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Thin-Client Solutions for K-12 Schools

A National Semiconductor White Paper

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Executive Summary

Most schools today regard integrating technology into the learning process a critical priority. Nearly every school in the country has access to the Internet (88.8 percent of public schools in 1999[1]), with the number of computers available for students and educators increasing each year. As access expands, the long-term costs for maintaining, updating, and managing technology spiral out of control. Schools need an affordable solution to today's demand for reliable, consistent access to technology for learning. This white paper examines the barriers to affordable technology for schools and reviews thin-client technology as one solution to the problem.

The idea behind thin-client computing is simple: centralize computing power, storage, applications, and data on "servers" (powerful computers) and provide users with an inexpensive "client" device that is easy to install with all maintenance and updates handled from the server. The client connects to the server through the network to process applications, access files, print, and perform services available to ordinary computers. "Fat clients" differ from thin clients in that they require substantial memory and computing power to keep up with regular updates of software. Schools invest in both the desktop computers and the network resources. Thin clients have a single point of administration and investment at the server. Other unique features of thin-client devices provide clear benefits to schools:

- Industry case studies show that thin clients require fewer staff to manage more machines, significantly reducing the Total Cost of Ownership (TCO) of technology.
- Centralized data and processing enables educators to control student access to applications and other resources. Software updates extend to every client computing device at once, eliminating version control and licensing problems by centralizing distribution from the server. Consistency of resources available on all machines improves the delivery of professional development training.
- Reliable access to applications and data from all types of clients means that teachers and students can share information seamlessly. They spend less time troubleshooting and setting up computers, leaving more time for teaching and learning.
- With processing power and storage centralized on servers, schools can leverage existing hardware, running the latest applications on the server connected to all types of computers.
- The robust thin-client design protects from viruses, lowers risk of theft, and makes backups feasible.
- Shadowing allows educators or technical support staff to control a desktop remotely to assist students or others. Because all processing is done on the server, no additional network resources are required for shadowing.

There are two basic types of thin clients: Network computers (NCs) and Windows®-based terminals (WBTs). This paper focuses on Windows-based thin-client solutions for schools because they build on the existing infrastructure, software investments, by incorporating legacy equipment such as existing computers, wiring, network equipment, etc. to provide a standard solution for all desktops in the school.[2]

1) QED's Internet Usage in Public Schools 1999, 4th Edition.

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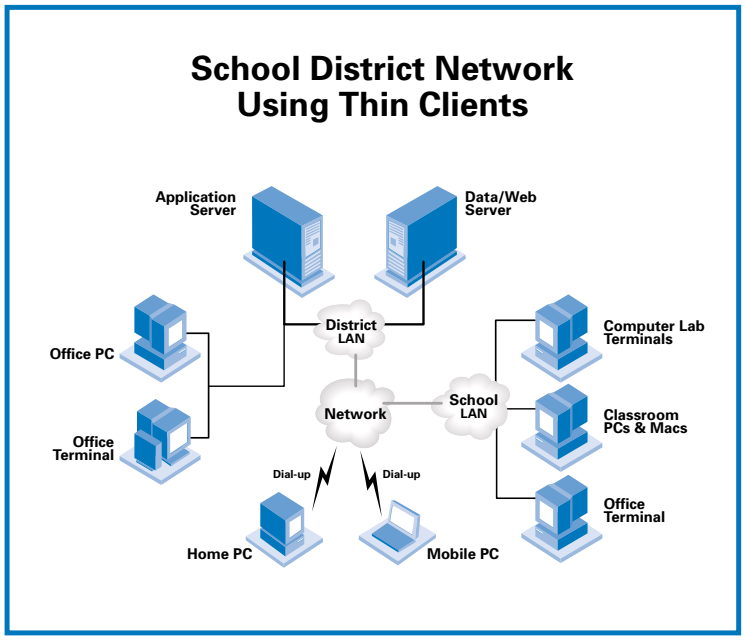
Thin Clients: A New Horizon on the Desktop

A thin-client computing environment consists of an **application server**, a network, and thin-client devices. The workhorse of the setup is the application server, a powerful computer (or computers) running two essential applications: Microsoft® Windows NT server 4.0, Terminal Server Edition, or Terminal Services in Windows 2000, and Citrix® MetaFrame™, using the thin-client protocol based on Independent Computing Architecture (ICA®). The **network infrastructure** is the pipeline between the server and the client. Thin clients use standard Ethernet or telephone networks and can run in addition to or instead of other computing devices. Any user device connected via the thin-client protocol is a **thin client**. A computer can function as *both* a traditional desktop machine and a thin client, allowing flexibility with CD-ROM and floppy drive access.



