

Life After Windows NT Server 4.0: An Alternative IT Infrastructure



Microsoft is withdrawing support for Windows NT Server 4.0. You need a migration strategy fast if you're still running this network mainstay. Take advantage of this forced move to look into powerful open source alternatives.

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Executive Summary

Windows® NT Server 4.0, and support for it, is being phased out by Microsoft. Microsoft has published a schedule by which this will happen, ending in 2005. The replacement products for Windows® NT Server 4.0 are fairly expensive, particularly considering that NT server and client licenses have already been paid for once. In addition, Microsoft is changing its software-licensing model, which is expected to increase software costs for a large majority of their current customer base.

Since there will be considerable additional costs involved in migrating to Microsoft's replacement products, prudent IT managers should seriously consider alternatives to going in that direction. The intent of this paper is to lay out a foundation for considering one very viable alternative to Microsoft platforms: Linux and Linux-based services. Both commercial and Open Source alternatives will be discussed. Where appropriate, mainframe-based Linux will also be considered.

Introduction

Windows® NT Server 4.0 Is Being Retired

In September 2001, Microsoft announced that it was "retiring" Windows® NT Server 4.0 in phases.

On their support Web page, they list these phases as:

- **October 1, 2001**, Windows® NT Server 4.0 (Standard or Enterprise Edition) is no longer available through Microsoft Volume Licensing programs.
- **July 1, 2002** - Windows® NT Server 4.0 (Standard and Enterprise Edition) Full Packaged Product (FPP) will no longer be available in the reselling channel.
- **July 1, 2002** - Windows® NT Server 4.0 (Standard, Enterprise Edition, Terminal Server Edition) will no longer be offered through the Direct OEM channel.
- **January 1, 2003** - Beginning on this date, customers requesting non-security QFEs will be charged a fee. (Premier customers should contact their Premier Technical Account Manager for details on associated fees.)
- **July 1, 2003** - Windows® NT Server 4.0 (Standard) will no longer be offered through the System Builder channel.
- **January 1, 2004** - Pay-per-incident and Premier support will no longer be available. Non-security QFEs ("hotfixes") will no longer be available.
- **January 1, 2005** (or later) - Online support will no longer be available.

Businesses most often choose to run supported software, since a serious outage can have a significant impact on the whole company, up to and including complete failure. The follow-on products that replace Microsoft Windows® NT Server 4.0 are Microsoft Windows® 2000 Server, Microsoft Windows® 2000 Advanced Server, and Microsoft Windows® 2000 Datacenter Server.

Reasons To Move Away from Microsoft Operating Systems

Increased Hardware Costs

System requirements for the listed follow-on products are significantly higher than for Windows® NT Server 4.0. Hardware upgrades will very likely be needed. Microsoft's absolute minimum system requirements are listed below. As anyone knows that has actually run these systems, the *documented* minimum is about 50 percent lower than the *practical* minimum needed for reasonable performance.

	CPU	RAM	Disk
Windows® NT Server 4.0	33 MHz 80486	16MB	125MB
Windows® 2000 Server	133 MHz Pentium	256MB	2GB
Windows® 2000 Advanced Server	133 MHz Pentium	256MB	2GB
Windows® 2000 Datacenter Server	400 MHz Pentium	256MB	2GB

Increased Software Costs

Whether new hardware is needed or not, new server licenses and Client Access Licenses (CALs) must be purchased for any systems that are upgraded. Prices vary widely between resellers, but a reasonable range might be:

1. Windows® 2000 Server Licenses (\$775-920 per system, includes 5 CALs)
2. Windows® Advanced Server Licenses (\$3,300-3,700 per system, includes 25 CALs).
3. Client Access Licenses (\$20-35/seat).

As can be seen, it doesn't take very much in the way of upgrades to turn into a significant cost for even a relatively small business.

Expensive New Licensing Programs

Microsoft's proposed subscription-licensing model ("Microsoft Licensing 6.0 Program") will increase licensing costs for a significant percentage of their customers. At a time when most companies are taking longer to migrate to new versions of desktop software, this means that in effect, they would be "paying more for less." In any economic climate, this is difficult to justify. In the current one, it may well be impossible. Indeed, a study performed by Sunbelt Software¹ showed that 36% of the firms they surveyed did not have the necessary funds to meet the requirements of Microsoft License 6.0.

Unacceptable Security Levels

Microsoft has been in the news for the wrong reason many times over the last few years. Microsoft Windows® systems have been compromised many different ways, and far in

¹ Sunbelt Software Microsoft Licensing 6.0 Survey, March 2002 http://www.sunbelt-software.com/survey_02mar.cfm

excess of what would be expected of another platform with the same market share. IIS in particular has been a frequent target, to the extent that Gartner Group has recommended that businesses "immediately investigate alternatives to IIS, including moving Web applications to Web server software from other vendors, such as iPlanet and Apache."² Strong words from an analyst group that has not been hostile towards Microsoft in the past.

The Bottom Line

As a result of all these factors, nearly 40 percent of current Microsoft customers are considering moving to alternative products and/or platforms³. It's safe to assume that the number of customers who do actually migrate away from Microsoft platforms will be far less than that. But, it's equally safe to assume that some percentage will, either now or later. One of the most popular alternatives today is Linux, along with various other Open Source and commercial software packages. That is the area on which this paper will focus.

What's Next?

There are a number of questions that have to be examined before making a move away from a part of your infrastructure that's probably been a mainstay for years. One of those questions is, just how much are you willing to replace, and when? While there may be good business reasons, there is no *technical* reason that would require a wholesale replacement of your existing infrastructure. Some parts will be more difficult to replace than others. Some pieces may not make business sense to change at all. The considerations, pro and con, for each piece will be considered in this paper.

1. What Windows® NT functions can be replaced?
2. What can replace them?
3. Which of those *will* I replace? That is, will I completely eliminate NT or not?
4. In what order will I replace them?
5. How do I get the replacements?
6. How do I get support for them?
7. What problems am I likely to encounter along the way?
8. What system management tools are available?

If you currently have IBM compatible mainframes in your shop, you will also want to consider the possibility of using Linux for S/390 and zSeries (Linux/390) and consolidating some of your servers onto that platform, rather than simply replacing "discrete" servers. This gets into a whole new level of planning complexity, so we won't cover this in any detail, but will mention it as an alternative where appropriate.

What Windows® NT Server 4.0 Functions Must Be Replaced?

If a company is going to move to a Linux environment, the first thing that must be examined is what functions their Windows® NT servers are performing. Typically those functions (and some potential replacements) fall into these categories:

² http://www3.gartner.com/DisplayDocument?doc_cd=101034

³ http://www3.gartner.com/DisplayDocument?doc_cd=101034

Function	Potential Replacement	Level of Difficulty
Domain Name System Server (DNS)	BIND	Low
Dynamic Host Configuration Protocol Server (DHCP)	DHCP	Low
Windows® Internet Name Server (WINS)	Samba	Low
File and print server	Samba, NFS	Low
FTP server	ProFTPD, vsftpd	Low
HTTP server (web)	Apache	Low to High ⁴
Web Application Server	Jboss(EJB), Tomcat/Catalina(servlets, JSP), WebSphere, Weblogic, iPlanet	Low
Remote Access Server (RAS)	pppd	Low to Medium
Domain controller	Samba	Medium
Email server	Exim, IMP, Postfix, Sendmail, Insight	Medium
Groupware (calendar, etc.)	Insight Server	Medium
Database server	MySQL, PostgreSQL, DB2, Oracle	Low to High ⁵
Proxy server/firewall	Dante, Guarddog, Squid, ipchains, iptables, FireWall-1	Medium

There are a number of other functions, such as clustering, terminal serving, and INN, that will not be covered here simply due to space limitations. Hopefully what *is* being covered will give you enough of an introduction to Linux , Open Source and commercial Linux products that gathering information on the rest will be much easier.

⁴ If all you have are static Web pages, installing Apache will be an easy task. If you have a number of Active Server Pages with a lot of dynamic content and back-end database queries, then the task becomes much more complex, with a corresponding increase in risk.

⁵ Simple applications making SQL calls that are essentially database implementation independent will be moderately easy to migrate. More involved applications that use implementation-specific features of a particular database will be correspondingly more difficult to migrate.

How you decide what to replace, and when, is very difficult. Most IT infrastructures have many, complex, interrelationships. Changing any given aspect without disturbing the rest will be nearly impossible. No one who is unfamiliar with your particular environment is going to be able to offer a cookbook approach to developing those kinds of plans. One of the goals of this paper is to give you enough information to make intelligent decisions in this area, so that you can minimize your ongoing costs, and minimize the risks of “getting there.”

How Is Open Source Software Obtained?

You have a number of choices in this area. With very few exceptions, Open Source software can be downloaded at no cost. In the case of Linux distributions, you can

1. Download the entire distribution.
2. Buy the distribution direct from the distributor.
3. Buy the distribution from many, many, different retail stores, online or otherwise.
4. Buy just the software (no manuals or support) from places like Cheapbytes.
5. Contract someone else to install it for you.
6. Think up some other way.

