



## Microsoft Exchange Server 4.0 vs. Lotus Notes 4.0

### KEY ARCHITECTURAL ADVANTAGES March 1996

In January 1996, Lotus Notes 4.0 was released. Lotus is positioning version 4.0 not only as a groupware development platform – but also as an enterprise messaging system. Many customers are currently making long-term investment decisions in client/server messaging systems, and need to understand whether a messaging product’s architecture is suited for the long term. This paper examines the messaging architectures of both products by looking at how each product supports a number of key customer requirements. It highlights the key advantages of Microsoft Exchange Server as a platform on which to build a long-term messaging infrastructure.

#### SCALABILITY AND RELIABILITY

##### Reliable data store with transaction logs

Borrowing an idea from production relational databases like Microsoft SQL Server, the Exchange Server information store and directory service use separate transaction log files to improve both performance and data integrity. All changes are quickly recorded in sequential transaction logs, then committed to the actual underlying database file. In the event of power loss or unexpected server shutdown this ensures that your data will remain intact and recoverable – right up to the last complete transaction. The architecture prevents the data from being left in an inconsistent or “corrupted” state.

Although Lotus calls their store a database, it has no transaction/recovery logging facilities. All database changes are written directly into the main database file, making it more likely for data to be left in a “corrupted” state in the event of abnormal server shutdown. All major systems facilities in Lotus Notes are built on top of this database architecture – the Directory, Mail routing, Groupware applications, Replication, Systems Management, etc. – and all are subject to its architectural limitations.

##### Fast automatic recovery using transaction rollback

When an Exchange information store or directory is started after abnormal server shutdown – the transaction log file is scanned to see if there were any incomplete transactions. If there were, these transactions are “rolled back” automatically to the state before they took place. This automatic recovery operation is relatively quick, since only the most recent transactions in the log have to be checked.

When a Lotus Notes server is restarted after an abnormal shutdown – a “FIXUP” program is run against every database file that was open. FIXUP must individually verify *every* field in *every* document in each database – a lengthy process that can take many hours for large databases. FIXUP also automatically deletes any “damaged documents” that it finds. Besides long recovery times, this raises the distinct possibility of critical data loss - an incomplete update to an existing document could result in the original document being damaged, and therefore deleted *entirely*.

The differences here in recoverability are exactly analogous to those between production DBMS systems like Microsoft SQL Server™ or Oracle™, and end-user databases like Microsoft Access™ or Lotus Approach™.

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### Single-instance storage with automatic referential integrity

Single-instance storage is a key requirement from customers who wish to store users' mail centrally, on the server. With single-instance storage, if 100 users on the same server all receive the same message – only a single copy of the message is stored on the server, and 100 “pointers” to the message are placed in the users' mailboxes. Significant space savings and server performance gains can be realized with single-instance storage.

Notes 4.0 introduces a rudimentary single-instance storage mechanism called “Shared Mail.” Notes Mail users all have their own separate Notes database files (.NSF files) on the server for their mailbox. Normally, if multiple users receive the same message it is stored multiple times, once for each recipient. When the optional Shared Mail feature is enabled, users' mail becomes fragmented – part is still stored in their personal mail file, and part is now stored in the shared mail file. Messages with a single recipient are stored entirely in the personal file. Messages with multiple recipients are split up – the message header and properties are stored multiple times in each personal mail file. The message body and attachments are stored once in the shared mail file. The Notes application creates links between the shared mail database file, and each of the users' personal mail database files.

When a user opens a message that has multiple recipients, the Notes application hides this complexity from the user. It opens both their personal and the shared mail database files, and resolves the links to create the “illusion” that the user has opened a personal copy of the message. The problem is the links between these separate database files. Because these are separate DOS files, the links between them are fragile and must be maintained by Notes' application-level code. They are not intrinsic to the Notes' database engine – there is no *automatic referential integrity* to ensure their consistency. If a user's mailbox is deleted, for example, then the pointers from the user's mailbox to the shared mail database are never updated. The shared mail database can easily be left with *orphaned* messages - taking up physical space, but not actually existing in anyone's mailbox. Administrators have to do a lot of manual work, using command-line LOAD OBJECT utilities, in order to avoid and correct situations like this.