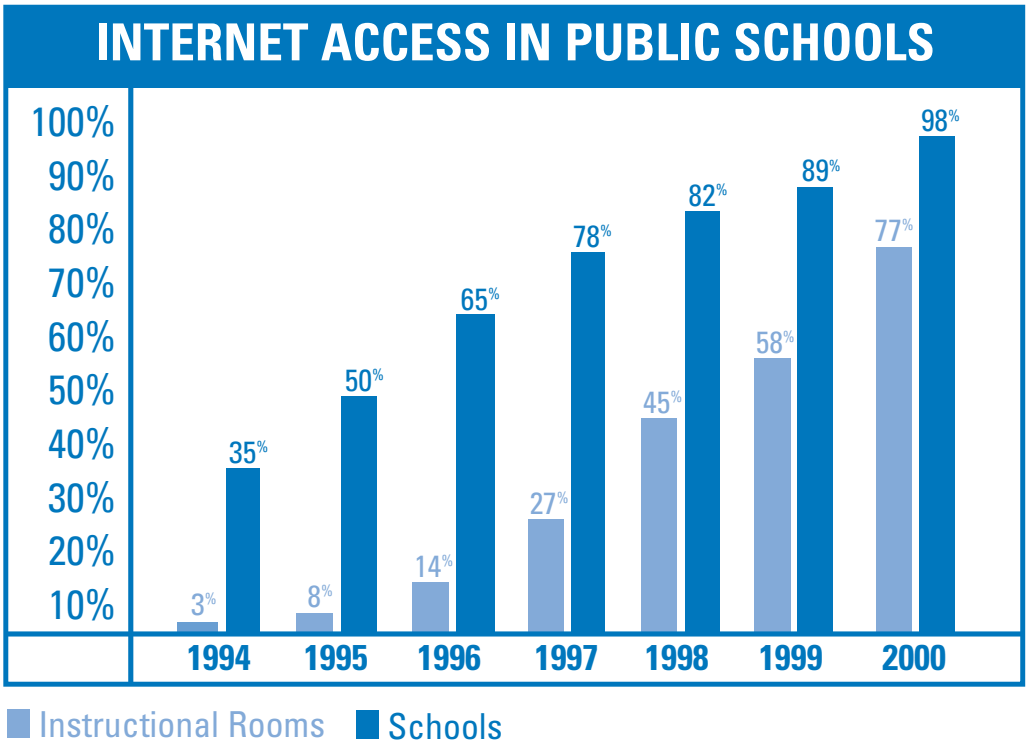
Certain devices are optimized for the thin-client protocol and provide the greatest cost savings. They are smaller than typical desktop computers (about the size of a textbook) and contain fewer parts: a microprocessor capable of processing graphics, network interface capability, a video subsystem, and enough memory (about 8 MB) to run the software to connect to the server. They do not need a hard drive, floppy drive, or CD-ROM drive. A sealed case design without open slots provides additional security. These optimized devices last longer, use less energy, and upgrades can be downloaded from a manufacturer's web site. Most productivity software such as word processing, spreadsheet, Internet browser, and e-mail applications will run on thin-client servers, providing access to the latest versions from every thin client. When software companies web-enable or optimize their graphic-intensive educational programs for network use, they too will work well on thin clients.

An alternative to purchasing and supporting the server and applications is to employ the services of an **Application Service Provider** (ASP). For an annual fee per user, the school can subscribe to a variety of software applications (instructional and productivity) and educational content resources through the ASP. The ASP owns, tests, upgrades, and maintains software applications and server equipment. The ASP centralizes the cost and complexity of managing and delivering applications and serves those applications over secure Internet connections to classroom and school computers. Costs are fixed at an annual service rate and lower than a more traditional computing environment, and there is less initial investment in on-site servers.