Linux distributors provide a very valuable service, aside from providing commercial support for their platforms. They act as system integrators, and generally do a very good job of it. Anyone who has tried to keep up with the myriad Open Source packages available, which versions are current, which versions "play well" with other packages, which have the least security/stability problems, and so on, soon discovers why having distributions available is a Very Good Thing™. Because of this, it's wise to buy your distribution from them directly, and at least consider them for your commercial support provider. They need revenue to stay in business and keep fulfilling the role of system integrators. In addition, many of them employ a good number of the Linux developers, and allow them to work at that task, full time. If all of the Linux distributors were to go out of business, the number of good quality choices available would be severely limited, reducing competition, increasing cost, and so on.

Linux distributions contain *a lot* of software, literally hundreds and hundreds of packages. In many cases, you may have no need for anything else. If you do, then again, what you need will be available for free download. It may not be available in a binary package for your distribution, but most well-written Open Source packages are fairly straightforward to compile from source.

A number of Open Source projects have commercial versions available also. In most cases, the commercial versions have more functionality, perhaps more robustness, and may have some form of support included in the price. A couple examples of this would be sendmail and Star Office/Open Office.

How Is Support for Linux and Open Source Software Obtained?

Since you don't want to go from one unsupported software platform to another, this question needs to be answered *before* you move important business functions. Fortunately, the answer will be relatively pleasant. One of the defining attributes of Open Source software is that anyone can get the source code. This has led to competition in the Linux support industry. Various industry analysts believe that the cost for Linux support is under-priced, which has

lead to the failure of some support companies. They expect this consolidation to result in rising Linux support costs, but believe those costs will top out at approximately 20% *below* the cost for proprietary UNIX systems, or Microsoft products. Concurrent with this consolidation of companies, as more businesses adopt Linux, the demand for Linux support increases.

There are a number of companies that provide support for Linux and Open Source software in general. Perhaps the easiest one to locate is the provider of whatever Linux distribution you choose. The major distributions all offer support contracts for their products. In the United States and Canada, the most common would be SuSE, Red Hat, Turbolinux, and Caldera. (A more complete list of reasonably well-established distributions is included in the Appendix.) If you decide to buy new hardware in the future, a number of the manufacturers offer support for Linux, as well as their own hardware.

One of the very good things about Open Source software is that if you are not satisfied with the support you receive from your Linux distributor, you can go to a different company for support. Depending on your needs, this could be a local Linux consulting company, or one with a national or global scope. For companies that are concerned about certification of their support provider's employees, there are two independent Linux-specific certification programs available, LPI (Linux Professional Institute), and SAIR (Software Architecture Implementation and Realization). These are similar in concept to that provided by Microsoft, but not tied to any particular Linux distributor. Red Hat Linux also has its own certification program, Red Hat Certified Engineer (RHCE).

If you want to reduce your dependence on any outside company, a final option might be to develop your own support staff. Since the source code is available, self-support is entirely possible, and in use. These in-house staff will have access to certification training as discussed above, as well as unpaid (hence best effort of whoever is willing and able) support via Usenet newsgroups, developer mailing lists, Linux User Groups, and so on. For most companies, this is likely not a reasonable course of action, but could be a viable alternative for the very self-sufficient.

What Training Will Your Employees Need?

If you currently have employees with UNIX skills, very little additional training will be required. The vast majority of UNIX skills are directly translatable to Linux, and vice versa. If your employees are only familiar with the various Microsoft operating systems, Novell, and the like, then training is going to be needed in order for them to do the basic tasks of installation and administration. Even if you don't intend to have your staff certified, looking at the various certification requirements will give you an idea of the sorts of training and experience needed. You should probably plan on a minimum of 40 hours of classroom training per employee to give them an introduction to Linux system administration. The cost of this can range up to \$2,700, or even higher, but that is the price companies such as IBM and Hewlett Packard charge. Much more affordable education should be available, perhaps even in your local area. In the same way that costs for Linux education vary widely, so does the quality of that education. Try to get recommendations for education providers from others who have already attended the course. Your local Linux Users Group, if one exists, may be able to offer recommendations (or warnings).

One of the big differences administrators of Microsoft operating systems face when being re-trained to support Linux or UNIX is the Graphical User Interface (GUI). In the Microsoft world, there is little alternative to using the built-in system GUI for performing nearly all their tasks. This is not true with Linux. There is no "registry" concept in Linux. Nearly everything is administered via changes made to plain text files. How these changes get made varies from distribution to distribution. Slackware, for example, provides no GUI tools for system administration. The expectation is that the system administrator knows, or will learn,

what files need to be edited, and what needs to be put in them to accomplish the desired goal. This is not to say that GUI tools are not available for Slackware. Packages such as Webmin, which provides a Web browser administration interface, are available that work well with Slackware, but they are not a part of the distribution. Other distributions do provide GUI administration tools. It may be a matter of philosophy, but you should consider whether you want your support staff to be aware of what system configuration files these tools are changing, and exactly what is being changed in them. Since the option is now available, you may want your staff to defer using the various GUI tools until they've gained some knowledge and experience with the (many!) system configuration files. Even if/when they do start using GUI tools, they will be different from what they've used in the past, representing yet another learning curve to overcome. The great positive to all of this is that if a configuration file is deleted or corrupted, it is much easier (and far more granular) to restore that one file to usefulness than a registry hive.

Apart from classroom education, you should seriously consider buying reference books for your staff. One of the leading publishers of computer-related books, O'Reilly and Associates, has a large library of well written books on just about any topic involving Linux and UNIX, including system and network administration. They also have a number of "CD Bookshelves." The CD Bookshelves include cross-indexed, searchable versions of six to seven of their books in each category, as well as one of them in hardcopy format, for much less than the cost of the same books in print. They are highly recommended.

Develop a Standard System Profile

Decide what software packages you want to have on *all* your Linux systems, as well as what additional packages will be needed for each "flavor" of system, i.e. Web server versus DNS versus Samba server, etc. This will involve some trial and error as your staff gains experience with what is available versus what is needed. Keeping it in mind as new systems are installed will help your staff's productivity. Having to figure out what is installed on a particular system, and how to use it, can waste a lot of time and cause a lot of frustration. It also increases the chances of errors being made that can cause service outages. Most distributions provide a means for creating customized installation profiles. Creating those should be fairly straightforward once you have defined your system standards. If it is not explicitly documented in the installation instructions, a query to the distributor's email support should get a usable explanation.

Replacement Package Considerations

Domain Name System (DNS) Server

Berkeley Internet Name Domain (BIND) is one of the many industry standard Open Source packages that make up much of the Internet infrastructure. More domain name servers run BIND than any other DNS package. Domain name serving is one of the easiest (and most transparent to the end user) conversions you'll face. From the perspective of your users, all they probably know about DNS is the IP address of the servers that were configured into their desktop systems, or acquired via DHCP.

You can easily configure a new server running BIND running on Linux and introduce it to your network as the secondary DNS server for that domain. Microsoft has online documentation⁶ that talks about migrating from BIND to a Windows® 2000 DNS server. The methods it describes could be used for migrating in the other direction. Doing the migration via a zone transfer will minimize the amount of manual editing that must be done, hence

⁶http://www.microsoft.com/Windows@2000/en/server/help/sag_DNS_imp_MigrationIssues.htm?id=1959

minimizing the chance of error. After sufficient testing for you to become comfortable that it works well, replacing the primary server should take no more time than the secondary.

If you put the new servers on the network with the same IP addresses as the servers they are replacing, your users will not have to make any changes to their network configuration, and will probably be unaware that any substitution has been made.

Again, it should be noted that BIND works from plain text configuration files, not a GUI. The person responsible for the ongoing maintenance of them must be familiar with the structure and syntax of the configuration files. O'Reilly and Associates publishes what is considered the definitive reference on BIND, "DNS and BIND, 4th Edition."⁷

As is true of most Open Source software, BIND also runs on Linux/390. In fact, it has frequently been the first use made of Linux/390 in many shops. It has been very useful as a proof of concept implementation on that platform.

Dynamic Host Configuration Protocol (DHCP) server

Dynamic Host Configuration Protocol (DHCP) is another industry standard Open Source package. It is also another infrastructure service with very low end-user visibility. This makes it an attractive target for replacement early in your implementation plan.

The Microsoft DHCP server keeps its configuration data in a .mdb file. Exporting this data and transferring it to a plain text file for further editing is likely not feasible. This will be an issue if you have a large number of scopes or reserved IP addresses. If you have few of these, then manually entering them should not be a problem.

Clients can be migrated in a piecemeal fashion to the new server by setting up a single scope on the new server before deactivating it on the Microsoft server. Clients in that scope requesting new or refreshed leases should receive them from the new server instead of the old. You can either continue in this manner until done, or enough confidence is gained to complete the rest in a single large cutover.

While DHCP will run on Linux/390, in most cases it will not work as desired. This is because most network interfaces in use on S/390 and zSeries systems do not support broadcast, and DHCP depends on that, both as a server and as a client.

Windows® Internet Name Server (WINS)

Samba can act as a WINS server, if needed. There is one parameter in the `/etc/samba/smb.conf` file that needs to be set (`wins support = yes`), and then the user's clients can be updated to point to the IP address of that server. The same considerations that apply to Microsoft WINS servers apply here as well, in terms of numbers of servers, backup/secondary servers, etc. Initially plan for a one-to-one replacement, with the possibility of reduction later on, depending on actual performance.

