Executive Summary: Scalable Lotus Domino on the IBM RS/6000 SP

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RS/6000 SP Parallel Subsystem Integration Team

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Overview - Lotus Domino Server and the RS/6000 SP

What is Lotus Domino Server Powered by Notes?

The Lotus Domino Server Powered by Notes (hereafter referred to as the Domino Server, or Domino) is an industry leading integrated messaging and groupware product. It is a client/server platform for developing and deploying groupware applications, a platform for highly specialized applications, and an open environment on which independent software developers can integrate their own products - with built-in ties to the internet.

Groupware is a convergence of three technologies:

- Communication - Email, messaging, and routing;
- Collaboration - includes topics such as shared databases, orderly replication, discussion groups, access control, and Internet access. Collaboration is a framework for exploiting the many ways users need to communicate and share information;
- Coordination - Workflow-like control of tasks and documents, such as orderly review and sign-off processes.

Lotus Domino combines three powerful group support technologies - messaging, distributed object store, and a rich application development environment - to form a component architecture that serves as the basis for a large variety of groupware applications. Advanced Domino functionality *enables* you to combine distributed databases with powerful communications, replication, and security layers--all tailor-made for geographically distributed corporations. The ability to integrate Domino applications with critical legacy systems provides for a powerful, flexible, and secure enterprise application development system. From front-end to transaction processing applications, Domino Rich-Text presentation interface brings new looks and function to your old character-based applications. This integration, combined with Dominos' support of Internet standards enables extremely powerful, interactive Web applications that leverage and exploit enterprise information.

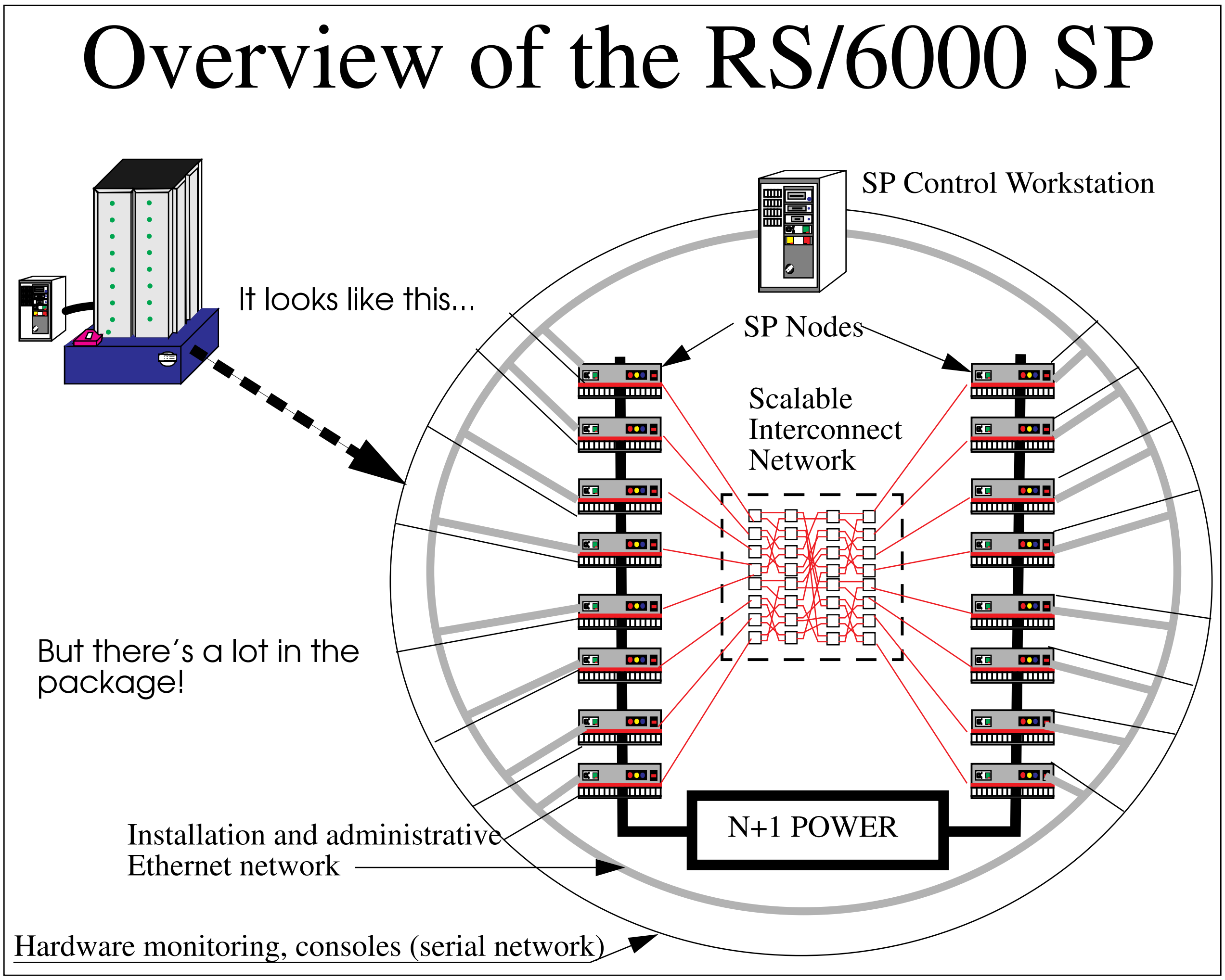
Lotus Domino is an excellent choice for wide-scale information sharing - other big software developers are frantically working on Domino alternatives, but its two closest rivals, Microsoft's Exchange and Netscape's Collabra Share, still can't match the power of Domino. Domino is the original ***Intra***net, and you can extend this connectivity seamlessly, with the Domino http server, into the ***Inter***net. Domino's recognition in the industry as both a groupware and internet application has been extremely positive - so much that Domino 4.5 finished second on PCWeek's top 10 product list.[1]

For more information on Domino please visit the Web site at *http://www.lotus.com*.

1. PC WEEK, December 16,1996

What is the RS/6000 SP?

The IBM RS/6000 Scalable POWERparallel System (RS/6000 SP) is a distributed parallel computing system comprised of up to 512 processing nodes. Each node is a complete RS/6000 workstation, with CPU, disk, and memory, running a separate copy of the AIX operating system. The nodes are all connected via the SP Switch, a non-blocking packet switch which allows high-bandwidth, low-latency Internet Protocol (IP) communication between all 512 nodes in the system. All nodes are connected to a single point of control - the RS/6000 SP Control Workstation - for ease of installation and management.



To state it simply: The RS/6000 SP system is a cluster of AIX[2] servers packaged with a high-speed interconnect between them - in a highly reliable frame - with superior system management capabilities.

Advantages of the RS/6000 SP system over usual LAN server implementations are

- ***Scalability*** - incremental additions of SP nodes increase capacity and workload while virtually eliminating any performance bottlenecks. Performance scalability is enabled by the SP switch, since the total bandwidth of the switch increases as nodes are added.
- ***Manageability*** - non-disruptive installation, configuration, and upgrades. Management of the collective of SP nodes is from a single point of control.
- ***Reliability and availability*** - key redundancies in SP frame power and SP switch provide a highly reliable hardware infrastructure. IBM's industry-leading HACMP for AIX *(High Availability Cluster Multi-Processing)* software allows the configuration of the SP system so that failures of node hardware can be recovered.
- ***Existing deployment -*** there are thousands of SP installations worldwide, where the SP is a preferred choice in deploying an enterprise-level server implementation.
- ***World-class service and support -*** IBM is there to guide and support you through its world-wide service and support organization. And you get the benefit of IBM's experience in providing leading-edge technologies such as symmetric Multi-Processing (SMP) nodes in the SP, PowerPC processors, and upgrades to the SP Switch.

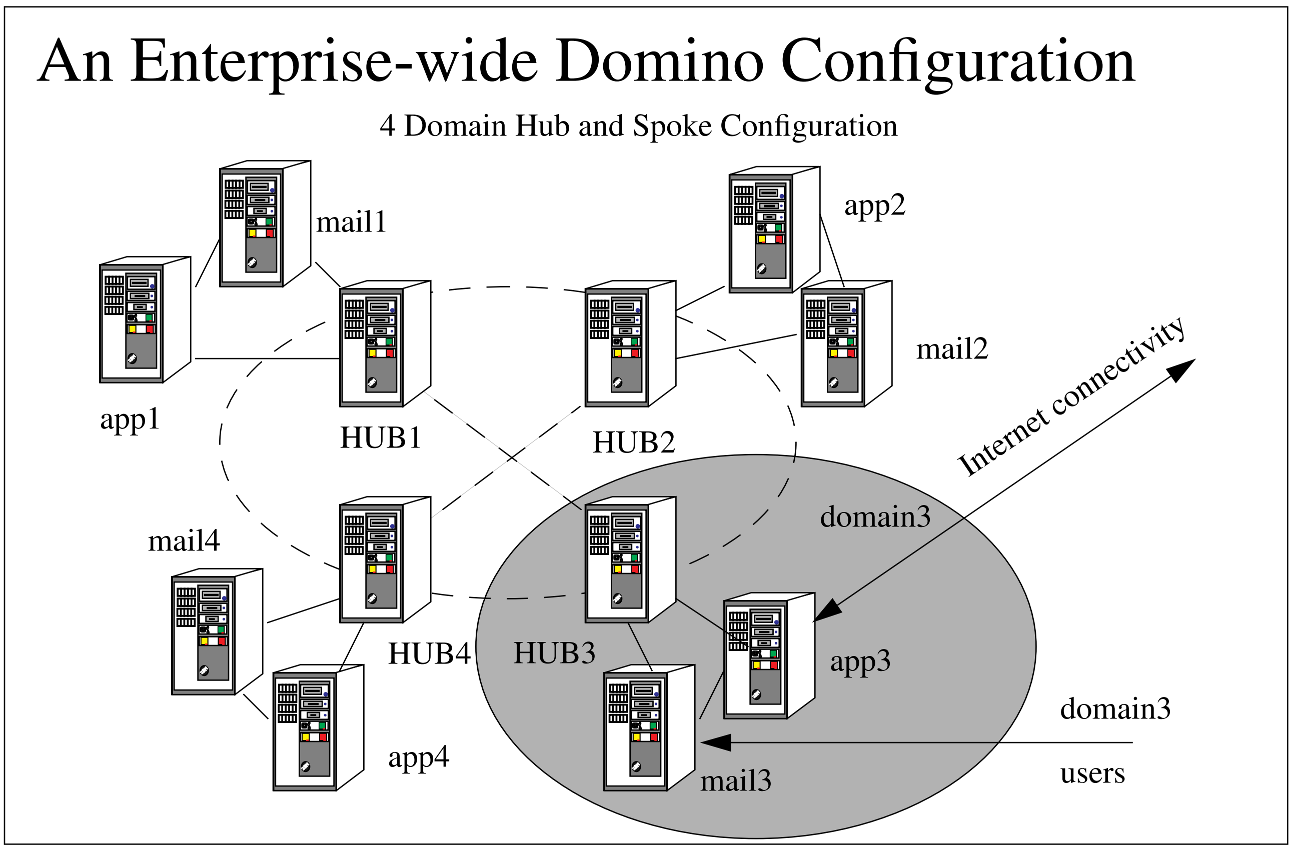
For more on the IBM RS/6000 SP system, see the IBM RS/6000 SP system web page at *http://www.austin.ibm.com/software/sp_products/sp2.html.*