2) Zona Research and the GartnerGroup have shown this through studies of multiple firms. Federal Express and National Semiconductor also have published case studies.

Budgeting for Technology

An administrator's first question about new technology is usually "how much will this cost?" The second one is "how does it fit with what I already have?" A third question should be asked as well: "who will support it?" The current model of individually supported desktop computers is not scalable from a computer lab to many classrooms. Most school districts lack the financial and human resources to provide such support, yet they are well on their way to needing it. Almost every school has Internet access, and the number of networked classrooms is rapidly rising.

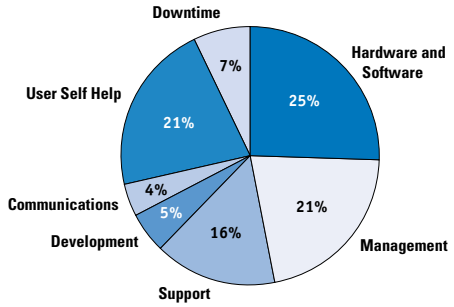


Source: QED's Internet Usage in Public Schools 1999, 4th Edition. Data from QED Research & U.S. Dept. of Education figures for 1994 and 1995 Instructional Rooms.

As schools expand, access from a computer lab supported by a technology coordinator or special instructor to computers in every classroom at a ratio of four students per device, the cost for support and training will skyrocket. A total cost analysis for technology will come as a surprise for many organizations. First, most school districts only provide support for the initial setup. Teachers either spend their own time managing computers, students provide volunteer support, or when problems arise, computers go unused. Second, most classrooms have few, if any, networkable computers in them. For years, the computer lab managers have felt overburdened by the task of keeping computers running, and they are the true believers in technology. When problems arise in the average classroom, educators may become frustrated or discouraged with technology, abandoning their plans and returning to more conventional teaching methods. Rather than add more staff to support increased technology, schools can take advantage of technologies that reduce the number of hours it takes to support each machine and improve reliability.

Most educational technology budgets only address the cost of hardware and software acquisition, about 25 percent of the actual lifetime cost of technology. The true cost of technology over a five-year period typically breaks down like this:

SCHOOL DISTRICT TECHNOLOGY COSTS



Source: http://www.microsoft.com/education/k12/technical/solution/tco/, 1999, p. 1.

Many organizations neglect to factor in management, support, development and planning, communication network costs, and lost productivity (user self help). Although instructional technology spending is on the rise in U.S. schools, the low percentage of total spending reported for support and training suggests that schools haven't factored in the real costs of current support and will be unprepared to support classroom computers.

These hidden cost issues were first recognized in corporations and resulted in studies of the Total Cost of Ownership (TCO) of technology. Zona Research estimates that organizations can save 57 percent of their system administration cost over five years with a thin-client solution vs. a traditional computing approach.[3] Thin clients reduce maintenance, simplify upgrades, and improve security. The cost advantages occur in the following areas:

- As older, less reliable desktop computers are retired, they are replaced with low-maintenance thin clients.
- Installation of thin-client devices is a matter of plugging them in—no need to install software, change settings, or add hardware such as memory or Ethernet cards.
- Fewer staff can support far more clients in a thin-client environment.
- Thin clients require fewer upgrades and can be upgraded remotely without touching each device or opening the case to install new hardware.
- With fewer moving parts and no open slots, the device itself lasts at least twice as long as a typical PC.
- Reliable computing devices with a consistent look and feel will encourage more educators and staff to integrate them into their curriculum and daily work.

INSTRUCTIONAL TECHNOLOGY SPENDING BY US SCHOOL DISTRICTS
(AVERAGE DOLLARS PER STUDENT)

Category	1997-98	100%	1998-99	100%	1999-00	100%
Hardware	$58.48	50%	$59.39	40.3%	$48.86	35.3%
Software	$11.34	10%	$11.39	7.7%	$12.10	8.7%
Supplies	$5.00	4%	$5.30	3.6%	$5.58	4.0%
Training	$6.66	6%	$11.70	7.9%	$11.85	8.6%
Service/Support	$5.85	5%	$12.20	8.3%	$12.26	8.9%
Internet	$2.34	2%	$11.03	7.5%	$7.52	5.4%
Networks	$24.31	21%	$29.11	19.7%	$29.76	21.5%
Other	$2.64	2%	$7.36	5.0%	$10.55	7.6%
Total	**$116.62**		**$147.48**		**$138.48**	

Source for 1997-98 data: Rebecca Quick, "Paying the Price," *Wall Street Journal*, Nov. 17, 1997, p. R4. Source for 1998-2000 data: 1999 QED's 1999-00 Technology Purchasing Forecast (preliminary).