Samba does *not* provide a mechanism for replication of the WINS database. Because of this, you should not try to mix Windows® NT and Samba WINS servers on the same network. Clients that register with one server will be unknown by the other server. You should either have all Windows® or all Samba WINS servers. In the case of the "all Samba" scenario, designate one Samba server as the WINS server. Have the other Samba servers act as WINS proxies by setting `"wins proxy = yes"` and `"wins server = xxx.xxx.xxx.xxxx,"` where `"xxx.xxx.xxx.xxx"` is the IP address of the Samba server acting as the WINS server. On the WINS proxy systems, you must *not* specify `"wins support = yes."` A Samba server can either be a WINS server, or a WINS proxy, but not both.

⁷ <http://www.oreilly.com/catalog/dns4/>

Because WINS does not rely on network broadcasts, Linux/390 would be a good fit as a WINS server. Having a Samba server act as a WINS server or proxy, in addition to doing actual file and print serving, should be entirely feasible where server consolidation is desired.

File and Print Server

Basic file and print serving is also a fairly transparent conversion for the end user. Samba was originally designed with the intent of looking as much like a Microsoft-based file and print server as possible. Over the years, this direction has been maintained as much as possible. Even so, there are a number of things to keep in mind when planning the replacement.

1. Automatic printer driver downloading for Windows® NT/2000 clients will probably require some amount of testing and trial and error. Windows® 9x clients will have no problems if you follow the documentation that comes with Samba. Support for the more modern clients is relatively newer, and not as well documented. This is due, in part, to changes Microsoft made for these clients that were not documented.
2. For printers that are directly attached to the server, i.e. not a network printer, so-called "Win printers" will be an issue since the actual printing engine is implemented in the printer driver software and not in the printer hardware. Unless the manufacturer provides a corresponding driver for Linux, the printer will not work.
3. You can expect better performance than Windows® as a file and print server. Recent tests show that Samba 2.2.x out-performs Windows® 2000 by a wide margin⁸.
4. Related to the "better performance" bullet (and part of the cause for it) is that Samba has lower system requirements than Windows®. Your current hardware will almost certainly work well, and perhaps give better performance than before.

If you decide to keep a Windows® server as a Primary Domain Controller, Samba can connect to the PDC (or a BDC) to authenticate users and file access against the domain security database. This requires making the Samba server a member server within the domain, which is accomplished by creating a "machine account" for the Samba system in the domain. This allows users to only have to update their passwords on the domain, and use the same userid and password for access to Samba maintained resources.

Transferring your existing permissions for files and directories should be relatively straightforward. David Boyes, of Sine Nomine Associates, provided two fairly simple methods⁹:

"The SLIST command (on the NT Resource Kit) will display the permissions applied to files and directories; I pipe that into a file and then process that with a Perl script on the Linux side. Another method I've seen is to enable NetWare Services and then use the NetWare to NT conversion tool included with NT to extract that info (it produces a nifty report that you can parse with REXX or Perl)."

⁸ <http://www.itweek.co.uk/News/1131114> and
<http://www.pcmag.com/article/0,2997,s%253D1474%2526a%253D16554,00.asp>

⁹ <http://www.marist.edu/htbin/wlvttype?LINUX-VM.28559>

For the more advanced permissions supported by Windows® NT, ACL support will need to be compiled into the Linux kernel so that it can be exploited by Samba. Unfortunately, this support is not included in the official Linux kernel, so it has to be added as a patch¹⁰. Adding this support, therefore, is probably not for a beginning Linux system administrator, as there may be conflicts between the ACL patch and what patches your Linux distributor has added to the kernel.

Setting up all your printers will be a manual effort, since there is no way to export that information from Windows®. Since you'll be working with plain text files, duplicating entries, and only changing what is different will speed the data entry effort.

Samba comes with a Web browser-based configuration tool, named SWAT (Samba Web Administration Tool). Getting it set up and working is usually handled automatically by the installation process. In those distributions where it is not, the task is trivial. Two files in the `/etc` directory must be edited (`inetd.conf` and `services`), and the `inetd` process signaled to re-read `/etc/inetd.conf`. In addition to configuring your Samba server, it also provides browser access to documentation for all the configuration options. This can be very useful when trying to figure out exactly what value should be entered for a particular option. SWAT provides its own HTTP function, so even if you don't have a Web server installed on your system, SWAT will still be usable.

NFS is another option for file serving, and one in wide use among Linux and UNIX systems. It is probably not the best choice for shops with large amounts of Windows® desktop systems. Microsoft does not include an NFS client for its desktop systems, so additional costs would be incurred to provide one. Additional end user training would be necessary to teach them how to use NFS effectively. Given that Samba implements the native Windows® file sharing protocol that your users are already accustomed to using, NFS isn't as attractive as it would be in a non-Microsoft environment.

File and print serving using Samba is another role where Linux/390 is a good candidate. The files to be served will be on the mainframe, where full volume and file-level backups are most likely performed regularly. Coupled with tape automation, restoring files can be accomplished more quickly and easily, and require less system administrator time than with typical "mid range" backup and restore solutions.

FTP Server

There are a large number of FTP servers available for Linux. The `wu-ftp`d server is one of the most common, but has a long history of security vulnerabilities. Since that is one of the things you're trying to get away from, you might want to consider two others, `ProFTPD` and `vsftpd`. `ProFTPD` is becoming more popular for a number of reasons, including being more secure. `vsftpd` hasn't had a lot of publicity, and isn't very common, but consider this statement on the package's Web page: "The latest release is v1.0.1. There has not been a new release in a while, simply because no-one has reported any bugs." You're more likely to find `ProFTPD` on your Linux distribution than `vsftpd` today, but that appears to be changing. Red Hat has included it in their 7.3 distribution, and Debian will include it in their next version.

Some additional planning will be necessary if you intend on having non-anonymous servers, versus anonymous servers. If you configure the FTP server for anonymous access only, you will not have to establish user accounts on the Linux system. For cases where all you want is to make files available for download, this is preferable to establishing accounts, since the FTP protocol is not encrypted in any way. Users signing onto the server will be sending their userids and passwords in plaintext, making them vulnerable to being intercepted by anyone running a network "sniffer." The data is also transferred "in the clear," making the whole

¹⁰ <http://acl.bestbits.at/>

transaction vulnerable. There are secure FTP servers and clients available, but they are not "transparent" to the end user, and not integrated into their favorite Web browser, making it difficult to establish their use in your infrastructure. If you are in a position to mandate the use of a secure server and clients, and can make it stick, it will be worth it in the long run.

If you absolutely need to establish non-anonymous access, please consider two other alternatives before resorting to insecure FTP. The Kermit project out of Columbia University has a secure FTP client available, and links to secure FTP servers. Besides Kermit, most SSH servers and clients come with a "secure copy" (scp) command that encrypts everything, including userids, passwords/keys, and the data. Since you would be establishing user accounts on the server anyway, this represents the best alternative to insecure non-anonymous FTP. Additional processor cycles will be consumed on both ends of the transfer to perform the encryption. Some hardware platforms have cryptographic co-processors available to offload that work from the main processors, but they are usually extra cost options. If you plan on doing a large amount of encrypted work anyway, such as SSL-secured Web server transactions, having a cryptographic co-processor can increase the amount of traffic your site can handle considerably.

If you have any applications or automation that parse the output from FTP "ls" or "dir" commands, these will need to be modified to work with the Linux-based server instead. The same will be true of any tools/utilities that scan the server logs. The commands supported by one FTP server versus another can vary also. While most Linux-based FTP servers tend to implement more of the FTP command set than Microsoft does, you should make sure that is the case for your workload.

FTP servers are good candidates for Linux/390, for much the same reasons as file serving. The regular discipline and ease of backup in the typical mainframe shop is very advantageous when data files are changing regularly.

HTTP Server

Apache is the most popular Web server in the world. According to the Netcraft Web server survey¹¹, Apache powers nearly 60% of the Web servers on the Internet. The most popular after that is Microsoft's IIS server, with approximately 30%. Netcraft documents the difficulty of obtaining accurate statistics on Web servers, but their methodology produces what is probably the best information that is currently available. In any event, Apache is another industry standard Open Source package that many companies routinely depend upon to run their business.

According to tests done by eWeek¹², Apache's performance running on Windows® 2000 is equivalent to that of IIS. Given Apache's history of being written for UNIX platforms first, and not Windows®, it's reasonable to assume that Apache running on Linux would see the same or better performance on the same hardware. Apache has far fewer security exposures compared to IIS, but there are still exposures. The recently discovered "chunked transfer encoding" vulnerability in Apache reinforces the point that keeping abreast of security fixes is an absolute necessity, regardless of the platform involved.

Web applications written as Active Server Pages will not run natively on any platform other than IIS. If you have a large number of these, and/or don't want to re-write them, there are some choices available to enable the support on non-Microsoft platforms. Halcyon Software has a product called InstantASP (iASP), and Chili!Soft (now part of Sun Microsystems) has a product called Sun One Active Server Pages (previously named Chili!Soft ASP). As with

¹¹ <http://www.netcraft.com/survey/>

¹² http://searchwebmanagement.techtarget.com/originalContent/0,289142,sid27_gci817631,00.html

competing products in any category, there are conflicting claims of performance leadership, capability, and so on. As always, an evaluation of both products would be necessary to determine which is best for any particular workload. The iASP product appears to involve pre-compiling the ASP applications, which would tend towards better execution-time performance. Access to COM objects is an issue for both products, but Halcyon claims their R-JAX product solves it. Again, evaluation will be necessary to substantiate any claims for your specific workload.