2. AIX: IBM's UNIX operating system

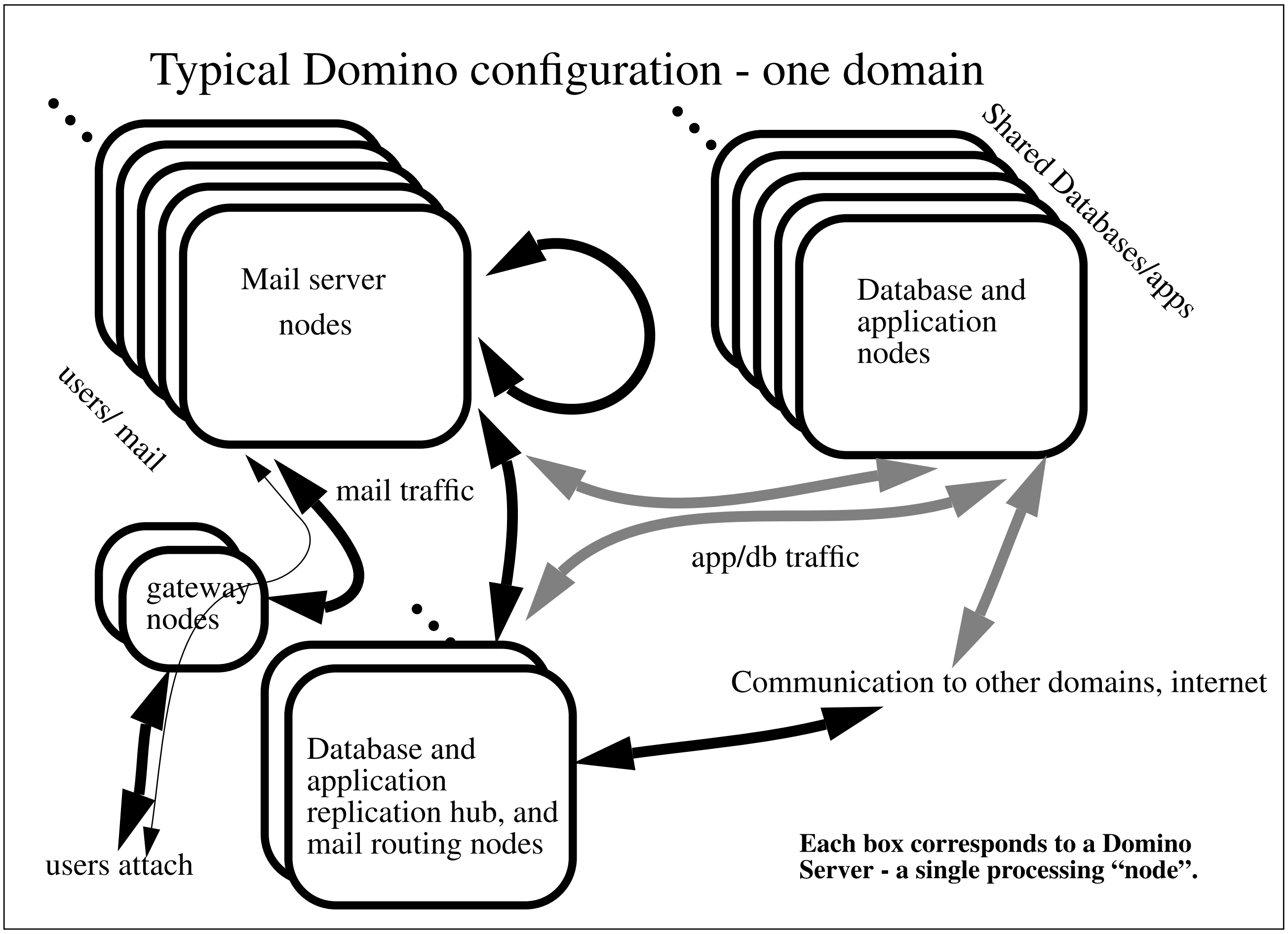
The integration of Lotus Domino and the RS/6000 SP

With the introduction of the Lotus Domino Server Powered by Notes, customers can now realistically configure systems (or networks of systems) to support thousands of users from a single location. As the capacity of your Domino servers increase, the degree to which your business depends on the availability of the Domino server complex will increase dramatically; bringing with it additional requirements and expectations. The RS/6000 SP system provides a scalable, complete solution for your Enterprise Domino Server.

A typical Domino configuration consists of mail, database, and replication servers. These servers are grouped into centrally administered domains which make up an enterprise-wide Domino environment, as pictured below.



The picture illustrates a hub-and-spoke topology, which is common in large sites and is the most adaptable for system growth and change. Within each domain, a dedicated hub or multiple hub servers are used to replicate information and route mail across domains. Within each domain, there are typically three types of servers: one type dedicated to data replication and/or mail routing; another as user mail servers; and the third for serving data and applications. Organization of the servers within a domain is shown in the following picture.



Database and application server nodes provide the shared database/collaborative applications for the Domino environment, **which includes internet and intranet connectivity**. Domino users are registered across the mail server nodes, which serve as a home base for users, physically holding their mail and routing mail to its destination. The replication server, or "hub", replicates and receives database/application updates between servers inside and outside this domain. In large Domino configurations, there may be dedicated mail routing hubs as well as database replication hubs, relieving mail servers from this task.

Many questions arise when planning a large configuration of Domino servers:

- As I add more clients and servers, can my networks handle the increase in network traffic?
- As I add more servers, how many administrators must I add to manage them? Can I manage the collective from one place?
- What if a server goes down? Can I detect it? Can I recover from it? How long does it take and what is the impact to my business?
- How do I integrate this configuration with the rest of my enterprise, and the internet?

Some readers may question the use of dedicated servers for the mail, database, and replication functions - after all, any one server could be configured to do all of these functions. However, in a large enterprise configuration, the ability to incrementally add function - applications, users, or availability of certain users or applications ***as needs change*** must be addressed in an orderly and organized way. For a large organization, the configuration pictured is best suited to this model as it compartmentalizes functions such that they can each be incrementally configured and administered.

As this document will illustrate, the IBM RS/6000 SP system is a robust, complete solution for an Enterprise Domino server. Here's why:

- ***It scales.*** The ability to easily add nodes as processing or user needs increase is well-suited to the RS/6000 SP system. This is done with virtually no decrease in user performance as the configuration grows, due to the distributed design of Domino and the scalability of the SP switch interconnect. Scalability is explained in more detail in the section Scalability of Lotus Domino on the IBM RS/6000 SP on page 11.
- ***Administration and management of the RS/6000 SP system is cost effective.*** Administration costs on the RS/6000 SP system can be greatly reduced compared to those required to manage the same number of distributed servers. This is because the RS/6000 SP system includes support and management software as part of the **Parallel System Support Program** (or **PSSP** for short). The PSSP provides the ability to control and monitor all nodes of the RS/6000 SP system from a single point. And that point need not be the physical computer (the Control Workstation) attached directly to the RS/6000 SP system. This monitor and control can occur from any computer network-connected to the Control Workstation (which is an RS/6000 workstation). Backup of the system is easily accommodated and can make use of the SP switch architecture to speed backup and restores. All this and more is explained in detail in Managing Lotus Domino on the IBM RS/6000 SP on page 17.
- ***High Availability can be easily implemented where required.*** Existing redundant hardware in the SP and the core technology of the RS/6000 processors it is built from provide an aggregate system of high reliability. Use of Advanced Services for the Domino Server (Domino serfer clustering product) and HACMP for AIX, IBM's

industry leading availability software - *only where you require high availability* - allows the SP nodes and/or Domino Servers to recover from single points of failure. Availability is covered in more detail in the section titled Availability and Lotus Domino on the IBM RS/6000 SP on page 23.

- ***It ties in with your legacy systems and the Internet.*** The SP supports a large number of hardware and software products that integrate and exploit your existing mainframe environments as well as existing client-server applications. Internet connectivity is integrated into the Domino server technology, providing access for your whole enterprise to the World Wide Web. This topic is described in more detail in Domino and SP connect to Legacy Systems and the Web on page 31.

Read on to learn more about why Lotus Domino and the RS/6000 SP system are an ideal match!

Scalability of Lotus Domino on the IBM RS/6000 SP

The concept of scalability is sometimes ambiguous, especially when differentiating between parallel applications, distributed computing and computers, administration, and networks. Let's explore what scalability of Lotus Domino on the RS/6000 SP is all about.

What does "scalable" mean?

Lotus Domino is a distributed, client/server application. Lotus designed Domino to be deployed in a distributed fashion across multiple server systems - which is exactly the system architecture the SP provides - with the added benefit of centralized control and management.

Multiple Domino servers, each running on one node, can communicate with each other, but they do not work together in parallel on a single operation. This is what we mean by Domino being a "distributed application" and is one of its inherent advantages (this if often referred to as "functional parallelism"). Information, in the form of Domino shared documents or mail, is replicated among multiple Domino servers, for quick access across the user population. This naturally distributes the information. The expense incurred in the replication is the bandwidth required in replicating data between servers, which also implies that as the numbers of servers (users, data, and applications) increases, so must the bandwidth of communication between those servers. With the increase in bandwidth comes an increased need for more CPU and disk performance - which may mean adding servers.

The RS/6000 SP, with its distributed architecture, high-speed scalable interconnect, and centralized management infrastructure, provides the backbone on which you can implement a reliable and manageable enterprise-level Domino environment. The SP will allow you to implement a system which will grow as your use of Domino grows. As you need to support more users, you can add more nodes to serve as mail servers. And they will automatically have high-speed connectivity to the existing databases which are already running on other nodes of the SP. As you need to add more data and applications, you can add more nodes for application servers, Internet access, and so on.

The RS/6000 SP scales Lotus Domino

The central component of the SP and its ability to scale users as you add nodes is the high performance SP Switch. The SP Switch provides a non-blocking, high-bandwidth, and low latency Internet Protocol (IP) network whose performance increases in a near linear fashion as additional nodes are added to the system. The switch provides a consistent high-speed path between all of the up to 512 nodes within the SP.

