Abstract
The purpose of this paper is to introduce zero-client architecture. This leading-edge technology enables peripheral devices to be deployed at any user interaction point without a dedicated PC or thin client at that same location and without requiring any modifications to existing software applications. Topics include a zero-client definition, benefits, deployment scenarios, virtual machine options, cabling options, software impact, management, and technology comparisons.
Overview

In today’s client/server world, the norm for most office, commercial or industrial applications is a dedicated PC or workstation running an application and accessing a variety of peripheral devices locally. The PC is then connected to a network server for backup and other uploading or downloading functions. This is the application architecture found in retail, financial, airline, food service, manufacturing and most other commercial markets.

While very flexible, this architecture has a variety of high costs. A PC or workstation is expensive to purchase – PCs or workstations can cost $400 to several thousand dollars, depending on configuration. The cost of operating system and client access licenses must be added to this cost for communication between client and server.

Standard PC hardware has unreliable moving parts such as hard drives and fans, with expected life cycles of only three to five years. PC operating systems are usually some version of Microsoft® Windows®, a large, complex and often unreliable platform. Consequently, support costs for PC-based applications can be in the range of $300-500 per year for PC-based systems. Windows-based virus protection can cost another $25-100 per workstation or server.

In many vertical markets, the actual size of a PC or workstation directly affects operational costs. In retail stores, pharmacies, fast food restaurants and other retail establishments, every square foot of counter or floor space is precious. If a 40-pound PC or workstation must be placed on a counter top occupying several square feet of space, that space cannot be used to display merchandise or place advertising. This can cost the retailer revenue every day. Eliminate that PC or workstation and the retailer can use the extra space for revenue-producing items, directly affecting his bottom line.

Finally, many legacy applications in mature markets are still based on dumb terminals, which are decreasingly available each year. Migrating terminal based applications to Windows graphics applications is also difficult, making the upgrade of an entire store chain problematic.

Zero-Client

A zero-client is an I/O redirector device that allows a full cluster of peripheral devices to be deployed at the desired point of service without a dedicated PC or thin client at that same location and without requiring any modifications to existing software applications. Zero-clients are network-based and contain interfaces for a variety of peripheral device types including VGA and other video monitor interfaces, serial, USB and optionally others such as audio or PS/2. The zero-client contains network protocols, allowing each of these interface types to be supported over a wired or wireless IP network without a local PC or thin client. They are connected over the network to applications running on a PC or server elsewhere on the IP network.

Zero-clients may run in two modes: standard remote device mode or terminal emulation mode. Remote device mode allows remote peripherals to connect to applications running on PCs elsewhere on the network. Terminal emulation mode allows the zero-client and standard devices such as printers and keyboards to replace legacy terminals.
Benefits of zero-clients include:

1. Eliminating dedicated PCs at the point of service
2. Reducing high maintenance costs associated with dedicated PCs
3. Increasing security of the application PC
4. Reducing space requirements
5. Increasing reliability
6. Running application software without modifications
7. Straightforward migration from older terminal-based solutions

The ConnectPort™ Display from Digi International® is the industry’s first zero-client solution. More information can be found at http://www.digi.com/products/usb/connectportdisplay.jsp.

**Web-Based Software “Zero-Clients”**

A variety of software companies have coined the term “zero-client” to refer to a software solution that runs on desktop PCs and eliminates the need for application software to run on those desktop PCs.

Most of these solutions employ a network connection from the desktop PC to a special program on a network server that translates application programs' inputs and outputs into network based communications. This can reduce the IT management on the desktop PC by making all users access the same version of the application on the server and the same client code (often a browser interface) to interface to that application.

While solving some of the problems of dedicated desktop PCs, this approach does not solve the basic problem of the hardware, operating system, and support costs associated with the desktop PC itself. PCs are still unreliable, with hard drives and fans that go bad. The Microsoft Windows operating systems that run on them still have the same high maintenance costs. This approach also makes it difficult for applications to access peripheral devices deployed at the desktop PC location, an absolute requirement for retail and other commercial applications.

**Deployment Scenarios**

A zero-client is designed to facilitate moving or eliminating dedicated PCs. Deployments may be done in a variety of different scenarios.
Point-to-Point
The simplest scenario is to move the formerly dedicated PC to a different location, often in a back room or data center location, while leaving the cluster of peripheral devices at their desired location. The PC accesses the peripheral devices over a standard TCP/IP network connection.

Benefits of this scenario include:
1. The user still interacts with the desired peripheral devices at the desired location.
2. The PC can now be placed in a completely secure physical location that is accessible only by security-cleared employees.
3. The PC may be removed from a hostile environment where temperatures, dust or electromagnetic interference can reduce its effectiveness or lifetime.
4. The PC is now in an environment where maintenance, upgrades or replacements can be done easily.
5. The space formerly occupied by the PC may now be used for other functions such as merchandising or manufacturing.