For more portable dynamic Web content, there are numerous choices.

1. Java Server Pages (JSP)
2. PHP scripting
3. Apache mod_asp module. (Support is provided via Perl scripting in the module. Access to COM objects is not possible, making this support of limited value.)

Web servers are another good candidate for Linux/390. This is particularly true when access to a database on OS/390 or z/OS is needed. Placing the Web server and the application requiring access to the database on the same physical hardware as the database can provide tremendous flexibility and I/O power. Halcyon's iASP product is available for many platforms, including Linux/390. Sun One ASP is available for Intel Linux, but not Linux/390. It is likely that it never will be available for Linux/390.

FrontPage Extensions are available for Apache, and work well on Intel Linux. Since parts of the extensions are Intel binary executables, not all of them will run on Linux/390. It is unknown at this time if they will ever be ported to Linux/390.

Web Application Server (Java)

Many areas of Java are rapidly changing: standards, reference implementations, and products. This is probably one of the most confusing and difficult topics to understand. The technical details of the various packages won't be discussed. Time and space simply won't allow for that. Instead, we'll try to touch on some of the highlights. Also, there is an extensive review of Web application servers available that was performed by Owendo Technology in 2001¹³. Getting access to the study requires registration, but it is free. With the exception of iPlanet, all of these application servers will run on Linux/390. As is noted in the section on WebSphere, the resource requirements of an application server may make it difficult to run many instances on a single mainframe, or to share a discrete server with other services. Take this into consideration when you begin planning.

Jakarta/Tomcat/Catalina

Just what the heck are all these names? According to the Apache Software Foundation Web page, "The Jakarta Project creates and maintains open source solutions on the Java platform for distribution to the public at no charge." Tomcat, a sub-project under Jakarta, "is the servlet container that is used in the official Reference Implementation for the Java Servlet and JavaServer Pages technologies." Catalina is a "new servlet container" initially implemented in Tomcat 4.0. And it only gets more confusing from there, as people more familiar with the terminology and technology throw these and other names around, seemingly at random.

Tomcat is probably the most popular Open Source Java Servlet and JavaServer Pages "engine" available. Even IBM includes it as a no-cost option with its HTTP server (which is

¹³ http://e-serv.ebizq.net/shared/goldclub.jsp?owendo_1b.html

based on Apache)¹⁴, for customers that don't have a need (or the money) for IBM's WebSphere product. In their marketing literature, IBM makes the point that Tomcat "does not support Enterprise JavaBeans, it is not J2EE compliant, it doesn't provide Domino integration and more," which is true. It is only intended as a Servlet and JSP engine. If that's what you need, and are looking for a good Open Source package to provide it, Tomcat is a good choice for you. Even if you do need more than that, Tomcat in conjunction with Jboss (see below) may very well satisfy your needs at a much lower cost. According to the Tomcat project Web page¹⁵, "The 4.x releases implement the Servlet 2.3 and JSP 1.2 specifications."

Jboss

The Jboss Web site declares that "Jboss is an Open Source, standards-compliant, application server implemented in 100% Pure Java and distributed for free," and lays claim to being "The Java App-Server reference implementation." The fact that a lot of job listings for Java developers explicitly list Jboss as a requirement would seem to back up their claims. A lot of discussions in Usenet news would do the same. Versions of Jboss prior to 3.0 required a separate Servlet and JSP engine to be complete. Tomcat was the product of choice for the Jboss project team, and most of the people that used Jboss. With the 3.0 version, Tomcat is no longer needed, although it is still an optional form of the Jboss packaging provided by the project team. There is little discussion or anecdotal evidence of what kind of performance Jboss is capable of delivering, but there is some, at least for older versions¹⁶. In general, the performance was reasonable, although it declines with increasing client load. Older versions of Jboss did not support clustering, which makes this a concern for high-traffic sites. Jboss 3.0 does support clustering, but new performance data on it is not yet available. CMIS Research has put together an ECPeRF test kit for Jboss, and made it available for downloading if you would like to do your own benchmarking. The only restriction is that you cannot *release* your results, because it would "be against the ECPeRF procedures."¹⁷

WebSphere

IBM's marketing group has caused a fair amount of confusion with their naming practices (nothing new for anyone already familiar with IBM). WebSphere initially started out being IBM's HTTP server. The application server part was just called the Web Application Server (WAS). Then, they changed WebSphere to mean the WAS, and the HTTP server became called HTTP Server. Then, they changed WebSphere to be a product line that includes a lot of applications that run on the WAS, with the WebSphere Application Server (still WAS) being the enabler for all the rest. So, when talking about WebSphere, make sure you understand exactly what is being discussed, or things will get even more confusing than they already are. With that bit of history out of the way, the things that you'll actually care about follow.

The WebSphere Application Server is a bit of a resource hog. IBM recommends that storage sizes *start* at 512MB, and that more may be needed. For Linux/390, this obviously limits the number of instances that can be run on a given machine. For other architectures, it limits what else may be running on the same server as WebSphere.

IBM's pricing for WebSphere on Linux and Linux/390 is the same, which could create some interesting opportunities for cost avoidance for an innovative shop with both Intel systems and IBM mainframes. WebSphere's reputation is that it is a very good product, just big and expensive. The fact that it runs on a number of different platforms, including Windows®, at a consistent price, means that the same application server could be deployed across all of them, providing some consistency for both application developers, as well as the system support

¹⁴ <http://www-1.ibm.com/servers/eserver/iserries/software/http/services/tomcat.html>

¹⁵ <http://jakarta.apache.org/tomcat/index.html>

¹⁶ <http://www.cmis.csiro.au/adsat/jboss.htm>

¹⁷ <http://www.cmis.csiro.au/adsat/jbossecperf.htm>

staff. Although WebSphere itself is fairly complex, the fact that it can reduce complexity in other areas is attractive.

iPlanet

iPlanet is a relative late-comer to the application server market, which is ironic considering Sun's role in developing Java in the first place. iPlanet started out as essentially an amalgamation of the Kiva/Netscape Application Server, and the NetDynamics Application Server, both of which Sun acquired from other companies. Since then, Sun has made a number of changes, but it still trails IBM's WebSphere and BEA's WebLogic servers in the market.

iPlanet is available for Intel Linux, but will likely never be available for Linux/390, due to Sun's antipathy towards Linux/390. This is largely due to the threat that Linux/390 poses to Sun's hardware sales. This limits the platforms on which iPlanet is available, causing constraints on flexibility that aren't there with other application servers. Still, that constraint is not a particularly onerous one, as it is available on AIX, NT, Solaris, Linux, HP-UX, and Compaq Tru64.

BEA WebLogic

BEA's WebLogic server consistently shows up at the top of many surveys on which products have the best support for various standards, which ones scale well, which ones are easy to manage, and so on. A good argument could be made that WebLogic is the all-around best commercial application server on the market. BEA's competitors are closing in on it, though, and in some cases surpassing it. The ECPerf benchmark results¹⁸ show that Oracle, Sybase, and IBM are either better performers, or better price-performers. Making a decision in this kind of a tight race for market would be difficult, to say the least, particularly when considering the dollar amounts involved. (One thing to note: Microsoft's application server products don't show up on the list at all.) To make it even more difficult, price and performance are only two of the factors to consider when trying to make a decision on a piece of software as potentially important as an application server. The Owendo Technology paper mentioned above would be a good place to start to help you define your own criteria and focus your search.

Remote Access Server

Using the pppd package that is included in every distribution, Linux can act as a remote access server for both the SLIP and PPP protocols. It also supports a variety of authentication protocols, such as PAP, CHAP, and RADIUS. Microsoft implemented their own version of the CHAP protocol, called MS-CHAP. This introduces some complexities to conversion, of course.

If your shop is using MS-CHAP authentication, your dialup users will need to change the properties of the dialup networking entry to correctly operate with a Linux server. The choices available for the "Dial-up Networking" properties are:

1. Accept any authentication including clear text.
2. Accept only encrypted authentication.
3. Accept only Microsoft encrypted authentication.

If you're concerned about network security (you *are* concerned, aren't you?), you will want to have your users connecting with "Accept only encrypted authentication." This means that the dialup user will be able to respond to any authentication scheme requested by the server,

¹⁸ <http://ecperf.theserverside.com/ecperf/>

except PAP, which is not encrypted. PAP is truly not desirable because all userids and passwords are transmitted in clear text. Given the human tendency to reuse the same password in different places, this represents a very real security exposure for your entire infrastructure.

Because Microsoft RAS authenticates dialup users in the same way it validates local logins, i.e. using the Windows® security database, there is no way to extract the userid/password pairs for migration to the Linux RAS system. These will have to be created manually with new passwords for each user. Since this will necessitate contacting every user, this would be a good time to validate that each user still requires RAS access.

IP forwarding must be turned on in the Linux kernel. This statement may not mean much to you now, but it will be important to remember. IP forwarding is what allows an IP packet from a dialup user to be sent through the dialup server to the system that it is really intended to reach, and vice versa.