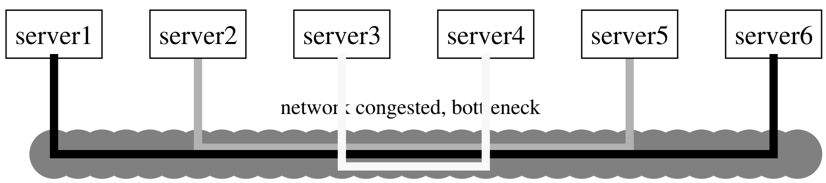
This impacts the performance and scalability of the SP Domino server in three ways:

- By providing a high speed path for all the replication and mail traffic being routed between nodes;

- By removing this server-to-server traffic from your external network, thus providing a much more stable (and dependable) network for connecting clients to the Domino servers; and
- Improving system availability by providing a better, highly-reliable network over which Domino server data will be transferred.

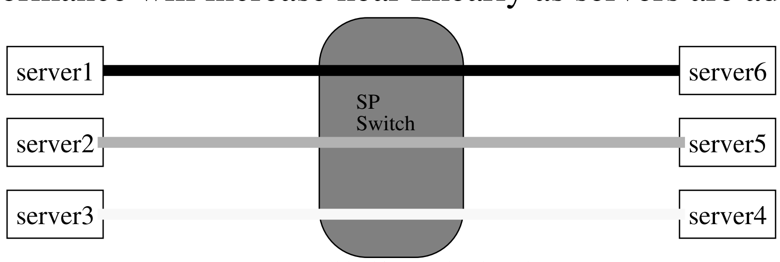
Scalability of the RS/6000 SP Switch

Typical networks saturate as servers are added to it. This is like a conference call where all parties cannot talk at the same time...



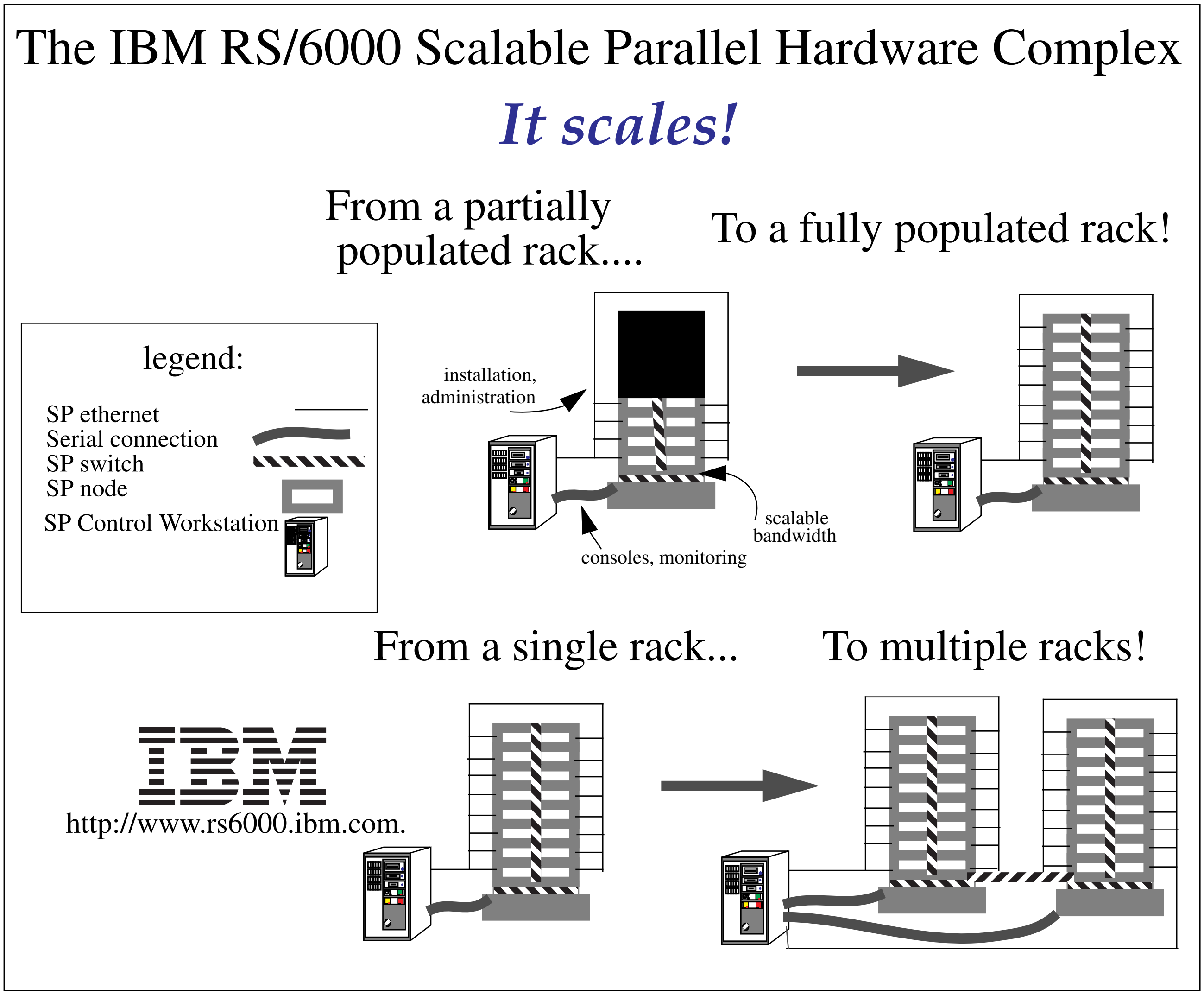
Ethernet, FDDI, Token-Ring, ATM

But the SP Switch is a non-blocking network, and allows multiple high-bandwidth connections in parallel. Each node has its own connection to the switch, scaling its connectivity and aggregate bandwidth as servers are added. This provides an infrastructure for a Domino server configuration where performance will increase near linearly as servers are added.



non-blocking, no bottleneck

One can use multiple nodes in the SP, connected to intelligent routers, to provide redundant, available, and scalable network connectivity for your client network into the SP system (both mail and database access). Remember that the switch is non-blocking and client-to-server transfers will not disrupt ongoing communication between other nodes - which might happen in a typical LAN-connected environment



The SP Switch and its high bandwidth will help you scale your Domino solution in other ways as well. Backup and restore of Domino data can be a drain on network and CPU resource as well as administrative staff. On the SP, an additional node can be used as a backup/restore server, once again accessing data from all Domino servers across the SP complex. And that's only the beginning of the applications you can consolidate onto the SP. If your Domino solution includes storing data in relational databases or moving data back and forth between your Domino system and a legacy system, you can do all these things within the footprint of a single SP system.

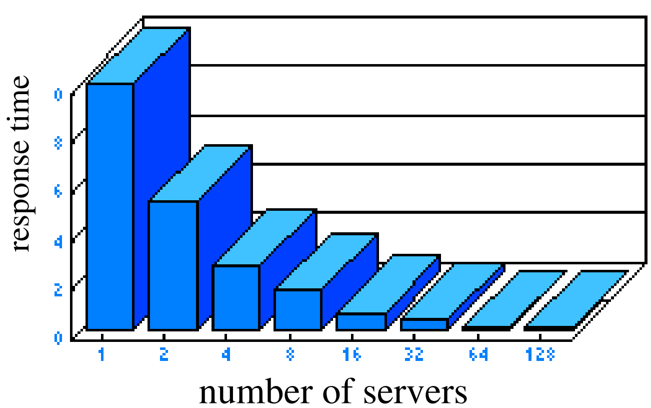
The SP switch is a highly reliable network. Inside the AIX IP device driver for each SP node's switch connection, there are 4 possible hardware paths established (at initialization time) between each pair of SP nodes. Should one path fail, another will be used instead, without impact on higher-level applications. Redundant cooling fans and power supplies are implemented, which make the SP switch an enclosed network that is exceptionally reliable.

Scaling compute power alone is not sufficient - the ability to scale your I/O configuration is also important. IBM SSA (Serial Storage Architecture) disk subsystems are an example of a robust I/O subsystem for Domino. The SSA subsystem’s high capacity (up to 432 GB per adapter), high throughput (up to 35MB/sec sustained), and flexibility of configuration make it a desirable choice to use with Domino. The ability to hot-plug both cables and disks without affecting system access to data through alternate routes makes this choice even more desirable for the enterprise. The SSA loop architecture makes it possible to physically configure a large pool of physical devices to be accessible by one of up to eight (8) nodes - this is important for configuring highly-available groups of servers. Logical reconfiguration of devices to specific volume groups and file systems can be done dynamically through the AIX logical volume manager (LVM), without having to disrupt the running applications. For more on SSA and other IBM disks subsystems please see the SSA storage Web page at *http://www.storage.ibm.com/storage/hardsoft/ssaovu.htm.*

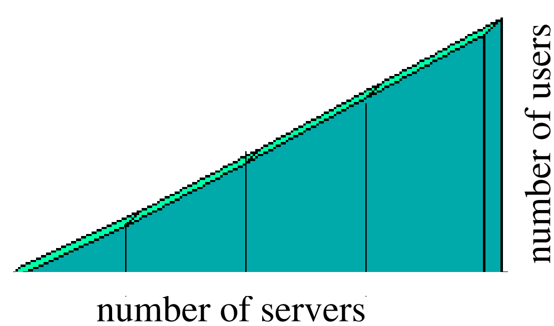
The SP hardware and PSSP (Parallel System Support Program) infrastructure continues to scale even for larger configurations. For multi-rack SPs, the Control Workstation has an Ethernet and serial connection to each rack so that administrative operations can still be parallelized without bottlenecks. Install servers can be dedicated in each rack to further parallelize and speed node installations and updates, and are easily configured on the control workstation via the PSSP. SP configurations scale from 2 to 512 nodes - from **both** an administrative/management and switch performance standpoint.

In tests run with Domino servers on multiple SP nodes, the SP has demonstrated excellent scaling and speedup characteristics. Two nodes running as Domino servers will support twice the user workload and workload throughput with a constant response time (scaleup). Adding two more nodes with constant workload and throughput allowed reduction in response times in excess of 40% (speedup).