3) "Desktop Clients: A Cost of Ownership Study," Zona Research, Inc., 1996, p. 5.

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- With regular backups of servers, all data is recoverable and secure.
- Travel expenses and travel time of support staff are essentially eliminated through the use of remote management tools, shadowing, and local server maintenance.
- Software costs can be reduced through site licensing, concurrent licensing, and standardization. Consistency of resources available at all machines simplifies professional development training. Usage can be tracked to determine whether applications should be upgraded or eliminated.
- Because thin clients are more reliable, users experience less downtime and self-administration.

A thin-client environment helps an organization rein in costs and keep them under control. Users at every site have equal access to applications regardless of their equipment. By switching to thin clients and lowering the cost of technology, a school district could correct inequities caused by site-based spending. To further control costs, an ASP offers a predetermined expense for maintenance, support, upgrades, and new software costs through subscription fees.

Reliable Tools for Teaching

Budgets are only one of the barriers to technology integration. With the patchwork of software and hardware in today's classrooms, teachers have to be experts in multiple platforms, various versions of software, and spend time troubleshooting problems rather than planning lessons or assisting students. Thin clients can provide equal access to all teachers and students, eliminating substandard machines and outdated software from the network. Increasingly, school districts have adopted network software for assessment and student records; the patchwork of networks needs to be affordably updated to handle confidential student records and link school personnel seamlessly.

Centralized Power, Access Everywhere

To the person using the device, thin clients look and act like ordinary computers, but they are less expensive, faster, more durable, and easier to maintain. The system administrator updates and maintains the clients by managing the server and its resources. New applications and upgrades are loaded only once onto the server, and they become instantly available on all devices, regardless of age, platform, or hardware configuration. There is no need to touch the desktop devices or track software licenses loaded on individual machines, because only key strokes, mouse clicks, and screen images travel the network. Thin clients use less bandwidth than fat clients that send files and more complex communications to the server.

Reliability and Consistency

The general trend in the computing industry is toward networking to manage applications and resources through log-ins and permissions. This approach reduces maintenance on individual machines and can be used to create a consistent look and feel for users. Thin clients take this idea to the next level—all of the computing power and data is stored on the server rather than doubled in the servers as well as the individual machines. When a teacher or student "logs in," the server provides them with their "desktop configuration." They see only the applications they need, and the system administrator controls the settings for a consistent look and feel. It no longer matters which thin client is used or who used the device during a previous session. Users can even access their "desktop" from home or other remote locations. A sick student could stay caught up with class or parents can connect with a teacher. These more reliable machines require less troubleshooting and essentially no set up, leaving more time for teaching and

learning. Because the server handles all application processing and memory demands, almost any computer can function as a thin client. Schools can connect 286 PCs and higher, or even with Macintosh® LCIIIs (68030) and higher, to the thin-client network and run up-to-date software.

Certain devices are designed specifically to be thin clients, and these "native" thin-client hardware devices offer particular advantages. They cost less because they do not need a hard disk or require much memory (RAM). The small, sealed case design contains few, if any, moveable parts that can break down, and no vulnerable openings such as floppy drives or CD-ROM drives. An optimized thin client will function without failure significantly longer than a typical computer.[4] A hybrid computing solution with a mix of fat and thin clients will give schools consistency with flexibility to use CD-ROMs and floppy disks when needed.

Secure Data and Equipment

By concentrating data, applications, and processing power on servers, the thin-client environment reduces security risks of data loss and equipment theft. Most organizations only backup servers, because a backup of the information resources of individual desktop devices is too costly. With thin clients, servers are the only devices storing data, and they can be secured in rooms with alarms and limited access. True thin-client devices have little intrinsic value. If they are stolen, the hardware is easily and inexpensively replaced and none of the data lost. Because information is available from any device, users won't need floppy disks to move files, reducing the risk of viruses.