Domain Controller

Samba can act as a Primary Domain Controller for a Windows® NT domain. If you don't have any Windows® 2000 or Windows® XP clients, using Samba as a Primary Domain Controller (PDC) should be relatively straightforward, unless you're using some of the functionality described below as not supported in the 2.2 releases. Acting as a PDC is one area where Samba is better suited for smaller shops that don't have more than one domain, have older desktop clients, and so on. Quoting from the Samba documentation¹⁹:

1. The following functionality should work in Samba 2.2:
 - Domain logons for Windows® NT 4.0/2000 clients.
 - Placing a Windows® 9x client in user level security.
 - Retrieving a list of users and groups from a Samba PDC to Windows® 9x/NT/2000 clients.
 - Roving (roaming) user profiles.
 - Windows® NT 4.0-style system policies.
2. The following pieces of functionality are not included in the Samba 2.2 release:
 - Windows® NT 4 domain trusts.
 - SAM replication with Windows® NT 4.0 Domain Controllers (i.e. a Samba PDC and a Windows® NT BDC or vice versa).
 - Adding users via the User Manager for Domains.
 - Acting as a Windows® 2000 Domain Controller (i.e. Kerberos and Active Directory).

¹⁹ <http://www.samba.org/samba/ftp/docs/htmldocs/Samba-HOWTO-Collection.html#SAMBA-PDC>

As you can see, some of the more advanced features of PDCs are not available in Samba. If those features are not currently in use, then Samba will perform well as a PDC. If the PDC is a Samba system, you can set up another Samba system to act as a BDC. You will need to use rsync to replicate the smbpasswd file between Samba Domain Controllers, since Samba does not do that itself. If you are replacing your NT PDC with a Samba one, there a utility named pwdump.exe on the samba.org FT server that will read the registry and extract userids along with their associated encrypted passwords, and write them out in a Samba format smbpasswd file. This program requires that you be logged on as "administrator" to run it. This makes migrating accounts from an NT PDC to a Samba one nearly painless.

If you are not using NT domains, just workgroups, Samba will function equally as well as a logon server for your Windows® 9x desktop clients.

While Linux/390 would most likely be a good candidate for the role of a Samba PDC, there has been little discussion of that in the Linux/390 community. This is most likely because Linux/390 is so new that few, if any, people have yet been able to convince their management to try it in that role.

Email Server

There are a number of things that need to be examined when talking about replacing your email server. Do you want your users to keep using the same desktop client? Are they only using POP or IMAP access, or are you using MSMail or Exchange? How much of the current email server functionality are they using? Normally, end users are very resistant to any sort of change in their applications. Email is certainly one of the "touchier" ones, particularly since email is a mission-critical application for most companies, even though it is not always recognized as such. Disrupt the flow of email, however, and it will be quickly apparent to many people just how much work gets done using it.

If your email users are currently using only POP or IMAP as their email protocol, there should be no disruption as a result of a migration. If they are using MSMail or Exchange, things get a little more complicated (and expensive). There are any number of email servers that provide POP and IMAP access. There are also a number of Web-based email interfaces that use POP and IMAP as the interface to the email server. For this paper, we will be discussing Exim, IMP, Postfix, Sendmail, and Insight.

With the exception of Bynari's Insight Server, setting up user accounts will be a largely manual process. Bynari claims to have developed tools to automate the extraction of account names and passwords from Exchange: "Administrators can provide migration of user's accounts on the server side programmatically. Numerous migration tools and custom scripts exist in Perl, the C Computer language, PHP, etc."

Sendmail is the oldest and most widely used Open Source email server. It is used on about 70% of the email servers in the world. It is also one of the most complex servers to configure. Entire books have been written on that task alone. The "Unix System Administration Handbook" calls Sendmail "The most complex and complete mail delivery system in common use..." Over the years, extra functionality and connectivity have been added to Sendmail, making it nearly impossible for any one person to understand completely. Still, it is an industry standard for a good reason. It is a very good, well-supported email server. It is included in just about all the major Linux distributions.

There is also a commercial version of Sendmail available, packaged as three separate "solutions": Mailstream Manager, Integrated Mail Suite, and High Volume Mail. These packages include maintenance and support services. The Open Source, non-commercial version of Sendmail has been delivering mail quite well for a long, long time. Whether your shop needs the added bells and whistles and cost of the commercial version is something only you can decide.

Exim is another popular Open Source email server, although not as popular as Sendmail. It does have a number of things to recommend it, however. It is much simpler to configure, and has very good performance characteristics. Because Exim was intended to be simpler to configure, it does not support some of the more esoteric features that Sendmail does. Exim handles addresses in RFC 822 domain format only. It does not support "bang paths" which is an addressing syntax that specifies the path from your host to a remote host and user with '!'s (bangs) used as a separator. For example: att!cblpf!joeThe only external transport currently implemented is an SMTP transport over a TCP/IP network. Do these limitations sound like things you will miss? I didn't think so. Exim has some "optional" features such as monitoring and performance tools. These will likely be of far more use than the "missing" features you won't be using anyway.

Postfix originated as an alternative to Sendmail. To quote the Postfix Web site, "Postfix attempts to be fast, easy to administer, and secure, while at the same time being sendmail compatible enough to not upset existing users. Thus, the outside has a sendmail-ish flavor, but the inside is completely different." In 1998, an IBM employee named Wietse Venema was distributing it as an Open Source package under the name IBM Secure Mailer. IBM never really marketed it, but they officially allowed the employee to work on it, and provided Web space for the project, discussion forums, and so on. It eventually became known as Postfix. Like Exim, it is not nearly as popular as Sendmail, but is generally considered less vulnerable to security exposures by design and performs well. It is designed as a "drop-in" replacement for Sendmail from a user's perspective.

Internet Messaging Program (IMP) is not an email server, per se. It is an Open Source package that provides your users with a web interface to whatever email server you are running. Written in the PHP scripting language, it can provide both POP and IMAP access. IMP will work out of the box with any standards-compliant POP/IMAP email server, including Microsoft Exchange. If your users have a need/desire for Web access to their email, take a serious look at IMP.

Bynari, Inc. offers three commercial products that are email and groupware related:

1. Insight Server Enterprise Edition - a Linux for S/390 and zSeries-based server that combines the functionality of both Insight Server Standard Edition, and InsightConnector.
2. Insight Server Standard Edition - an Intel-based SMTP server with server-side calendaring that works with Outlook and many other email clients.
3. InsightConnector for Outlook - allows generic mail servers (such as Insight Server SE) to provide complete Exchange server services to Microsoft Outlook users, plus some that Exchange does *not* provide²⁰. The list is very impressive.

Bynari used to provide a fourth product, Insight Client, which allows UNIX and Linux workstations to participate in Microsoft Exchange environments. Bynari has stopped development of that in favor of endorsing Ximian's Evolution product. Even though development has been stopped, the software is still available for free download. The software "key" is available on their Web site²¹.

²⁰ http://www.bynari.net/bynari/insightcon_features.html

²¹ <http://www.bynari.net/downloads.html#keys>

Bynari also offers free download of the Intel version of their Insight Server. The verbiage on the download page is a little confusing, however. They state "You can use Insight Server to test or use InsightConnector with Outlook, for production use with any email client such as Outlook Express, Eudora, Pine, Netscape Messenger and or Ximian's Evolution. This offer is unlimited however, we hope you will only download one server per individual, company or organization." Perhaps they're concerned about conserving bandwidth on their servers, but that doesn't sound very plausible. In any case, being able to test the software at no cost before deciding to commit your infrastructure to it is very attractive.

Insight Server is made up of various Open Source packages, plus some Bynari-written Outlook Extensions code to tie them all together and implement the desired features on top. The Open Source packages are:

1. Cyrus (Mail Delivery Agent, POP3 and IMAP)
2. OpenLDAP
3. Exim (Mail Transfer Agent, SMTP)
4. Apache Web server
5. ProFTPD FTP server
6. SASL (Simple Authentication and Security Layer)
7. PAM (Pluggable Authentication Modules)
8. GDBM (GNU database indexing library)
9. DB (Berkeley Database)

Insight server both performs better than Exchange and scales better. The current recommendation for Exchange 2000 seems to be 2000 email user accounts per server. Insight Server by contrast scales well enough to support 64,000 mail users on a single-processor IBM S/390 system. Running on the same Intel hardware as Exchange, Insight Server should deliver better performance.

For shops with both S/390 hardware, and large numbers of Exchange Servers, the scalability of Insight Server can provide enormous savings over migrating to Exchange 2000. Since perhaps only one Insight Server will be needed to support your email users, only one server license will need to be purchased. Client licenses are in the range of \$20 or less, not much different from what Microsoft charges for large orders. The Bynari Web site has a TCO study that IBM developed (so take it with a grain of salt, to say the least, and try to see how it relates to *your* environment) on this scenario²².

As can be deduced from all the above discussion, email serving is another category that is a good fit for Linux/390. All of the products that have been discussed here are known to run on that platform.

Groupware Server

As discussed in the email considerations, Bynari Insight Server and Insight Connector allow Outlook users to continue to use all the features of Outlook without an Exchange server. Some of the groupware functions that users require, such as sharing calendars and meeting scheduling, are satisfied in that manner, but there are others that are not.

²² http://www.bynari.net/whitepapers_lechner.html

Some shops use tools such as NetMeeting for collaboration when teams are geographically dispersed. The application sharing and audio/video conferencing can be very helpful in cutting travel costs and lost time due to travel. The downside to NetMeeting is that frequently performance can be poor, even for moderate numbers of people in a "meeting", and particularly if any attendees are connected via dialup lines. Still, the functionality is there, and if it's being used, it will need to be replaced in some way.