SPEEDUP (example)



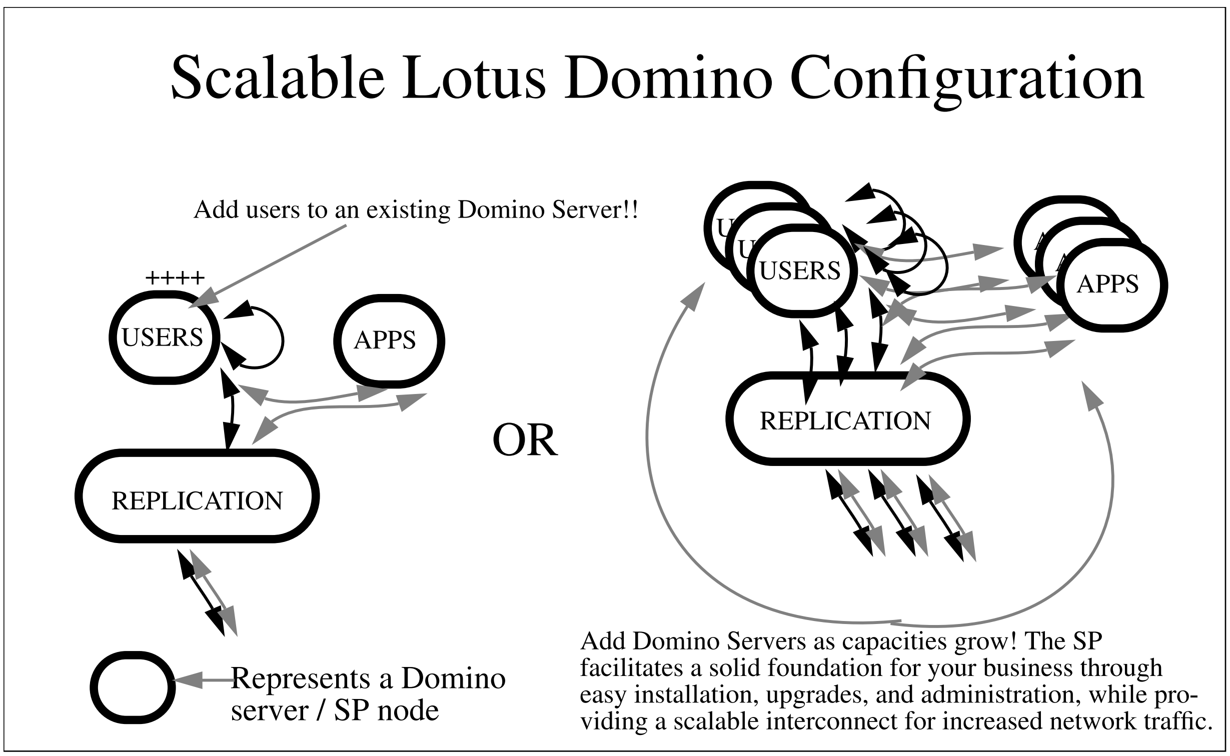
SCALEUP (example)



Administration costs remain constant

Operational costs of a server complex can be a large percentage of your total cost of operation. With this in mind, one thing you don't want to scale is the size of your support staff required to administer this growing environment. The SP includes support and management software as part of the **Parallel System Support Program** (**PSSP**). It provides the ability to control and monitor all the nodes of the system from a single point. And that point need not be the physical computer (the Control Workstation) attached directly to the SP system. This monitor and control can occur from any computer network-connected to the Control Workstation (which is an RS/6000 workstation).

Scaling your investment



Finally, the SP will allow you to scale your investment. The SP is constructed such that incremental addition of SP nodes is easy. Like building blocks, the new SP nodes can be plugged in, installed, monitored, and maintained from the SP control workstation. As technology evolves, the SP allows you to upgrade or add to the system either new processors or disk subsystems within the existing infrastructure. These upgrades can be made non-disruptively, which ensures that your investment continues to provide a solid foundation for your business.

Managing Lotus Domino on the IBM RS/6000 SP

Lotus Domino is a distributed, client/server application. Lotus designed Domino to be deployed in a distributed fashion across multiple LAN connected systems - this is exactly the system architecture the SP provides - with the added benefit of centralized control and management.

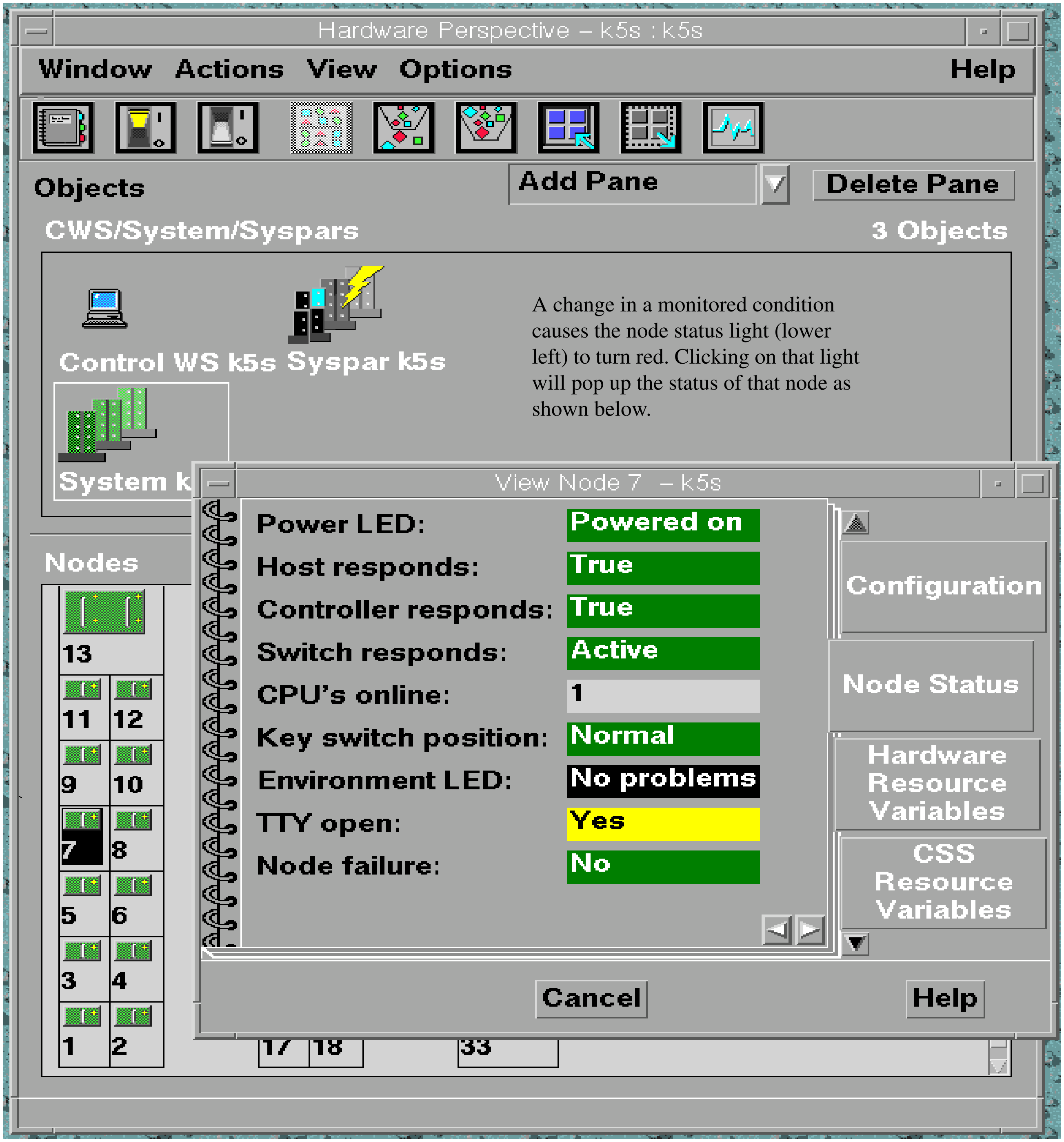
Monitoring, managing, and upgrading your RS/6000 SP

Your SP complex can be monitored and managed as a single system, from a central control point, called the SP Control Workstation. This is made possible by the ***PSSP***, or Parallel System Support Program, which is included with your SP. Through AIX windows, command line and PSSP Graphical User Interfaces (GUIs), your system administrators will be able to monitor the health and activity of all the Domino servers in your enterprise. Don't forget that since the PSSP is an AIX application, the control workstation displays can be exported (viewed) anywhere in your enterprise to persons with proper authority, allowing administration from your home (if desired) as well as remote LANs.

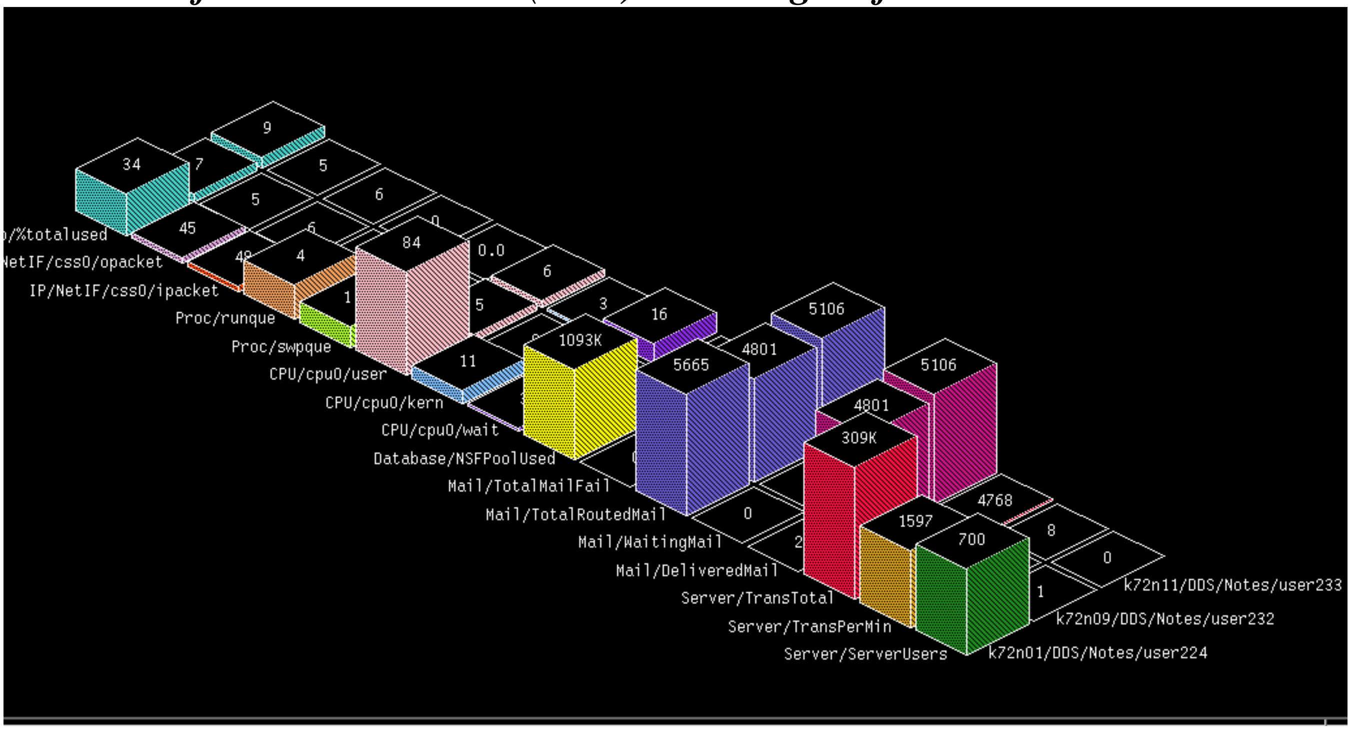
Here are just a few of the features that the PSSP allows you to perform:

- **Node installation.** Multiple nodes can be installed in parallel. This can be used for node AIX installation as well as updates and application installation.
- **User administration.** AIX users and passwords can be created centrally on the Control Workstation, and all SP nodes will automatically pick up those users.
- **File collections.** Predefined collections of files are maintained as consistent among the control workstation and groups of SP nodes. Updates are run automatically - the pull-based implementation ensures that even if nodes are off-line, when they come back on-line they get the latest collection.
- **Performance and network monitoring.** All node performance statistics and networks can be monitored from a single point, and tied in with other tools such as NetView for AIX. NotesView for AIX will allow monitoring of Notes statistics in this fashion.
- **Security.** All administrative access is authenticated via remote commands utilizing the *Kerberos* standard, ensuring secure administrator access to the SP nodes.
- **Privilege Groups.** The *sysctl* utility allows you to control which administrators can perform certain functions in your administrative hierarchy. For example, system operators my have reduced privileges compared with lead system administrators, without impeding their effectiveness.
- **System Time Synchronization.** NTP (Network Time Protocol) is automatically configured via PSSP and used on the SP control workstation and nodes to keep the system in sync.
- **Parallelization of administration tasks.** The PSSP allows you to run AIX and Domino administrative commands in parallel on all or designated groups of SP nodes.

RS/6000 SP Control Interface Example



AIX Performance Toolbox (PTX) - PTX Agent for the Domino Server



Managing AIX

Having the right operating environment for your critical business asset - Domino - is important. But manageability of that environment is also an extremely important issue. AIX is a UNIX operating system and may or may not be new to your organization. AIX, independently appraised as a leader in UNIX operating systems[1], provides menu-driven, graphical systems administration tools to make the transition to UNIX easy, and allows hands-on, real-life learning along the way. Both SMIT (Systems Management Interface Tool) and VSM (Visual Systems Manager) make adding users, groups, devices, file systems, and more, a breeze. And with everything done through the menus or drag-and-drop icons, the actual UNIX command is shown at the bottom of the screen. This allows a new administrator to learn UNIX by associating the commands with the action taken.

Enterprise-wide systems management

IBM's SystemView for AIX is a robust and complete monitoring and management tool for your enterprise. It consists of over twenty-five (25) tools to help with network management, performance management, configuration management, software distribution, problem management, and many

1. AIX 4.X Sustains IBM's Leadership in Open Systems, D.H. Brown Associates, 8/95.

more. And they all work together, over almost any network protocol, and can manage almost any type of device attached to a network...servers and clients from IBM and many other vendors, network routers and hubs, all the way down the line.

The 1995 Enterprise Management Summit Shoot-Out was conducted in October 1995. Participating vendors were Groupe Bull, Cabletron, Digital Equipment Corporation, and IBM. Hewlett Packard, SunSoft and Computer Associates were originally scheduled to participate, but chose to pull out of the competition. IBM’s NetView for AIX (part of System View for AIX) won the overall first place in this competition. The Shoot-Out was conducted using a network built by the Enterprise Management Summit (referred to below as the “managed environment”). The network consisted of NetWare, Netbios and TCP/IP. It also included DOS, Windows, Windows NT, UNIX, and OS/2 Warp operating systems. In addition, the “managed environment” included applications, databases, messaging networks such as Lotus Notes, Internet applications such as Netscape, enterprise management platforms, and third-party management applications.

For integration of Domino with your enterprise SNMP environments, Lotus NotesView for AIX works with TME10 NetView for AIX to manage multiple Domino servers from a single control point. NotesView for AIX will support 32-bit, multi-threaded operation, enabling it to manage a virtually unlimited number of servers. NotesView will also allow management and monitoring of Domino server disk space and Mail/User traffic. NotesView also will provide a way as to analyze how information is distributed and replicated - the replication map. Using the replication map, the shortest path for information replication between servers can be determined, and administrator(s) can force mail delivery, restart mail routers and replicators, compact databases on any server, and more - all from a single control point.

For more information on these products, see the world wide web at *http://www.lotus.com,* and *http://www.tivoli.com*.

Backup and Restore with ADSM

ADSTAR Distributed Storage Manager (ADSM) is a comprehensive solution for backing up your Domino configuration. The IBM ADSM family of software products is an enterprise-wide solution integrating unattended network backup and archive with hierarchical storage management and powerful disaster recovery planning functions.

Organizations that use Lotus Domino as a communications and organizational tool for mission-critical data may not be able to take data off-line to back it up - making it difficult to find a reliable and effective protection solution for Lotus Domino systems. Many mistakenly believe Domino replication protects databases. Only after errors or accidental erasures are replicated, damaging all database replicas, is it clear that Domino replication is not a backup solution.

Many backup software products do not understand the complex logical structure of Lotus Domino databases, viewing them merely as independent workstation files. Even if just one document in a Domino database is changed, these products must back up the entire database. If only one document needs to be recovered, these products must restore the database as a whole. Companies with large Domino databases, small backup windows, and 24x7 operations may not have the time to perform full backups and restores. Another weakness of some backup products is that they blindly back up every Domino database. This is wasteful when these databases are replicas. Also, some products don't provide a comprehensive solution. They back up only the Domino databases, ignoring backup of important Domino server and client files.

ADSM provides on-line, incremental backup of Lotus Domino systems. The ADSM Lotus Domino Backup Agent is an integrated Lotus Domino application that runs on AIX. It uses the Lotus Domino and ADSM Application Programming Interfaces (APIs) to back up and restore Domino documents and databases to and from an ADSM server, *which can be an SP node* and leverage the scalability of the SP switch.

The ADSM Lotus Domino Backup Agent performs incremental and full backups of Domino databases (data and design elements), restores individual Domino documents and entire Domino databases, and restores deleted Domino documents. Additionally, the standard ADSM backup client backs up and restores Domino server and client files, including notes.ini, cert.id, and desktop.dsk, providing a comprehensive Domino backup solution.

For more information on the ADSM family of products, see the web at *http://www.storage.ibm.com/storage/software.*

Availability and Lotus Domino on the IBM RS/6000 SP

There are several things to consider when protecting your system against potential failures. What do you do? Proper configuration of reliable hardware and judicious use of high availability techniques is the best answer - and IBM provides industry leadership in both of these categories. Even better - this environment integrates seamlessly with the SP and is controlled and monitored from a single point.

How to configure your system to avoid potential failures

With Domino servers handling thousands of users, enterprises demand those servers be up when needed. And with Domino's mobile support, this may mean 24x7 availability. IT departments need to be able to rely on high availability environments to ensure that the Domino servers are available when required.

Deciding which pieces of the Lotus Domino configuration need to be made available are up to you and depend on your availability and service level requirements. The following table details the spectrum of potential hardware failures that could occur in **any** Domino environment and how to configure this environment on the SP system for recovery from such failures.

All availability configurations assume external disks are used for application data. External disks provide enhanced connectivity to multiple nodes, improved performance, larger disk capacity, and allow for concurrent maintenance - making them the logical choice.

The failures are listed in order of the likelihood that they may occur.

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Table 1: Recovering from failures

Failure	Priority	Result	How avoided[a]	SP Protected Result	SP Protected Repair
Processor Failure	1	Node crashes - server unavailable	HACMP - reliable node failure detection and failover to backup node	5 or less minutes of system reconfig where failed server is not available	Concurrent - repair node and reintegrate
External Disk failure	2	Lost or corrupted data	Mirrored or RAID adapters and disk for data	System continues running on backup disk	Concurrent - hot plug disk and resynch disks
Network Adapter Failure	3	Node alive but “hung”	1) Redundant adapters with HACMP - multiple paths (for external networks) 2) Use HACMP network_down notification to failover to backup node (SP switch)	1) 5 or less minutes of server reconfig of backup adapter where reconfig server is not available 2) 5 or less minutes of system reconfig where failed server is not available	1) Concurrent - failover node, replace adapter, and reintegrate node 2) Concurrent - replace adapter and reintegrate node
Disk Adapter Failure	4	Lost or corrupted data	Backup adapter with mirrored or RAID disk	System continues running on backup adapter and disk mirror	Concurrent - failover node, replace failed adapter, reintegrate node and resynch disks