Exchange Server has built single-instance storage into its information store design from the ground up, as opposed to simply stringing together existing databases. Single-instance storage is *always* in effect, requires no special configuration or administration, and most importantly is *intrinsic* to the information store. When a message or user mailbox is deleted, the right thing always happens; messages cannot be orphaned or lost. Pointers cannot get out of sync between files – because everything is stored in a *single file*, and referential integrity is handled internally by the database engine.

The net result is that Exchange Server is optimized for efficient, reliable storage of messages on the server. Lotus Notes' Shared Mail may meet the minimum bar to get a “single-instance storage” checkbox – but its complexity and fragility will almost certainly increase the administrator's workload.

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### Single-instance storage with per-user storage limits

A more obvious problem with Notes Shared Mail is that admins must forgo the ability to limit individual user storage. Notes can only limit the *overall size* of a database file – there is no way to limit an individual user's storage quota within a database. One user could easily hog all of the available shared mail storage.

Years of working with large Microsoft Mail customers impressed upon us the importance of giving control of storage to the administrator. Research shows that one of the most common reasons for

mail system outages is simply the inability to limit user storage, which eventually causes servers to fill up and cease working.

Therefore, within its shared mail information store, Exchange Server allows administrators to set and enforce disk quotas – either an overall default, or individual user limits. Users can be given a warning limit as well as a “hard” limit. The hard limit is enforced by prohibiting the offending user from sending any new email until they clean up their mailbox. In this way, this user won’t miss any critical incoming email messages, and other innocent users won’t be penalized by receiving “non-delivery” notices from the offender’s mailbox.

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### **Live online backup to tape for 7x24 operation**

Microsoft Exchange has built-in support for on-line backups directly to tape media. The server does not have to be shut down, nor do users have to be logged out. Furthermore, Microsoft Exchange backup is integrated with Windows NT Server backup, allowing administrators to back up both Microsoft Exchange servers and file servers from the same location. Administrators can perform full, incremental, or differential backups directly to a wide variety of tape devices, from ¼ inch cartridges to high-capacity DAT systems.

Lotus Notes 4.0 includes no tape backup facilities. The Administrator’s Guide suggests that you use your NOS-provided backup utilities to back up Notes data files. However, Notes database files cannot be backed up while they are open – Lotus suggests shutting down the server to ensure that central files like NAMES.NSF (the directory) can be backed up. Alternatively, they suggest replicating important files to a separate “backup server,” and then taking that server off-line for backup. Either way, there is no support for online backup of a live database – a critical omission for a 7-day-a-week, 24-hour-a-day production system.

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### **Incremental backup to tape**

When backing up an Exchange Server to tape – you have a choice of doing a full backup (which also re-sets the log files) or an incremental backup of just the log files. A full backup may take considerable time, so it is usually done only once a day, once a week, etc. In the interim, the “current” transactions can be quickly and incrementally backed up by backing up only the log files.

In the event of a total server loss (disk crash, fire, physical damage, etc.) you can restore the last full backup of the database, then restore each of the incremental log backups. The log files will automatically be *rolled-forward*, applying each of the logged transactions to the database in turn. This will bring the system back to the state as it existed when the last incremental backup was done.

Lotus Notes has no direct tape backup support. Since it also has no transaction log files – only *full* backups to tape are possible, using your Network Operating System-supplied tape backup program to backup the Notes data files. Full backups can take considerable time in the case of large database files. This only adds to the length of time that a Notes database must be off-line in order to be backed up.

Conversely, in the event of database loss or corruption – Notes databases can only be restored to the state from the last *full* backup, possibly resulting in loss of data entered since that time.

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### **Location-transparent replicas**

Exchange Public Folders support groupware applications like discussions, document libraries, and tracking applications. Distributed replicas of these folders are automatically kept in sync via Exchange’s fault-tolerant replication. Users don’t need to know which server a particular folder replica resides on – they are automatically connected to the nearest replica. This location transparency of Exchange Public Folders can dramatically lessen the administrative burden. Administrators can freely move folders, add/delete replicas – without having to re-configure individual users’ desktops.

Lotus Notes users have to connect to a specific replica of a database, on a specific server. If an administrator wishes to move a database to a new server, they need to tell the users to explicitly open the file on the new server location. Notes does provide some tools to help the administrator do this – for example, they can email new “database link” pointers to the users – but it is still a manual process nonetheless.