Fortunately, the NetMeeting server is essentially just an LDAP server that NetMeeting clients use to figure out where other people or computers are on the network so that they can connect to them directly. Unfortunately, NetMeeting violates the LDAP protocol in a number of ways²³ so standards-compliant packages such as OpenLDAP must be modified to work with the "broken" NetMeeting clients. Documentation on how to set up a Linux-based NetMeeting server is available in the form of the "Linux NetMeeting HOWTO" at the freesoft.org Web site. They have appropriately modified software on their FTP server (called the NetMeeting Directory Kit) that can be easily installed. Since the only important information held by a NetMeeting server is obtained when users connect to it, there will be little in the way of configuration needed, and that is also contained in the HOWTO document. The modifications needed to let OpenLDAP work with NetMeeting do *not* prevent it from performing normally when standards-compliant clients connect to it. Therefore, you will not have to have a separate OpenLDAP server to handle just NetMeeting tasks.

Other collaboration tools, such as Internet Relay Chat (IRC), Instant Messaging (ICQ), and Usenet News (INN) all have one or more established Linux-based servers available on just about any Linux distribution. Getting them running in your environment shouldn't involve much more than following the installation and configuration documentation that comes with the software.

All of these server types have been ported to run on Linux/390. They are typically not very CPU-intensive, and so would be good candidates for that platform.

Database Server

There are a number of database packages available for Linux, covering a range of capabilities, with a corresponding range of complexities in setup and management. Which one (or few) you choose will depend on your needs in any particular situation. While it's helpful to keep your software portfolio as simple as possible, you might want to consider whether you really need the highest-powered server for use in all circumstances. The cost in system administrator time alone might make it worthwhile to have more than one choice available.

There are a number of Open Source SQL-based packages available. By far the most popular two are MySQL and PostgreSQL. For quite a long time, MySQL offered the better performance, while PostgreSQL had more functionality, and supported "transactions," which MySQL did not, and still does not. The last few releases of PostgreSQL have closed the performance gap considerably. There are some areas in which it actually is better. In any case, both are good choices. They are major products, of commercial quality. They are both well supported, with a large user base. Both of them are included on just about all the major Linux distributions.

SAP AG has given their SAPDB product over to Open Source, in hopes of increasing the market share for it, and hence their other products that use the database. Whether that strategy is working or not is unknown, but having another commercial-quality Open Source database available is good for Linux, and good for people and businesses that want to use Linux. The product is being actively developed and supported by SAP AG, using the Open Source methodology. In this case, that means a number of SAP AG employees are primarily

²³ <http://www.freesoft.org/software/NetMeeting/a490.html>

responsible for development, and they also act as a gateway for community contributions to the product.

Firebird is the last Open Source database to be discussed, although there are many others. Firebird is based on the Interbase database that is available from Borland Software Corporation (previously known as Imprise Corporation). The history of how this came about is rather convoluted, and won't be covered here, but the Firebird project page covers it if you're interested. Suffice it to say that the source became available, and a group of people took it and formed the Firebird project. Their first production quality version, 1.0, was released on March 12, 2002. Firebird has essentially the same functionality as Interbase, so if you're familiar with that, Firebird should present no real surprises.

If you've outgrown the capabilities of the various Open Source databases, commercial database products for Linux have been available for some time, and the number of them is increasing. In fact, Microsoft's SQL Server is just about the only major database product for Windows® that is not available for Linux. Oracle, DB2, Informix, Ingres, and Sybase are all available, and in wide use. Configuration for these products should be the same as their Windows® counterparts. Migration of configuration should be fairly straightforward, and supported by tools from the software supplier if needed.

IBM's S/390 and zSeries hardware is unsurpassed in its ability to move data. Because of this, using Linux/390 is a good fit either as a database server, or as an interface between a database running in a different LPAR (or VM guest), and the network. Oracle, DB2, Ingres, and the Open Source products are all available on Linux/390.

Proxy/Gateway/Firewall

Linux comes with a native firewall and transparent proxy/gateway capability. Linux also has native support for Network Address Translation (NAT), also known as IP masquerading. In the 2.2 kernels, the firewall/NAT software is called "ipchains." In the 2.4 kernels, it is "iptables." The capabilities of iptables are considerably better than ipchains, in that it is what is called a "stateful" system. That is, when it examines a particular network packet, it can determine if it is associated with a previously seen packet, and make decisions about what to do with the new packet based on that knowledge. This provides a lot more power and flexibility to the firewall administrator to allow wanted traffic while preventing unwanted traffic.

Since iptables is relatively new, there is not a large body of documented prior user experience to draw on. As time goes on, and more people share information and experiences, this will change, just as it did when ipchains first arrived. The NAT/IP masquerading aspects haven't changed significantly, so much of the information that's available for Linux 2.2 should still apply.

Creating the "rules" for the firewall consists of entering ipchains/iptables commands in a text script file, which gets executed at system boot time before connecting to the network. There are GUI tools to simplify this, some of them quite sophisticated. One of these is Guarddog, but certainly not the only one. In many cases, terribly complex firewall setups are not needed. If you follow the basic security philosophy that "whatever is not explicitly permitted is denied," your firewall rule sets can be relatively short. There is even a Web site²⁴ maintained by Robert Ziegler, the author of "Linux Firewalls" that will generate an ipchains script for you based on selecting which services and which clients you want to be able to traverse the firewall. This is an excellent way to get a "starter set" of rules established that can then be easily maintained as your needs evolve.

²⁴ <http://www.linux-firewall-tools.com/linux/firewall/index.html>

If you're more interested in a commercial firewall product, Check Point Software Technologies, the makers of Firewall-1, do offer a Linux version of their product. Other firewall software suppliers are doing the same, or soon will. If you're already a user of one of these products, and would feel more comfortable sticking with it, most likely it is available for Linux, or will be soon. Linuxworld Magazine had a three-part series on firewalls for Linux, covering Open Source, proprietary, and Linux "appliance" products.²⁵ It was written in late 2000, but is still worth reading to get an idea of what ipchains looks like, and what Open Source and commercial products are on the market.

If you're currently running a socks proxy server, there are socks proxy servers available for Linux, such as Dante, that support both versions 4 and 5 of the socks protocol. Your socks-enabled clients should not notice any difference between your current proxy server and Dante.

Squid is probably the best, and best-known, Open Source proxy server. In addition to being an HTTP, FTP, and SSL proxy server, it will also perform caching of "Internet objects," reducing access time as well as bandwidth requirements. Squid can be run in transparent mode, or require your users to authenticate themselves before they can get to the "outside," as your policies dictate. There is quite a bit of documentation, as well as an extensive Frequently Asked Questions (FAQ) document, on setting up and using Squid on the Squid Web site.

Using Linux/390 systems running on VM or z/VM as firewalls raises some interesting possibilities for network configurations. Very complex network architectures can be created with multiple levels of firewalls, proxies, Web servers, database servers, and so on, all within the confines of a single physical box. Some of IBM's more impressive-looking proposals for the use of Linux/390 have been along these lines and demonstrate the power and flexibility that Linux/390 can bring to bear.

System Management Software

There are a number of products available to help you effectively manage your systems, far too many to cover in any detail. Some of them are Open Source while others are commercial products. Many of the commercial products are ones you may already be using on your Windows® systems from suppliers such as BMC Software and Computer Associates.

Some products that you were using previously, such as pcAnywhere or Remotely Possible, will probably not be needed any longer. Linux has several methods that allow a system administrator to login remotely, telnet, and SSH. SSH is preferred, since it is secure and encrypted. There is a secure telnet client available from the Kermit project out of Columbia University. The project also has links to secure telnet servers. Secure telnet has not been widely adopted, but it is certainly worth examining. Since secure telnet is not included on most Linux distributions, it is less convenient than installing OpenSSH. The Kermit project documentation claims that SSH is insecure, even though encrypted, since the initial exchange of public keys is done over the same channel as the rest of the authentication process. There is some validity to this argument, but SSH does have means built into it of making the risk from this manageable. Many, many people use SSH with few reported problems. There was a major vulnerability reported against versions 2.3.1 to 3.3, so make sure you have a current version installed.

SSH will also "tunnel" X Window traffic so that your administrators can use a GUI to access the systems they're administering. This is not really recommended, since the network load is high, but it is possible. It also requires having an X Window server running on your desktop system. There are several of these available for Windows®-based systems, but the good ones

²⁵ <http://www.linuxworld.com/linuxworld/lw-2000-10/lw-10-fwproducts1.html>

are not cheap. For all these reasons, the Virtual Network Computing (VNC) package is more popular for exporting graphical environments over a network.

Application Migration Considerations

If you develop your own internal applications, porting applications from Solaris and other UNIX systems is generally not a problem unless operating system features unique to that platform have been exploited. Then things can get very complicated, very quickly. IBM has published a guide on porting applications from Solaris to Linux that may be useful.²⁶

Porting applications from Windows® NT/2000 is likely to be much more difficult, with a correspondingly higher level of risk. It may be advisable to defer re-writing those applications until they are due for complete replacement. Please note that this discussion is only for applications that need to be run *on a Windows® server*. If an application's executable files reside on a file server, and are executed by a client on the client system itself, no porting, per se, should be necessary. Samba is just as happy serving up win32 applications to your users as anything else.