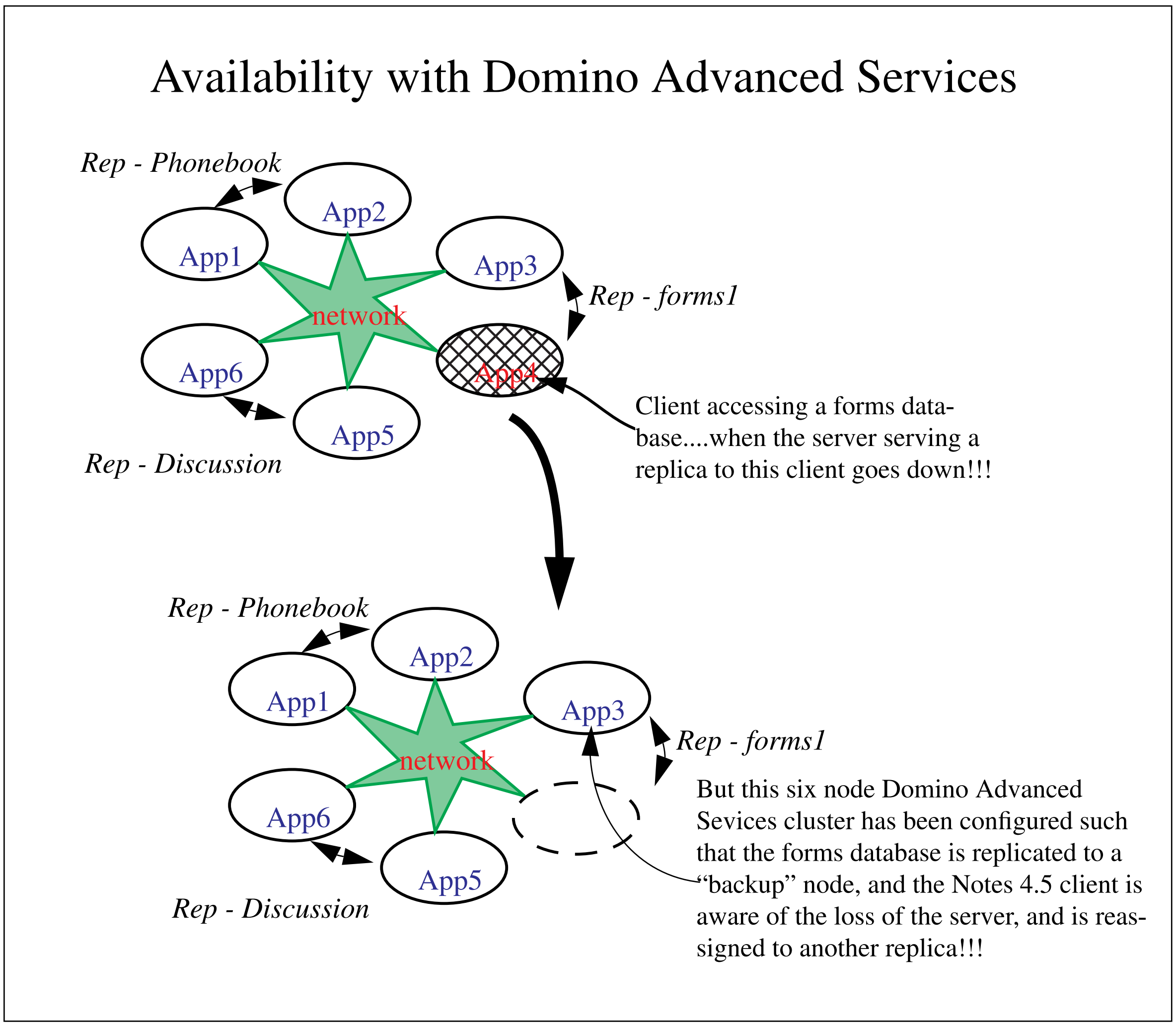
a. Advanced Services for the Domino Server provides failover capabilities similar to HACMP, and will be discussed shortly.

Disk Mirroring or RAID

The perfect example of the power of external SSA disks and the AIX Logical Volume Manager (LVM) is its ability to allow configuration of mirrored disks - if a disk should fail, the system keeps on running, and the LVM makes a note of this to the operator error log. The replacement disk (which can be hot plugged) is serviced concurrently while the system continues to be up. After the disk is replaced, the LVM automatically resynchronizes the data between the good disk and its new mirror. SSA RAID technology reduces the amount of redundant disk required (by mirroring) by sixty percent. The LVM, with its capability to utilize many external disk configurations and provide concurrent maintenance, is such a strong feature of AIX that it has been licenced to other UNIX suppliers.

Recovering from failures - Domino Advanced Services

In the Domino Server Powered by Notes release 4.5, Domino Advanced Services (a separate product for Domino) provides event driven replication of any database, between all nodes in a (up to 6 node) cluster. Should a server of one of the database replicas fail, the Domino Advanced Services will failover the user to a server of another replica. This is very similar to an HACMP failover, with the added benefit of user load balancing across the cluster.



Domino Advanced Services fit in well with the RS/6000 SP:

- **Domino Advanced Services recommend a high-speed LAN for the event replicator** - the SP Switch is the logical choice for this function.
- **Load Balancing -** Users are evenly spread across servers of database replicas. In addition, you can set a limit for a number of users accessing a server - if the number of users exceeds this then the extra users are directed to another replica.
- **Flexibility** - you can add and create Domino Advanced Services clusters only where you require them.
- **Scheduled Maintenance** - Through Domino Advanced Services administration you can mark a database replica as off-line, so that server can be stopped and maintenance performed.

Recovering from failures - HACMP

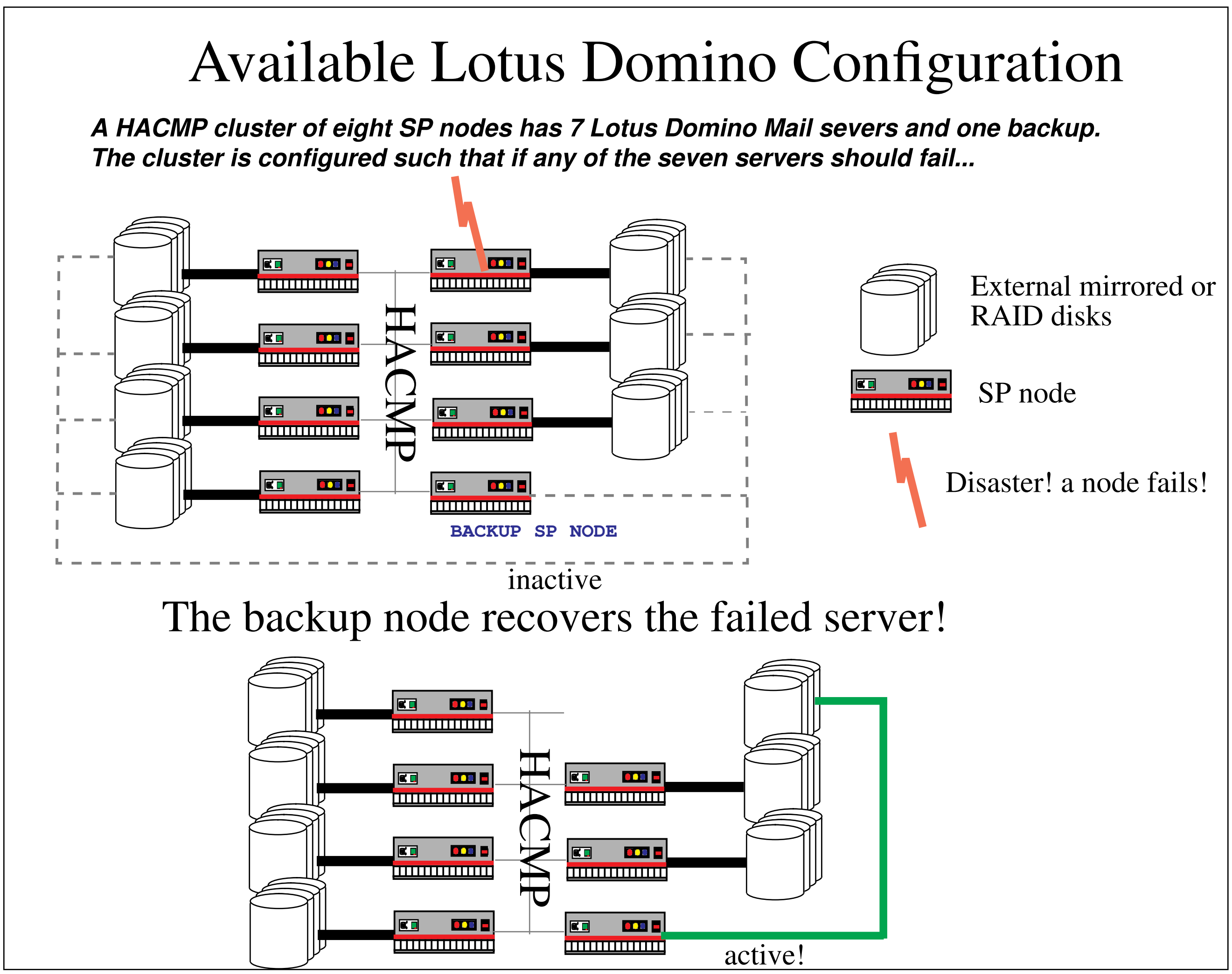
HACMP for AIX is an IBM product that runs on any IBM RS/6000 processor. On the SP, HACMP recovery software allows detection and recovery from SP node and other hardware failures. SP nodes can be grouped in "HACMP clusters" of up to 8 nodes. These clusters share connectivity to mirrored or RAID external disks where Domino applications and data reside. More than one cluster can be configured inside the SP, allowing you to pick and choose which groups of servers you require to keep available from node or adapter failures and selectively use HACMP to protect and recover these Domino servers. HACMP for AIX has been independently reviewed along with all other UNIX availability products[1], and has year-in and year-out been acclaimed by D.H. Brown as the industry leader in multi-system High Availability (HA). Reasons for this leadership include

- **Centralized management and control** - HACMP allows configuration of the availability from one central point. HACMP GUI toolkits allow you to standardize a "snapshot" of one availability configuration and use that as a template for other configurations.
- **AIX** provides the fundamental backbone for HACMP, such as mirroring and RAID support in its LVM and device drivers, and the capability to dynamically reconfigure the AIX kernel.
- **Flexibility** - the HACMP software allows you to configure any failover configuration you need - hot standby, mutual takeover, and so on - in up to eight node configurations. HACMP also offers easy ways to tailor your failover configuration, if you need to.

1. *UNIX Leapfrogs in High Availability,* D.H. Brown (1994), *Delivering Comprehensive HA Solutions,* D.H. Brown (11/95)

- **Verification of your configuration -** the HACMP software comes with a configuration checker that certifies and validates your availability configuration - so you can be sure that everything is set up correctly and will recover.
- **Tie-in with the rest of your Enterprise** - HACMP supports and provides an interface for connectivity with NetView for AIX, so you can monitor the status of your HA configuration as you monitor everything else.
- **Scheduled Maintenance** - You can initiate a takeover manually on a server in an HACMP cluster so that server is freed up for maintenance.

The following picture provides an example of the flexibility and leadership of HACMP - in a Lotus Domino environment - where mail servers can be recovered should they fail.



In the event of a node outage renders a node unusable, HACMP software detects this and runs recovery so a failed Domino server is "recovered" - i.e., a backup SP node will assume ownership of the external disks and necessary IP addresses and restart Domino - keeping the server available. Users will be unaware in most cases of a switch to a backup server.

HACMP can also be used with Domino application servers, routing servers, replication servers, etc. You can configure HACMP and customize it to your changing business needs. You can drop in HACMP where **you** require it, providing differing levels of availability to users and applications as needed. A final benefit - since HACMP is centrally administrated from one point, HACMP can be installed, configured, and managed from one single point - it integrates perfectly with the SP architecture. For more on HACMP, visit its web page at *http://www.austin.ibm.com/software/Apps/hacmp.html.*

Where to use Domino Advanced Services or HACMP

Both HACMP and Domino Advanced Services can provide availability for Mail, application, and replication servers. As such, there is confusion over where to implement what. Since Domino Advanced Services provide nearly identical function to HACMP, is there any need for HACMP in your implementation? The answer is up to you, but the following recommendations are those that are the easiest to implement and most cost-effective.