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### **Automatic replica fail-over and load balancing**

In Exchange Server, if a particular Public Folder replica is down for maintenance, or is removed, users are transparently connected to another replica. If a new replica is added – the system automatically starts connecting users to it in order to balance the load.

Lotus Notes databases, by contrast, have no “failover” capability – the burden of connection is on the user, not the system. Users must know the specific server name they wish to connect to. If that server is down, the best Notes can offer is a manual “hunting” feature: the user will be presented with a list of available servers; the user can try searching each one in turn to see if a replica exists.

Load balancing in Notes 4.0 is entirely manual. If a new replica is created, users must explicitly start using the new server name in order to connect to it. If an administrator wishes to balance the load among 3 replicas of a Notes database, they must manually instruct 33% of their users to connect to Server X, 33% to Server Y, and 33% to Server Z.

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### **Maximum application database size**

The maximum size of an Exchange Server Public Folder is 16 GB. The maximum size of a Lotus Notes database is 4 GB. To be fair, a single Exchange Server can hold a maximum of 16 GB of Public Folder data in total (spread across 1 large folder, thousands of small folders, or anything in between). An application of this size would require a server be dedicated to that single Public Folder application. Notes could theoretically host multiple Notes applications, each up to 4 GB in size on a single very large server, totaling more than 16 GB of storage – however, very large applications in the multi-gigabyte range tend to be deployed on dedicated servers anyway.

Additionally, Exchange Server’s location-transparent Public Folder replicas make it easy to distribute applications across multiple servers, as dictated by storage requirements. Users and administrators don’t have to worry about knowing which application is hosted on which server.

The bottom line is that for most types of workgroup applications, an Exchange Public Folder offers that application up to four times the storage capacity of an individual Lotus Notes 4.0 database.

(As a side note – Exchange Server actually provides a total of up to 48 GB of storage per server: 16 GB for mailboxes, 16 GB for Public Folders, and 16 GB for Directory objects.)

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### **Supports up to 1500 concurrent users on a single-Pentium server**

Exchange Server has been tested using the built-in Load Simulator tool to satisfactorily support up to 1500 concurrently logged-on, active mail users on the following server configuration:

- single Pentium 90 processor
- 64 MB RAM

See *Microsoft Exchange Performance Whitepaper: Users Per Server* for further details of the test.

Lotus publicly demonstrated 1500 concurrent mail users at their Lotusphere conference in January 96, using a Beta version of their simulation tool called *NotesBench*. The server configuration was:

- 4 x Pentium 133 multi-processor
- 768 MB RAM

Clearly these two tests were not performed under “apples-to-apples” conditions, but the relative resource requirements between the two systems should be apparent even at this gross comparison level.

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### **Supports up to 20,000 concurrent users on multi-processor servers**

Exchange Server has been tested using the built-in Load Simulator tool to satisfactorily support up to 20,000 concurrently logged-on, active mail users on the following server configuration:

- 4 x 275 MHz DEC Alpha RISC multi-processor
- 1024 MB RAM

Realistically, this many users on a single Exchange Server would have very limited server-based mailbox storage available, due to the 16 GB per server mailbox limit in version 4.0. But since Exchange Server allows the choice of server-based or local mailboxes (or both) – this limitation could be offset if users have their mail delivered to Personal Folders on their machines. The main point of this test was to demonstrate the inherent scalability in the Exchange Server architecture. The 16 GB per server limit will be raised significantly in a future release of Exchange Server – and the architecture already exists to take full advantage of it.

To our knowledge, Lotus has not offered any test results on this scale. Again, see the *Users Per Server* whitepaper referenced above for further details of these tests.

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## **DIRECTORY SERVICE**

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### **Integration with Server Operating System**

Microsoft Exchange Server is built on top of the Windows NT Server operating system - which gives customers a wide choice of scaleable server platforms to run on: Intel, MIPS, Alpha, PowerPC – in both single and multi-processor configurations. Windows NT Server provides a secure, reliable, and scaleable platform for file and print services as well as providing a rich platform to run your server applications. The Windows NT architecture provides unmatched security (the only Server Operating System that is C-2 certifiable), straightforward easy administration, and interoperability with existing platforms. Microsoft Exchange Server's tight integration with the Windows NT Server operating system and other Microsoft BackOffice™ products running on the server reduces overall system administrative costs by allowing a distributed computing environment coupled with a centralized administration model.