Your developers will need to learn to use new development tools, as the one's they're used to will likely not exist for Linux. This *will* have a significant impact on developer productivity for at least the short term. GUI-based integrated development environments (IDEs) do exist for Linux. A quick search on Freshmeat²⁷ will show over 100 IDEs for various purposes. As in other areas, there are commercial development tools available. Some of these, such as CodeWarrior, are tracked on Freshmeat along with their Open Source counterparts.

The Downside to Migrating

There is always a downside to everything, whether you leave things alone, or decide to make a change. We covered some of the downsides of leaving things the way they are in the "*Reasons To Move Away from Microsoft Operating Systems*" section. Here, we'll talk about some of the possible negative consequences to making a change to Linux servers.

1. **Initially increased training costs.** Your technical support team is going to need additional training to prepare them for supporting Linux and Open Source software. This training can be relatively simple if you plan to rely heavily on a commercial support company. If you want to have a moderate amount of self-reliance, the training requirements increase considerably. If you want your staff to be Linux certified, the time and money requirements will go up even more. Linux system administrators are not created overnight, any more than Windows® system administrators are, so some patience will be needed in this area. You may also face employees leaving because they don't want to change to supporting Linux systems.
2. **Possibly finding new support provider(s).** If you are an entirely Windows®-based shop, you will need to find a Linux support provider. If you already have some amount of UNIX work running, your current support company may, or may not, be willing to add your Linux systems to the contract. In any case, shop around, as competition will save you money when negotiating the support you need. You may very well change support providers multiple times before finding one that gives you the service levels you need at a price you can afford.

²⁶ <http://www.ibm.com/developerworks/linux/library/l-solar/>

²⁷ http://freshmeat.net/browse/65/?topic_id=65

3. **Having to learn new ways of obtaining software and support.** You will spend some time and effort figuring out the best way to get fixes for your problems and getting software for your needs. If you're choosing Open Source products, you'll need to do some more research than usual, especially if the particular package isn't one of the "big" ones that most people use. (You should be doing this with Windows® applications as well, but many shops don't.) After a while, all of this will be second nature, but in the beginning it will be very confusing, frustrating, and frightening.
4. **Some hardware suppliers don't provide Linux device drivers.** This has always been the case, but is only a problem if the manufacturer won't disclose the details of the interface. Some manufacturers have chosen to allow the Open Source community to develop drivers from their specifications. Others have not, and have also not provided their own Linux drivers. As Linux gains more and more ground in businesses, and particularly in large corporate environments, this has started to change. More and more companies are producing Linux drivers for their products in parallel with Windows® drivers. Still, in relative terms, Windows® supports more hardware than Linux at this point in time.
5. **Open Source software is subject to Sturgeon's Law.** Science fiction author Theodore Sturgeon, once said, "Sure, 90% of science fiction is crud. That's because 90% of everything is crud." Open Source software is no exception. You need to know what you're getting into when you start looking at anything other than the major, well-accepted and tested packages. Smaller, less well-supported packages may be poorly written, not scale well, or even be abandoned by the developers. You will still have the source available, so it will be possible to have it maintained or improved as needed. This is an improvement over proprietary software that is no longer actively marketed and supported, but still not something you want to have happen frequently. Of course, you also have to remember that proprietary software is equally subject to Sturgeon's Law.

What If You Want to Go All the Way and Replace Desktops Also?

What functions would have to be replaced for desktop use of Linux? We won't go into any detail, as any real discussion would require a complete paper for each function. So, just as food for thought, consider these common categories.

1. Email clients
2. Office Suites
 - Word processor
 - Spreadsheet
 - Presentations
 - Lightweight database
3. Groupware clients

4. Window manager/desktop environment
5. Network configuration tools
6. Web browsers
7. Web page design/HTML editing
8. Graphic design/image editing

Understand that end-user training *will* be needed. Any sort of wholesale replacement of desktops without training is reasonably sure to fail. Also keep in mind that short-term productivity will be affected. Your users have years of experience in doing their jobs with Windows®-based tools. There will be a learning curve associated with any sort of change. Over time, though, it's entirely likely that you'll see an increase in productivity due to less system and application failures on their desktops. Just remember that swapping out desktops would not be a good idea if the user cannot afford the productivity loss at that particular time. You might consider having all or part of your technical support staff use a Linux desktop system. That would provide them with a day-to-day exposure to Linux, increasing their familiarity and confidence with it.

Other References

For other reading on the topic of migrating from Windows® to Linux, consider the following two articles. The first is from Dan Shearer of Linuxcare, written in April of 2000. It has some interesting ideas on assessing your current infrastructure, and how to move to one based on open standards and Open Source software. The second is from Quinn P. Coldiron of the University of Nebraska - Lincoln, written in 1997. That article is more of a "user's experience" that talks about initially migrating from Novell to Windows® NT, and then to Linux, and why each step was taken, and how. Coldiron talks specifically about Red Hat Linux, because that is the distribution that was chosen in his case, but the various migration activities he describes are certainly applicable to just about any Linux distribution.

<http://www.linuxcare.com/viewpoints/article/04-19-00ep1>

<http://citv.unl.edu/linux/LinuxPresentation.html>

Summary/Action Plan

With the impending withdrawal of marketing and support for Windows NT Server 4.0, IT managers are faced with the prospect of considerable additional expense to remain on supported versions of Microsoft software. The following summarizes the various steps that should be taken to consider whether, and how, Linux and software that runs on it can be a reasonable alternative.

1. **Review the costs of upgrading to the Microsoft replacement products**, including server licenses, client access licenses, hardware upgrades, increased Microsoft support charges, and the effect of Microsoft Licensing 6.0 Program on your particular organization.
2. **Review what introducing Linux will cost**, including proprietary software licenses, possible consulting fees, support charges, and training costs.
3. **Decide** if you're going to give Linux a place in your shop.

4. **For shops with S/390 systems, consider obtaining an Integrated Facility for Linux (IFL) processor**, running Linux/390 on z/VM, and using that platform for server consolidation.
5. **Decide** if you're going to replace Windows® NT Server completely or partially.
6. If partially, **decide which functions you're willing to replace**.
7. **Decide what replacement products will be deployed**.
8. **Decide on the order of replacement** as the beginning of your implementation plan. Choose something easy for the first few projects, then move on to what will give you the most business value.
9. **Investigate the system management tools** that are available for Linux and Linux/390.
10. **Select a Linux distribution**, and decide how to obtain it.
11. **Select a support provider *before* proceeding** with any implementations.
12. **Develop a training plan** for your internal support staff.
13. **Develop a standard set of software packages** for systems.
14. **Create the customized installation profiles** to implement those standard packages.
15. **Install the software and test** well before trying a test implementation.
16. **Install the system as a test server** and continue testing.
17. **Install the system** in production.
18. After gaining some experience with Linux in a server/infrastructure role, **consider whether Linux has a place on your desktop systems**.

Implementing Linux as a replace to Windows NT Server 4.0 will involve a significant amount of planning and effort. Done properly, the amount of disruption to the end users can be very minimal. Over the long term, significant cost savings can be achieved as a result. Perhaps the most significant benefit that might be gained is one various Open Source advocates have been making to business leaders in recent years. Linux and other Open Source software can give you more control over your business. You will be far less vulnerable to the demands of any one supplier because you will have more *choice*. To anyone trying to run a business, having choices is a Very Good Thing[tm].

Appendix**Web Sites and Online Documentation of Software Discussed in This Paper:**

Apache	http://httpd.apache.org/ http://httpd.apache.org/docs-project/
BIND	http://www.isc.org/
Check Point FireWall-1	http://www.checkpoint.com/
Chili!soft ASP	http://www.chilisoft.com/ http://www.chilisoft.com/caspdoc/
Dante	http://www.inet.no/dante/ http://www.inet.no/dante/doc/
DHCP	http://www.isc.org/
Exim	http://www.exim.org/ http://www.exim.org/docs.html
Firebird	http://firebird.sourceforge.net/ http://firebird.sourceforge.net/index.php?op=doc
Guarddog	http://www.simonzone.com/software/guarddog/ http://www.simonzone.com/software/guarddog/manual2/index.html
Ingres	http://www3.ca.com/Solutions/Product.asp?id=1013
Informix	http://www.ibm.com/software/data/informix/ http://www.informix.com/documentation/
Insight	http://www.bynari.net/ http://www.bynari.net/whitepapers.html
IMP	http://www.horde.org/imp/
InstantASP	http://www.halcyonsoft.com/
iPlanet (now Sun ONE)	http://www.sun.com/software/ http://www.sun.com/documentation/
Jboss	http://www.jboss.org/ http://www.jboss.org/online-manual/HTML/

Kermit	http://www.columbia.edu/kermit/ http://www.columbia.edu/kermit/ftpd.html
Linux Access Control Lists	http://acl.bestbits.at/
Linux, ipchains, iptables	http://www.linux.org/ http://www.tldp.org/
MySQL	http://www.mysql.org/ http://www.mysql.org/documentation/index.html
NetMeeting Directory Kit	http://www.freesoft.org/software/NetMeeting/index.html
OpenSSH	http://www.openssh.org/ http://www.openssh.org/manual.html
Oracle	http://www.oracle.com/
PHP	http://www.php.net/ http://www.php.net/docs.php
Postfix	http://www.postfix.org/ http://www.postfix.org/docs.html
PostgreSQL	http://www.us.postgresql.org/ http://www.postgresql.org/idoocs/
ProFTPD	http://www.proftpd.org/ http://www.proftpd.org/docs/
Samba	http://www.samba.org/ http://www.samba.org/samba/docs/ http://www.samba.org/samba/ftp/docs/htmldocs/using_samba/
SAP DB	http://www.sapdb.org/ http://www.sapdb.org/sap_db_documentation.htm
Sendmail	http://www.sendmail.org/ http://www.sendmail.com/