Multiple Point-to-Point
The point-to-point scenario described above may be extended to multiple point-to-point connections within the same facility. The network topology is the same as for single point-to-point connections, only with more connections.
In addition to all of the advantages of single point-to-point connections mentioned earlier, this scenario adds the following benefits:

1. It allows a single TCP/IP network to be leveraged across multiple connections between PCs and their peripherals.
2. It offers the flexibility of rack mounting individual PCs or replacing them with a blade server. Each option (rack or blade) has its advantages. Regardless of the choice, each connection between PC and peripheral device is still point-to-point.
3. It makes it much easier to swap out a failed PC (or blade) and substitute a backup unit.

**Point-to-Multipoint**
The multiple point-to-point scenario may be extended by consolidating multiple PCs onto a smaller number of servers using a virtualization technology such as Microsoft Virtual Server or VMware ESX Server.

With this scenario, connections to peripheral devices still appear to be point-to-point, although the connections are between the peripheral devices and a unique virtual machine running on the virtualization server. While somewhat more complex to implement, the point-to-multipoint scenario offers all of the advantages of the first two scenarios and adds several of its own.

1. The total number of PCs required can be reduced dramatically.
2. Hardware reliability can be increased dramatically.
3. Maintenance costs can be reduced substantially.

Virtual Machine Options

The tradeoff in using virtualization software is that while PC consolidation reduces costs, the resulting solution is somewhat more complex to maintain. For example, a single server can run multiple virtual machines supporting multiple remote clusters of peripherals and their applications. To accomplish this consolidation, however, that server must run a host operating system, a virtualization application and multiple copies of guest operating systems—all on a single hardware platform. Depending on the virtualization platform, some combinations of guest operating systems may be allowed and others may not.

The operating system and perhaps the application software on each virtual machine must be licensed just as if it were on separate physical PC. Point-to-multipoint architecture may reduce hardware and maintenance costs, but may not reduce software license costs.

Cabling Options

It is possible to design zero-client solutions using either proprietary cabling or more standard IP networks. Proprietary cabling enables a secure connection between a zero-client and PC host, but severely limits the flexibility of network connection topologies. For example, multiple segment networks or redundant networks are significantly more difficult to configure. This approach also secures only the single segment of the network between the zero-client and the PC—not the entire network in which the PC exists.

A more common approach is to use standard IP networks for connecting zero-clients and PCs. This allows the use of wired networks using Ethernet, wireless networks using 802.11, or a wide variety of other network technologies. For distributed applications that do not require low latencies, connections can even be made over wide area networks.

The variety of IP-based networks and their management features make this approach much more viable for most situations. It also allows network technology upgrades as newer network technologies are developed. The Internet Engineering Task Force (IETF) has also added state-of-the-art security technologies to IP networks over the years. As newer security protocols move from research to development, they are nearly always applied first to IP-based networks.

Software Impact

Operating Systems

In a zero-client solution, the station formerly occupied by a dedicated PC and its peripheral devices is now occupied by the original peripheral device cluster and a much simpler zero-client. The operating system of the zero-client itself is typically a simple embedded operating system, the function of which is I/O redirection and possibly terminal emulation.

The network-based PCs or servers are typically installed with the same operating system, or a compatible one, as the original dedicated PCs. This guarantees portability of the application software used in the original dedicated PC environment.

If PC consolidation is done with virtualization software such as Microsoft Virtual Server or VMware ESX Server, a network-based server has this virtualization software installed. Multiple virtual machines are configured on top of the virtualization software. Each virtual machine has the identical operating system as was used in the former dedicated PC environment.

In most cases, the operating system licensing is similar to that of the original dedicated PC environment, as each PC, PC blade or virtual machine (depending on the deployment architecture used) has its own operating system with its own license.

Application Software

In moving applications from dedicated PCs or workstations to backroom PCs or servers, the application connection protocol
used will have different impacts on the required changes to those applications.

**VNC Solutions**
VNC (Virtual Network Computing) software makes it possible to view and fully-interact with one computer from any other computer or mobile device anywhere on an IP network. VNC software is cross-platform, allowing remote control between different types of computers or devices. For ultimate simplicity, there is even a Java viewer, so that any desktop can be controlled remotely from within a browser without having to install software. Zero-client solutions based on VNC can be used to allow display and USB peripheral devices to interact with application PCs elsewhere on an IP network. Adding IP-based COM port redirection such as Digi’s patented RealPort® protocol completes the peripheral interface types. Such solutions are usually transparent to the application software itself, requiring no changes to those applications while still interacting with the same peripheral devices.