Table 2: Where to use HACMP and where to use Domino Advanced Services

Domino Server Function	*Preferred Availability Solution*	*Rationale*
Mail	either HACMP or Domino Advanced Services	Domino Advanced Services will support Mail user failover if a mail server is unavailable. However, shared mail is not yet supported and HACMP may be easier to implement for Mail availability.
Mail Router	HACMP [a]	Notes Advanced Services does not fail over mail routing functions. HACMP can failover / restart this functionality.
Application	Domino Advanced Services	Domino Advanced Services will load balance and failover users to a backup for properly replicated databases.
Out-of Domain-Replication	HACMP [b]	Domino Advanced Services does not failover out-of-domain replication. Therefore if it is required to keep a dedicated replication server available, use HACMP.

Table 2: Where to use HACMP and where to use Domino Advanced Services

Domino Server Function	*Preferred Availability Solution*	*Rationale*
Internet/ Domino	HACMP [c]	Domino functionality / IP addresses is not failed over by Notes advanced Services as with HACMP
Internotes	Domino Advanced Services	Internotes Servers are part of the advanced services functions/servers that can be failed over

a. **Note:** HACMP may not be required. Your requirements may not demand that the Mail Router be available all of the time, since no data will be lost (if mail spool disks on this server are mirrored). Mail-in-flight will be delayed until the Mail Router is repaired.
b. **Note:** HACMP may not be required, since you might not demand that a replication server be available all of the time, since replication can be completed when the server is repaired, or there might be muliple replication servers each covering different priority replication which will cover the replication on a different time scale.
c. **Note:** If you are using load balancing (LoadLeveler ISS) across multiple Domino servers with the same data, HACMP might not be required.

SP system partitioning

It is important to note that the SP PSSP allows configuring a single SP system into one or more logical partitions - each system partition is managed like a complete SP system. The separate partitions are isolated from a hardware and configuration (security) standpoint.

The partitioning capability allows you to separate different application domains in your SP, or segregation of your Domino production and development environments.

Providing a reliable, available external network connection for clients

There are many ways to configure external networks and connect them to the SP. Consider the following two options for attaching an external network to the SP:

- Have an adapter card in each node to attach to the external network.
- Have a dedicated node or “nodes” with adapters to be gateways into the SP switch network.

The first option becomes cost-prohibitive as the number of nodes in your configuration increase.

The second option is more scalable and allows you to leverage the bandwidth of the SP switch to attach clients to your system. This is more attractive for the following reasons:

- **Availability** - You can configure gateway node pairs with pairs of intelligent routers to route client traffic to and from a number of mail and database nodes to provide some network traffic and load balancing (split the network traffic by sub-netting) and availability / failover (via HACMP) between the two gateway nodes. You could place these two gateway nodes in separate frames of the SP to increase the availability, as well as placing the two routers on different power boundaries (separate circuit breakers).
- **Cost Effectiveness** - Using a dedicated gateway into the SP Switch reduces the number of external network connections into the SP - fewer parts are easier to manage. Also, network hardware requirements for the SP and site (ATM switch ports, for example) will be reduced.
- **Simple management and easy growth** - When you want to add a mail (or database) server node - the network infrastructure does not need to change (until your gateway capacity is exceeded) - you can simply add a node to the SP and start putting users there. (SSA simplifies this by making it easier to physically share disks among a group of nodes and re-assign disks to different nodes as the need arises).
- **Performance** - Large network pipes (ATM) may not be practical on each node, but large pipes on gateways into the high-speed switch should provide better throughput and greater stability, since the more traffic that gets taken off the external network, the more stable the external network should be.

The SP switch network is a highly reliable network. Inside the AIX IP device for each SP node's switch connection, there are 4 possible hardware paths established (at initialization time) between each pair of SP nodes. Should one path fail, another will be used instead, without impact on higher level applications. Redundant cooling fans and power supplies are implemented, which make the SP switch an enclosed network that is exceptionally reliable.

SP High Availability Control Workstation (HACWS)

If the SP Control Workstation should fail, the SP nodes running Lotus Domino will continue to operate. However, the ability to perform monitoring or reconfiguring of the SP will not be possible until the Control Workstation is returned to operation. To ensure continuous availability of the Control Workstation and its data, use the **High Availability Control WorkStation (HACWS)** product. HACWS (an optional feature) uses HACMP and provides the capability to provide a backup Control Workstation that will take over if the primary Control Workstation should go off line. HACWS keeps SP configuration data (on the Control Workstation) on external disks that can be mirrored or RAID, so that both primary and backup Control Workstations can access this vital SP data. There is also a redundant serial connection on the SP frame so that both primary and backup Control Workstations can connect to the SP for monitoring and control.

Domino and SP connect to Legacy Systems and the Web

One of the distinct advantages of the SP is that it can be connected to just about anything in your enterprise - your mainframes, your networks, and with Lotus Notes, you can incorporate the Web into your Lotus Domino-based intranet as well as other applications running inside or outside the SP. This capability makes the SP appealing as a platform for consolidating all of your enterprise applications.

The RS/6000 SP connects to your Enterprise

The RS/6000 technology on which the SP is based makes it easy to connect to other systems and applications inside your enterprise. Any SP node can

- Use ESCON to communicate to a mainframe via TCP/IP or SNA protocols.
- Use Service Director (part of NetView for AIX) to provide a "call home" capability for your SP complex, so that IBM service can be notified automatically should any problem occur.
- Use Lotus NotesView for AIX and AIX Performance Toolbox (the PTX agent for the Domino server), which will allow monitoring of Domino as well as SP and AIX performance statistics.
- Use ADSM (AdStar Distributed Storage Management) backup and restore products for reliable backup of your SP complex. ADSM can be run on an SP node, thereby realizing scalability benefits of the SP switch. ADSM supports connectivity to all enterprise-grade tape devices and libraries, and supports backup of many heterogeneous operating systems (OS/2, HP UX, Microsoft Windows NT).

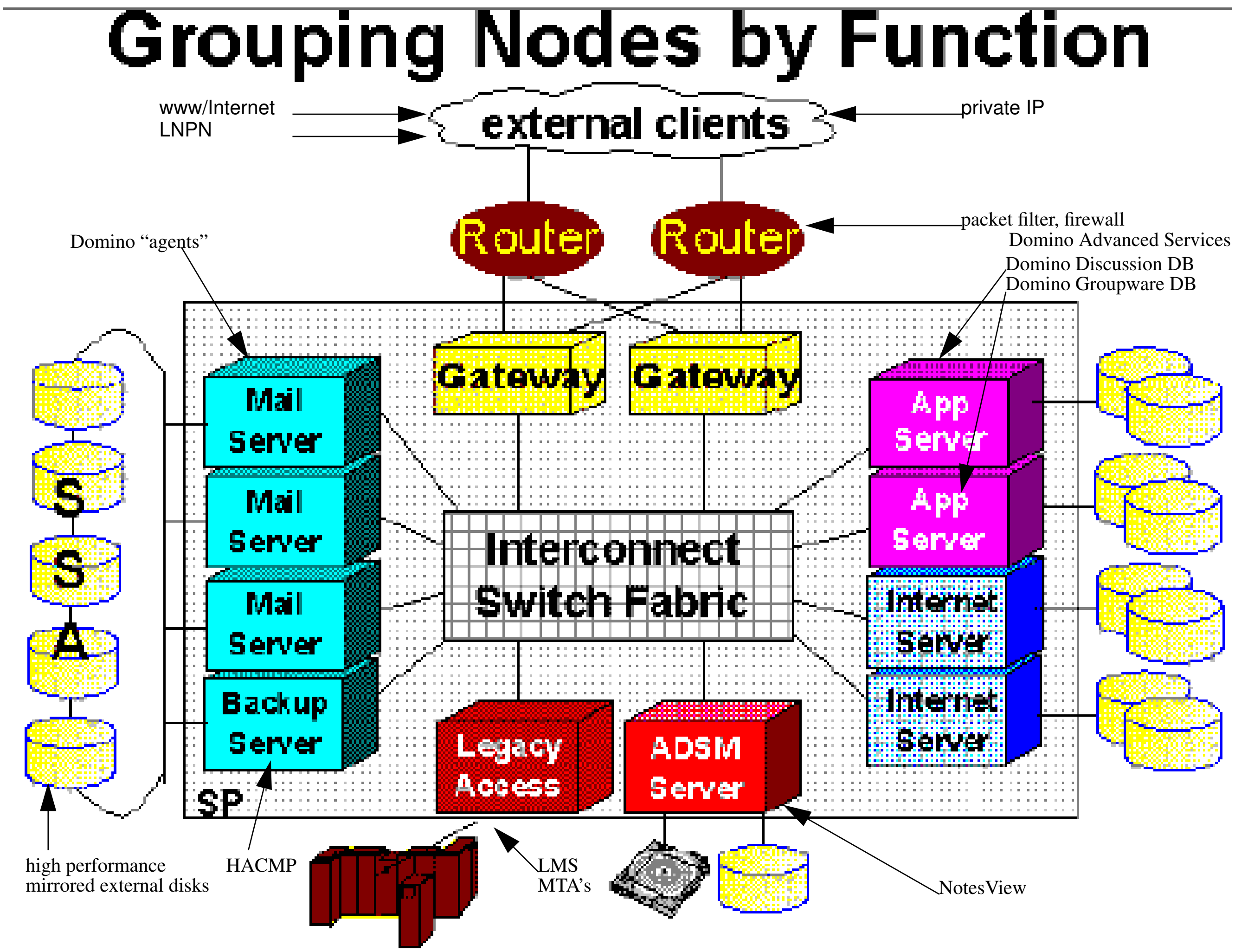
Connectivity between Domino and other applications and systems

Equally as important is software to enable connectivity from Lotus Domino to other applications and systems. Lotus has announced several products that make it easier for organizations to effectively access and integrate information from their transaction-based and relational database systems into groupware, Internet, and intranet applications through Lotus Domino. The combination of these products extends Domino's position as one of the most complete client/server enterprise development and deployment platforms. These products can all be run on SP nodes and derive scalability and manageability advantages from the SP architecture and high performance switch network.

The products include:

- **IBM MQSeries link for Lotus Notes** - provides an enhanced link through a LotusScript Extension to transaction-based systems, and provides the ability to seamlessly integrate Domino and transaction processes at the programming level. For more information visit the IBM web site at *http://www.hursley.ibm.com/mqseries.*

- **LotusScript:Data Object** - permits Notes clients and Domino servers to access and update any ODBC-compatible RDBMS (relational database management system) using LotusScript. The LotusScript:Data Object is automatically installed when the Notes client or Domino server software is installed. For more information visit the web site at *http://www.lotus.com/devtools.*
- **Lotus NotesPump** - will provide scheduled, high-volume, server-based interchange, allowing developers and database administrators to keep relational databases and Notes databases synchronized. This is ideal for moving data between your legacy systems and the SP complex. For more information visit the web site at *http://www.lotus.com/devtools*.