Squid	http://www.squid-cache.org/ http://www.squid-cache.org/Doc/
Sybase	http://www.sybase.com/home http://www.sybase.com/support/manuals
Tomcat/Catalina	http://jakarta.apache.org/tomcat/index.html http://jakarta.apache.org/tomcat/tomcat-3.2-doc/index.html http://jakarta.apache.org/tomcat/tomcat-3.3-doc/index.html http://jakarta.apache.org/tomcat/tomcat-4.0-doc/index.html http://jakarta.apache.org/tomcat/tomcat-4.1-doc/index.html
UDB/DB2	http://www.ibm.com/software/is/mp/linux/software/db2.shtml http://www.ibm.com/software/data/db2/linux/
VNC	http://www.uk.research.att.com/vnc/ http://www.uk.research.att.com/vnc/docs.html
Vsftpd	http://vsftpd.beasts.org/
WebSphere	http://www.ibm.com/software/is/mp/linux/software/websp.shtml
WebLogic	http://www.bea.com/index.shtml
Webmin	http://www.webmin.com/ http://www.webmin.com/index2.html

Independent Linux Certification Organizations:Linux Professional Institute (LPI) <http://www.lpi.org/>

Software Architecture Implementation and Realization (SAIR)

<http://www.linuxcertification.com/>**Independent National Linux Support Companies:**Caldera Global Services <http://www.caldera.com/services/>²⁸

²⁸ Caldera Global Services is unique in that its parent company, Caldera, provides its own Linux distribution, OpenLinux, but the Global Services division offers commercial support for *any* Linux distribution.

- Linuxcare, Inc. <http://www.linuxcare.com/>
- Mission Critical Linux <http://www.missioncriticallinux.com/> (High Availability clusters)
- Sine Nomine Associates <http://www.sinenomine.net/>
- Sytek Services <http://www.sytek-services.com/>

Hardware Companies that Provide Linux Support Contracts:

- IBM <http://www.ibm.com/>
- HP/Compaq <http://www.hp.com/>
- SGI <http://www.sgi.com/>

For an April 2002 Information Week article, "Teamwork Pays off for Linux," on Linux support companies Caldera, Linuxcare, HP, and IBM, see http://img.cmpnet.com/nc/1309/graphics/1309f3_file.pdf?ls=NCJS_1309rt.

For an August 2001 Gartner Viewpoint article published by ZDNet, "Linux support services: Like any other operating system?" see <http://techupdate.zdnet.com/techupdate/stories/main/0,14179,2808791-1,00.html>.

Common Linux Distributions:

The following list of relatively well-known Linux distributions (and the description of each of them) was taken from the "home" web site of Linux: <http://www.linux.org/dist/list.html>.

"Mainstream" distributions

Caldera OpenLinux <http://www.caldera.com/>

The Caldera OpenLinux Product line is a multi-tasking, multi-user operating system that gives you the power and reliability of UNIX on a personal computer. OpenLinux is Caldera's "distribution" or package of Linux and is surrounded with utilities, graphical interfaces, installation procedures, third party applications, and much more. OpenLinux is ideal for small, medium, and large companies who must optimize their investment in existing systems, hardware and training. Several versions are available.

Conectiva Linux <http://en.conectiva.com/>

Mainstream distribution developed in Brazil. Offers all of the major advantages of a mainstream distribution including ease of installation and setup. The edition for workstations and clients comes with major software packages including StarOffice, Netscape (in native languages), games, image manipulation applications and other utilities. The Server Edition comes with software for network administration, e-commerce and support for RAID and clusters.

Debian GNU/Linux <http://www.debian.org/>

Debian GNU/Linux is a free distribution of the Linux based operating system. It is maintained and updated through the work of many users who volunteer their time and effort. Along with its large selection of prepackaged software, it contains advanced package management tools that allow for easy installation and maintenance on individual systems and workstation clusters. Extensive pre-release testing is done to ensure the highest degree of reliability possible, and a publicly accessible bug tracking system provides an easy way to monitor customer feedback.

Linux Mandrake <http://www.linux-mandrake.com/>

Linux-Mandrake is a friendly Linux Operating System, which comes with KDE, Gnome, Window Maker, Enlightenment and other graphical interfaces. It provides ease of use for both home/office and servers. It is freely available in many languages, all over the world.

Red Hat Linux <http://www.redhat.com/>

Red Hat Linux is one of the most popular distributions in the world. It is geared toward all levels of users. The beginner will find ease of installation and configuration. The advanced user will find a robust and highly configurable computing environment adaptable to any need.

Slackware Linux <http://www.slackware.com/>

Slackware Linux is compatible with most Intel PC hardware. Slackware will provide stellar performance on high-end systems, including support for symmetric multi-processing (up to 16 processors), PCI, and special code optimizations for the 486, Pentium, and Pentium Pro and AMD Athlon.

SuSE Linux <http://www.suse.com/>

The current version is SuSE Linux 8.0. It contains 7 CD-ROMs (or 1 DVD) with more than 1,500 applications. SuSE can be installed and maintained easily with their YAST program, currently in version 2. SuSE Linux is also available for IA 32, IA 64, PowerPC, Alpha, and S/390.

Turbolinux <http://www.turbolinux.com/>

Turbolinux provides a suite of high performance Linux products for the workstation and server markets. Available in English, Japanese and Chinese, Turbolinux offers Linux solutions geared towards corporate needs as well as the home desktop.

ZipSpeak <http://www.linux-speakup.org/zipspeak.html>

Based on ZipSlack, ZipSpeak is intended for blind and visually impaired users. Speakup, a screen reader/voice synthesizer program is included in the distribution.

Specialty distributions

RT-Linux <http://www.rtlinux.org/>

RT-Linux is a Linux operating system in which a small real-time kernel co-exists with the Posix-like Linux kernel.

Security enhanced distributions

CAEN Linux <http://www.engin.umich.edu/caen/systems/Linux/caenlinux/>

Security enhanced distribution based on Red Hat.

EnGarde Secure Linux <http://www.engardelinux.org/>

EnGarde is a secure distribution of Linux that implements advanced security techniques. It can be used as a Web, DNS, mail, database, e-commerce, and general Internet server.

Immunix OS <http://www.wirex.com/>

Immunix OS is a Linux distribution designed to be secure both now and in the future. The Immunix security tools (StackGuardT, SubDomainT, and CryptoMarkT) provide security bug

tolerance so that even if security vulnerability is found in one of the programs supplied with Immunix, the vulnerability will probably not be exploitable by attackers. Immunix OS is based on Red Hat 6.2, but with all C source-available programs re-compiled with the StackGuard compiler. The result is a system that is fundamentally compatible with Red Hat Linux, but is secured against a majority of all Internet security attacks. It was developed as part of technology funded by DARPA - U.S. Defense Advanced Research Projects Agency.

Security-Enhanced Linux <http://www.nsa.gov/selinux/>

Secure Linux distribution developed by the U.S. government's National Security Agency and Secure Computing Corporation with contributions from the University of Utah

smoothwall <http://www.smoothwall.org/>

Distribution geared toward those who have unused older equipment that they want to convert into firewalls.

Trustix Secure Linux <http://www.trustix.net/>

Trustix Secure Linux is a project to make a hardened Linux distribution for servers. It features OpenSSL, OpenSSH, Apache w/SSL&PHP, Postfix, POP3 and IMAP with SSL support, ProFTP, and ftpd-BSD.

Linux/390 distributions

Caiman <http://linux390.linuxkorea.co.kr/>

Debian <http://www.debian.org/ports/s390/>

Marist <http://linux390.marist.edu/>

Red Hat <http://www.redhat.com/software/linux/s390/>

SuSE http://www.suse.com/us/products/suse_business/sles/sles_s390/index.html

ThinkBlue <http://linux.s390.org/>

Turbolinux <http://www.turbolinux.com/products/s390/>

Additional Linux/390 resources:

Linux/390 mailing list <http://www.marist.edu/htbin/wlvindex?linux-390>

Linux/390 mailing list Web site <http://linuxvm.org/>

IBM Linux/390 Web site
<http://www10.software.ibm.com/developerworks/opensource/linux390/index.shtml>

About The Author

Mark Post is an Information Technology and Systems Management consultant with over 20 years of experience in the Information Technology industry. The majority of his career has been spent working as a systems programmer with mainframe operating systems such as MVS and VM. In the last 8 years he has added Microsoft operating systems and Linux to his professional interests.

Since May of 2000, Mark has been heavily involved in the evolution of the Linux for S/390 and zSeries platform, also known as Linux/390. In 2001, he co-authored the second IBM Redbook on Linux/390, "Linux for zSeries and S/390: Distributions", SG24-6264, and is currently the webmaster for the Linux-390 mailing list companion web site, <http://linuxvm.org/>. Mark is also becoming a regular speaker at technical conferences, because of his ability to speak to mainframe systems programmers and Linux system administrators in terms they both can understand.

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