**RDP or ICA solutions**
Other protocols used, frequently with distributed PCs or thin clients, are Remote Desktop Protocol (RDP) and Independent Computer Architecture (ICA). The RDP protocol is part of the total solution used with Microsoft Windows Terminal Services. The ICA protocol is part of the total solution used with Citrix MetaFrame.

For applications already converted to work with Citrix or Windows Terminal Services, the easiest approach is simply to continue using the ICA or RDP protocols when communicating with a zero-client. However, for applications that formerly ran on dedicated PCs or workstations, the cost of application conversion to work with Citrix or Windows Terminal Services can be sizable. In this case, the port redirection found with VNC solutions will likely cost significantly less to implement.

**Management**
Two key management functions may be used with zero-client solutions: one for troubleshooting individual units, their peripherals, and connections, and one for more global management of larger populations of zero-clients and their peripheral clusters.

**Monitoring/Troubleshooting**
The VNC protocols supported by zero-clients may also be used for troubleshooting individual units and their peripheral
clusters. This is done by embedding not only a VNC client but also a VNC server in the zero-client. This embedded VNC server allows remote IT personnel to access the zero-client easily through its IP address. With such a remote connection, IT personnel can obtain device status of the zero-client itself as well as status of each device in its peripheral cluster. It may even see the display buffer for a display device, exactly as it is displayed on the device itself.

Managing Multiple Clients
A zero-client may also be provided with higher level management software for managing a larger population for zero-clients. Software packages such as Digi Connectware® Manager can provide assistance in secure management functions for installing, configuration, monitoring and managing such deployments.

**Technology Comparisons**

Client-server applications may be implemented with three kinds of client devices. A dedicated PC, also called a “fat client,” is the more traditional solution and demonstrates all of the advantages and disadvantages described earlier. A zero-client has also been described earlier along with its advantages and disadvantages. The third client type is a thin client. As a dedicated computer, although smaller and less complex than a PC, it possesses many characteristics of a fat client and some of a zero-client.

<table>
<thead>
<tr>
<th>Fat Client (PC)</th>
<th>Thin Client</th>
<th>Zero-Client</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port counts</td>
<td>Robust</td>
<td>Limited</td>
</tr>
<tr>
<td>• Serial: 0-8+</td>
<td>• Serial: 0-2</td>
<td>• Serial: 2-8+</td>
</tr>
<tr>
<td>• USB: 2-8+</td>
<td>• USB: 2-4</td>
<td>• USB: 2-8+</td>
</tr>
<tr>
<td>• Parallel:0-2</td>
<td>• Parallel: 0-1</td>
<td>• Parallel: 0-1</td>
</tr>
<tr>
<td>• PS/2: 0-4</td>
<td>• PS/2: 0-2</td>
<td>• PS/2: 0-4</td>
</tr>
<tr>
<td>• Display: 1-16</td>
<td>• Display: 1</td>
<td>• Display: 1-2</td>
</tr>
<tr>
<td>Size</td>
<td>• Up to 18” x 20”</td>
<td>• 8.2” x 9.5”</td>
</tr>
<tr>
<td></td>
<td>• Up to 40 lbs</td>
<td>• 8-20 lbs</td>
</tr>
<tr>
<td>Reliability</td>
<td>• Low</td>
<td>• Modest</td>
</tr>
<tr>
<td></td>
<td>• Hot (35-75W)</td>
<td>• Warm (15-40W)</td>
</tr>
<tr>
<td></td>
<td>• Many moving parts</td>
<td>• Fans on some</td>
</tr>
<tr>
<td>Support costs</td>
<td>• High</td>
<td>• Modest</td>
</tr>
<tr>
<td>Operating system</td>
<td>• Windows XP</td>
<td>• Windows CE</td>
</tr>
<tr>
<td></td>
<td>• Windows 2000</td>
<td>• Embedded XP</td>
</tr>
<tr>
<td></td>
<td>• Large: 128-512 MB RAM</td>
<td>• Moderately large: 16-256 MB RAM</td>
</tr>
<tr>
<td></td>
<td>• Unstable</td>
<td>• Moderately stable</td>
</tr>
<tr>
<td></td>
<td>• High virus risk</td>
<td>• Modest virus risk</td>
</tr>
<tr>
<td>Client licensing</td>
<td>• Windows XP</td>
<td>• Windows CE</td>
</tr>
<tr>
<td></td>
<td>• Windows CAL</td>
<td>• Windows CAL</td>
</tr>
<tr>
<td>Target functions</td>
<td>• Applications</td>
<td>• User interface</td>
</tr>
<tr>
<td></td>
<td>• User interface</td>
<td>• I/O</td>
</tr>
<tr>
<td></td>
<td>• I/O</td>
<td>• Terminal emulation</td>
</tr>
<tr>
<td>Applications</td>
<td>• Dedicated to PC</td>
<td>• RDP/ICA to server</td>
</tr>
<tr>
<td></td>
<td>• Written for PC</td>
<td>• Must be rewritten</td>
</tr>
<tr>
<td>Price</td>
<td>Expensive</td>
<td>Moderate price</td>
</tr>
<tr>
<td></td>
<td>• $400-$2,000</td>
<td>• $350-$1,200</td>
</tr>
<tr>
<td></td>
<td>• $25-$100 virus protection</td>
<td>• $25-$100 virus protection</td>
</tr>
</tbody>
</table>
While a complete comparison between all vendors’ models of each category is beyond the scope of this paper, the following comparison table provides a summary.