Integrate with Existing Technology

A thin-client solution uses the standard network infrastructure adopted by the majority of schools. Almost all schools have Internet access and most are planning to expand networks to their classrooms. They have invested in Ethernet-capable wiring, servers, desktop computers, and versions of software products for each computer platform. Unlike fat clients, which send large packets of information such as data files to a printer across the network, thin clients send only keystrokes and screen shots. They require less bandwidth although network reliability becomes more critical.

A school district can start slowly and migrate to thin-client computing by connecting a single computer lab in a single school or starting with administrative computers, which perform a particular function. As they expand, they receive true cost savings through economy of scale, particularly in the area of support. With a sufficient network connection, a school district could maintain servers for all schools in a single location. The district trains and hires a system administrator with appropriate expertise to plan and manage the technology investment. By centralizing training, maintenance, and purchasing, districts achieve a lowest cost per user without trading reliability.

Shadowing

Shadowing allows certain users access to another user's desktop in real time to support student learning and teacher training. A teacher can show a student how to solve a problem remotely. Or a technology support person at the district office can support a teacher in a classroom. Although several applications on the market offer similar features, the thin-client software performs this function on the server rather than the desktop, reducing the computing and network resources required.

4) "Data Center Implementation of Thin-Client Computing," Allen D. Northcutt, Technical Advisor, Common Desktop Integration, Federal Express, October 15, 1998, p.5.

Spotlight on Lemon Grove School District

Lemon Grove Elementary School District, an urban district with eight schools near San Diego, California, envisioned a learning community with access to information resources from every classroom and home in the community. They realized the importance of providing this access at a low cost and to achieve it, turned to thin clients in a hybrid computing environment. The district serves 4,600 students with two middle and six elementary schools linked by a high-capacity wireless backbone using microwave links. Each classroom has eight to twelve thin clients and four powerful multimedia PCs for access to specialized software. Lemon Grove leverages their investment in bandwidth and a server farm (12 servers, scaling up to 45) by offering inexpensive access in the evenings to students from home. Teachers receive regular training and support to integrate the technology into their curriculum, and assessment software helps everyone track the students' progress. The vision held by these technology leaders matched by support at all levels of the organization has had impressive results. Teachers spend more time interacting with students and each other, and reading and math scores have improved significantly, particularly for at-risk middle school students who reported gains of nearly 40 percent in the program's first three months.[5]

The Evolution of Computing

The centralized thin-client/server computing model might cause a case of deja-vu, but this is not a return to mainframes. Thin clients are the next step in the evolution of computers. The first computers were massive "mainframes" that users accessed through "dumb terminals"—a simple monitor and keyboard using text commands. Mainframes computed over slow networks using proprietary software. Personal computers freed computing power from the backroom and made it available at every desk with an easy-to-understand "graphical user interface" (GUI). Advancements in network technology made it possible to send larger packets of information across networks at faster rates, and personal computers were networked to share resources and move data. They functioned as both individual computers and clients of servers. However, the desktop control that made personal computers so appealing also made them increasingly complex, a challenge to support, and limited users' ability to collaborate.

Thin clients simplify management and allow multiple platform computers to share resources seamlessly. Like a mainframe, they rely on a server, where resources and maintenance can be centralized, but they also run the latest productivity software and have an easy-to-use GUI interface like a personal computer. Some districts may use all three: mainframes for mission critical data, personal computers for teachers to try out new software, and thin clients for general use.

Conclusion

The introduction of networks and computers transformed the business office in ways that no one predicted. While computers have been used in educational business offices and some classrooms, they have not yet been fully integrated into the learning process. The complexity of the machines, the capital investment needed for widespread access, and the lack of educational resources have prevented their potential from being realized. The convergence of community, business, and government support for technology is producing a sea of change in education. The thin-client model offers educational organizations a realistic and cost-effective way to manage technology and make it available to teachers and students.

5) "Smart Links: Schools That Use Technology for Learning," article from conference sponsored by *Business Week* and The McGraw-Hill Educational and Professional Publishing Group in collaboration with the Council of Chief State School Officers, p. 11.

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