- **Oracle LSX** - allows Notes clients and Domino servers to read and write Oracle databases and systems using SQL*Net (Oracle native network protocol stacks). For more information visit the web site at *http://www.lotus.com/devtools.*
- **LMS** (Lotus Messaging Switch) from Lotus SoftSwitch - will allow Lotus Domino mail to be converted to internet, X.400, and mainframe mail protocols, and vice versa. For more information visit the web site at *http://www.lotus.com.*
- **LotusScript Extension (LSX) Toolkit** - enables corporate developers and Lotus Business Partners to extend Domino by creating new custom objects that can be accessed from LotusScript by adding their own custom functionality to the Notes client and Domino server platforms. The LSX toolkit enables a wide range of applications and users to take advantage of Domino's groupware and Internet application development capabilities.The LotusScript Extension Toolkit is now available and can be downloaded from the Lotus Web site at *http://www.lotus.com/devtools.*

The ability to integrate Domino applications with critical legacy systems provides for a powerful, flexible, and secure enterprise application development system. This integration, combined with support of Internet standards through the Domino HTTP server, enables extremely powerful, interactive Web applications that leverage and exploit enterprise information. This broad, open set of capabilities expands Domino’s connectivity, integrating the strengths of transaction systems with the strengths of Domino applications to create an offering that's much more than the sum of its parts. And when combined with Domino’s Internet application development capabilities, these extensions provide developers with the ability to exploit the corporate knowledge base.

Lotus Domino integrates with the Internet

Lotus' Internet strategy has rapidly evolved since the initial shipment of InterNotes Web Publisher in May 1995. Web Publisher allows transformation of Domino-based documents to HTML-based Internet formats. In addition, the InterNotes Web browser, part of the Notes 4.x server, allows browsing on the Internet from any Domino server. Via InterNotes, Internet connections or “hotspots” can be incorporated into Domino documents with point and click access from Domino to the Internet.

Lotus has successfully extended its intranet technology to the Internet with the Lotus Domino Server powered by Notes. Domino is targeted at meeting users' needs not only for publishing static information, but for the new class of highly interactive Internet and intranet applications now being demanded by customers. Domino stands alone among Web servers in offering the types of directory, agent, replication, application development, management, security, and enterprise integration services needed by customers today. Lotus also leads through its support by a rich community of over 12,000 Business Partners, many of which have been building interactive groupware applications for more than six years.

In Lotus Notes Release 4.5, Lotus incorporates the Domino server technology with the new Notes Release 4.5 client, featuring integrated calendaring and scheduling, direct Web access, and support for Java applets and Internet Plug-ins. Lotus' strategy is to offer a complete, yet modular set of products for Internet and intranet users. For those desiring a market-leading client/server messaging solution, Lotus Notes Mail offers superior price/performance. For users who want a rapid application development and deployment environment for groupware solutions with enterprise integration, broad connectivity and platform support, Lotus continues to offer and enhance the Domino Server powered by Notes.

Domino's recognition in the industry as both a groupware and internet application has been extremely positive - so much that Domino 4.5 finished second on *PCWeek's* top 10 product list.[1]

Lotus also offers applications that aid in exploiting the Domino server technology. Net.Apps are a set of interactive applications that build upon Domino services. Net.Apps can be used "out-of-the-box" as Web applications that support Web browsers, as well as Notes clients. They can also serve as extensible templates with which customers and Lotus Business Partners can build customized applications. Net.Presence is specifically designed to allow customers to create a Web site intranet presence in about an hour.

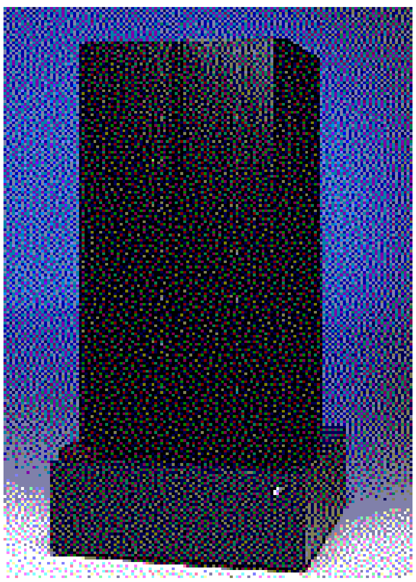
Lotus Domino provides an ideal communications infrastructure by combining enterprise-ready, client/server messaging and the global access and distribution of the World Wide Web, together with a platform for rapidly developing and deploying strategic groupware applications. Domino enables individuals and organizations to communicate with colleagues, collaborate in teams, and coordinate business processes within and beyond their organizational boundaries to achieve improved business results.

Domino incorporates technology for Web publishing, Web browsing, and managed access to the Internet. In addition, it offers replication, authentication, messaging, and security services - fully integrated with Internet protocols - in a single package. Lotus Domino is the software solution for extending business applications to the Internet.

1. PC Week, December 16,1996

Conclusions

In summary, there are many aspects to the deployment of a large-scale Domino complex. The RS/6000 SP system provides a scalable infrastructure from a performance and administrative perspective that is secure and reliable for running applications - and the distributed nature of Domino fits well with this architecture. The high level of system scalability and the management characteristics of the RS/6000 SP system make it the ideal platform on which to deploy an enterprise-level Domino system.

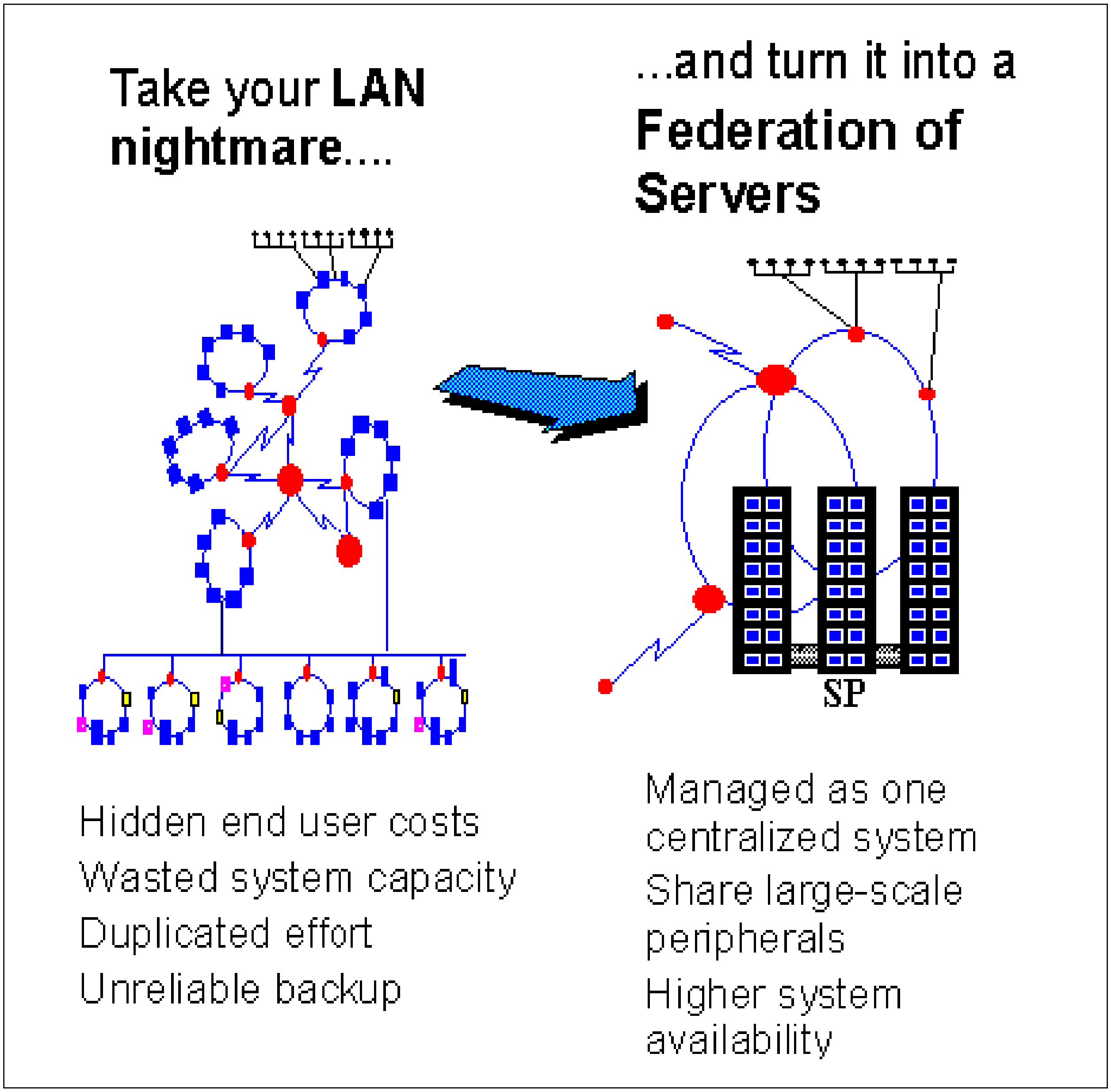


http://www.ibm.com
http://www.lotus.com

RS/6000 SP

Advanced Domino functionality *enables* you to combine distributed databases with powerful communications, replication, and security layers--all tailor-made for geographically distributed corporations. Your enterprise-wide groupware, messaging, and development environment will have built-in ties to the Internet. You will have the ability to integrate Domino applications with critical legacy systems and provide a powerful, flexible, and secure enterprise application development and deployment system. And, you'll have extremely powerful, interactive Web applications that leverage and exploit enterprise information.

The bottom line is this: By choosing Lotus Domino on the RS/6000 SP system, your business will be able to employ a cost-effective, reliable, and available scalable open system server technology - the RS/6000 SP system. You will be able to easily add cost-effective, incremental performance that ties into your high-performance network - the SP switch. Even better, your administration costs can be controlled as you add more and more servers - and you'll be able to tie into your existing enterprise environments and effectively monitor and manage it - with the capability to consolidate other legacy applications or functions that can take advantage of this exceptional scalability. You'll get the benefit of IBM's experience in providing new technologies -such as PowerPC processors, Symmetric Multi-Processing (SMP) SP nodes and new SP Switch technologies - as they evolve. And let's not forget what IBM is best known for: **World-Class Service and Support** - IBM is there to guide and support you through its world-wide service and support organization.



IBM has chosen the RS/6000 SP system and Lotus Domino for it's own intranet - it will have hundreds of thousands of people and hundreds of applications on RS/6000 SP systems and Lotus Domino in 1997. IBM and Lotus together have the skill and vast knowledge from their experience in setting up an enterprise-wide Domino configuration - and will share it with you - so you can use it to your competitive advantage.