**Application Migration**

For those considering zero-client solutions, it may be useful to look at examples of how to migrate from current fat client, thin client or dumb terminal solutions to a zero-client solution.

**PC to Zero-Client**

For users of dedicated PC solutions, conversion to a zero-client solution is relatively straightforward. The largest decision to make is which of the previously described deployment architectures is desired: point-to-point, multiple point-to-point, or point-to-multipoint.

For point-to-point or multiple point-to-point connections, the dedicated PC or workstation is simply moved to the desired location, a zero-client is connected to the peripheral cluster, zero-client drivers are installed on the PC in its new location, and the application is ready to run. There is also the option to convert the former PCs to more up-to-date rack mounted units or blade servers, but this is not required.

For point-to-multipoint connections, the virtualization software, Microsoft Virtual Server or VMware ESX Server, must be installed on the network-based server. Installation of zero-clients and their drivers then follows the same procedures as for multiple point-to-point deployments. The only difference is that driver installation and port connections are made to virtual machines instead of individual physical PCs or blades.

**Terminal to Zero-Client**

Zero-clients also typically include terminal emulation capability. In this case, they can easily be drop-in replacements for existing terminals while allowing the use of more standard peripheral devices such as off-the-shelf LCD displays, keyboards, mice and touch panels. Since the zero-client can also be used in non-terminal mode as described in the PC case above, they give users the flexibility to convert to more feature rich non-terminal applications at a later date without having to replace the zero-client or the peripherals attached to it.

**Thin Client to Zero-Client**

In most cases, a thin client solution has already had to go through the process of application software conversion to function. This makes the benefits of conversion to a zero-client somewhat smaller than those described in the two scenarios above. However, if the cost of the thin clients, their operating systems and maintenance are sufficiently compelling, a conversion to a zero-client solution is still relatively straightforward, provided that their RDP or ICA based solution is supported on the zero-client as well.

**Applications**

Zero-clients may be deployed in nearly any application environment that currently uses dedicated PCs to run applications at service points and also has an in-house network. Retail checkouts, restaurant kitchens, bank teller stations, manufacturing, advertising, airline ticket counters and flight status displays are just a few such applications that can take advantage of the
many benefits of a zero-client solution.

Traditional Retail
Zero-clients can be used in a variety of traditional retail or point-of-sale applications. Eliminating dedicated PCs from checkout lanes frees more space for merchandising and provides a more efficient and reliable configuration. Placing zero-clients in retail kiosks also provides significant flexibility to market unique products or services without requiring a standard PC as part of the kiosk.

Zero-Clients at Checkouts

Zero-Clients in Kiosks

Restaurant/Food Service
Zero-clients can be used for restaurant checkouts just as in traditional retail. They may also be used to drive kitchen display systems in order preparation areas. Many of the latter are currently based on dumb terminals. A zero-client can be used as a drop-in replacement for dumb terminals while enabling the restaurant to migrate to more full featured graphical applications at
Financial/Banking
Zero-clients make an excellent solution for connecting bank tellers to applications that run on secure back room servers. This enhances the security and reliability of this critical application.

Zero-Clients in Restaurant Kitchens

Zero-Clients at Bank Teller Stations

Manufacturing
Zero-clients provide manufacturing applications the flexibility to move PCs out of dangerous, hot, humid or dusty manufacturing
environments while allowing critical peripheral devices to remain where they are needed in manufacturing processes.

Zero-Clients in Manufacturing

Zero-clients can be used for a variety of electronic advertising applications such as in airport concourses or high-rise elevators.

Electronic Advertising

Zero-Clients for Airport Advertising

Zero-Clients for Elevator Advertising

Transportation/Airlines

Zero-clients may be used in a variety of other airport applications. For ticketing, their use resembles traditional retail, with deployment at ticket counters and self-checking kiosks. They may also be used to replace dedicated PCs in flight status displays on airport concourses.

Contact a Digi expert and get started today

PH: 877-912-3444
www.digi.com

Digi International - Germany
+49-89-540-428-0

Digi International - Japan
+81-3-5428-0261

Digi International - Singapore
+65-6213-5380

Digi International - China
+86-21-5049-2199