ins.

It also stays within SCHEMA's aim of providing easy-to-use computing to our users because the SCHEMA user does not have to manage Windows. All they have to do is use Windows. The installation of applications and any other Windows configuration issues are handled on the server that the user connects to. Even complications, like someone accidentally setting an option within an application that changes its behaviour can be easily handed. The server administrator has direct access to each user's configuration on the server and so can investigate and fix any problems caused by wrong settings. There is no need to attempt to fix this over the phone or physically get to the machine. This model is very similar to the NetPC

NetPC

Microsoft and Intel have also developed the NetPC concept and specification in response to the NC. It has largely similar goals but differs from the NC specification in important ways. For instance, the intention is to have a 32-bit operating system running on the NetPC. The design is targeted largely at corporations wishing to minimise the cost of maintaining, upgrading and supporting personal computers on a network. The full NetPC specification is given in the appendices.

Summary

From a technical prospective, SCHEMA's main goal is to deliver simple-to-use computing. We plan to use the NC model to do this and will use whichever of the interfaces described above suits for individual modules in the development phase of SCHEMA.

We have based our work on open standards are far as possible. The two learning environments (Proto and TELSI) are based on HTML, JavaScript and Java (although Proto does allow for the use of streaming video) and so adhere to Internet Standards. There is no standard for the interface on a computer although Windows sometime appears to be one! Bearing this in mind we see no problem with using this interface via MetaFrame (if we choose to do so) as SCHEMA's standard as this allows us to side-step issues such as that various plus-ins are not available for the NC. The use of MetaFrame means that we can deliver the Windows interface to non-Windows machines which means we can also handle issues of the non-availability of some application or plug-in on that platform. This is not to say that we are committed to Windows– the other approaches remain to be investigated with real users (specially in relation to video conferencing).

The NC provides a very robust computing environment. The main issue to be resolved and one not addressed elsewhere in this report (because it is not a technical issue) is that of cost. In particular, the cost of being online– many potential users of NCs may be put off by what they perceive as the high cost of being online. The NC can function without the network after it has booted– for instance, the word processor other application (once download) only need to access the server when saving files but the MetaFrame solution requires a permanent network connection and this may prove to be problem especially in relation to ISDN.

7. Further Reading

Blair, J.D. 1998 *Samba: Integrating UNIX and Windows.* SSC: Seattle

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Kirch, O. 1995. *Linux Network Administrator's Guide.* O'Reilly & Associates: Sebastopol

Laurie, B. and Laurie, P. 1997 *Apache: The Definite Guide.* O'Reilly & Associates: Sebastopol

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Stern, H. 1992 *Managing NFS and NIS.* O'Reilly & Associates: Sebastopol

Wall, L., Christiansen, R. & Schwartz, R.L. (1996) *Programming Perl (2nd ed).* O'Reilly & Associates: Sebastopol

Welsh, M. & Kaufman, L. 1996 *Running Linux*. O'Reilly & Associates: Sebastopol

URLs

Apache	www.apache.org
Acorn	www.acorn.com
Intergraph	www.intergraph.com
Linux	www.linux.org
Redhat Linux	www.redhat.com
Microsoft NT	www.microsoft.com/ntserver
Network Computers	www.nc.com
TopCat	www.microlynx.co.uk

Appendix A:The NC Specification

Apple, IBM, Netscape, Oracle and Sun introduced the NC Reference Profile. This gained final approval in August 1996.

The NC Reference Profile consists of a set of open standards and guidelines which form the basis of an NC. :

- The following resources guidelines:
  minimum screen resolution of 640 x 480 (VGA) or equivalent
  pointing device
  text input capability
  audio output
  persistent local storage not required
- Internet Protocol - NC devices participate in an IP-based network and will support IP as an underlying protocol. Specific hardware attachment to the network is not specified.
- The following IP-based protocols:
  TCP - the Transmission Control Protocol creates a stream-based network above IP. Secure connections, if supported, are provided by the Secure Sockets Layer (SSL).
  FTP - the File Transfer Protocol allows NC-branded devices to exchange files using the popular FTP protocol. This is required only for those NCs which implement either a local or distributed file system and support file transfer.
  Telnet - telnet is a standard client/server protocol which enables character-based terminal emulation access to remote hosts. This is required only for those NCs which support a character-based console access to remote hosts.
  NFS - Network File System supports distributed file systems for NC devices. NCs which do not implement a distributed file system need not implement this protocol.
  UDP - the User Datagram Protocol is utilized by NFS and enables end-to-end application-specific communications.
  SNMP - Simple Network Management Protocol enables NC devices to participate in a network-managed environment
  The following boot and configuration options:
- DHCP - to simplify administration and installation Dynamic Host Configuration Protocol enables an NC to boot itself over the network, to dynamically acquire an IP address and to transmit configuration information over the network.
- Bootp - enables an NC to boot over the network
- The following World Wide Web standards:
  HTML - HyperText Markup Language is the publishing format for WWW sites (including CGI).
  HTTP - HyperText Transfer Protocol allows browsers to communicate with remote Web servers and for servers to communicate with NCs.
  Java Application Environment
- the Java Virtual Machine and runtime environment

- Java class libraries
- The following mail protocols:
  SMTP - Simple Mail Transfer Protocol
  IMAP4 - Internet Message Access Protocol Version 4
  POP3 - Post Office Protocol Version 3
- The following common multimedia formats:
  JPEG
  GIF
  WAV
  AU
- Security features supported through emerging APIs
  Optional security standards:
- ISO 7816 (SmartCards)
- Europay / MasterCard / Visa specifications

Additionally, the NC Reference Profile includes recommendations for printing.

Any device carrying the NC logo must conform to the specification given above. Additional features can be added, for instance the Acorn NC does include a smartcard and the Ethernet version has support for NetBEUI and uses this type of communication to connect to Microsoft NT server when using the TopCat[1] software to provide a virtually fully functional Acorn RISC OS desktop.

[1] For further information on TopCat: www.microlynx.co.uk

Appendix B: NetPC

- Minimum 133Mhz Pentium or equivalent
- 16Mb RAM
- DHCP
- TFTP
- ACPI (Advanced Configuration and Power Interface) and software configurable
- OnNow
- WakeUp on LAN
- Sealed case
- Internal hard drive
- USB support
- Unique system ID structure
- Mouse and keyboard