Because it's intended to be platform-independent, Lotus Notes *by design* offers little or no integration with any of the popular Server Operating Systems on the market. Instead, Notes re-invents the wheel in many key areas – security, directory service, systems management – by providing its own version of these standard system services that work only with Lotus Notes.

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### **Single user logon to all network resources**

Because Microsoft Exchange Server uses the Windows NT Server Directory for its basic user authentication – this allows end users to have a single account and logon for file/print services, email, groupware, scheduling, SQL databases, Internet access – all BackOffice services.

Lotus Notes is not integrated with Windows NT Directory logon, nor with the logon from other Network Operating Systems. This means that users almost always have two user accounts on two different systems – including two different passwords to remember and manage.

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### **Single-step user account creation for networking, email, groupware, scheduling**

Because Exchange Server is tightly integrated with Windows NT Server and the NT Server Directory – with a single step, administrators can create a user's single BackOffice logon account, create their mailbox, and create their calendar – all without leaving the Windows NT User Manager

program. Perhaps even more importantly – admins can also globally *delete* or disable the user's account with a single step, in the event the user leaves the company.

Lotus Notes allows single-step creation of user ID files for use only within Notes, for e-mail and groupware only. Lotus Organizer calendars must be created separately, and linked to a user's Notes ID. Notes offers no integration with other Network Operating System user accounts.

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### **Directory scales to 5 million users**

The Microsoft Exchange Server directory service has been successfully tested with up to 5 million names in a single Global Address Book (theoretical limits are actually higher). The size of such a directory fits well within the 16 GB directory size limit for Exchange Server 4.0, and end-user response time on queries and browsing remained less than one second.

At this time, we are not aware of any Lotus-published performance results with large directories of this scale. Size and response time should be of concern here. Like any Notes database, the Public Name & Address Book is limited to 4 GB maximum size, and Notes Views and indexes can take considerable time to re-build after changes are made in large databases. It is common practice among large Notes customers to split their directory into several smaller “cascading” Name & Address Books, to achieve acceptable performance – despite the added administrative overhead this entails.

Also, keep in mind that the Lotus Notes directory is built on the same non-transactional, non-recoverable database technology as any other Notes database.

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### **Directory Links with automatic referential integrity**

The Exchange Server directory provides fast, reliable links and “backlinks” between many types of directory objects. For example, you can look at a Distribution List, and see which users are members of the list. You can just as easily look at a User, and see which Distribution Lists of which they are a member. Simply adding a user to a list creates both links automatically. Removing the user from the list, or even removing the user altogether will automatically and immediately update both links. This *referential integrity* is automatically maintained within the directory service.

Another innovative example of these links is the built-in “*Corporate Org Chart*” feature of the Exchange Server directory. Each user has a “Manager” field, which is a link to another user in the directory. When this is entered, the Exchange directory automatically maintains corresponding “backlinks” that allow you to immediately see all of the “Direct Reports” for a given user, as well as his/her manager. Users can click on a person's manager, the manager's manager, and so on to “walk” the corporate hierarchy up or down. Manager data can be entered manually by point and click, or it can be periodically imported and updated from Human Resources export files.

Lotus Notes databases, including the Public Name & Address Book, do not provide automatic links or referential integrity between documents. For example, when you delete a user from the Address Book, the server actually runs a script that hunts through all the groups, deleting the user from any they were a member of. Likewise, when you look at a *Person* document in the Address Book, you cannot view the groups that they are a member of (although you could possibly write some code that loops through all the groups to find this information).

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## CENTRAL SECURITY MANAGEMENT

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### Secure central deletion of user accounts

Microsoft Exchange provides *centralized* security management of user accounts, thanks to its tight integration with Windows NT Server directory and security. Administrators can specify user security policy such as password aging, and have tools such as automatic intruder detection and account lockout to help prevent system attacks. With Microsoft Exchange, when a user leaves the company, their account can quickly be deleted centrally and this change will immediately apply across your messaging infrastructure. If a user account's password is forgotten or compromised, the administrator can globally reset the password with a single action, preventing any future security breaches due to the compromised password.

Most importantly, if an administrator ever leaves the company then their account can be quickly and globally deleted – or the password can simply be changed centrally. This prevents disgruntled administrators from being able to leave any “back doors” into your Windows NT/Exchange Server system.

By contrast, Lotus Notes relies exclusively on distributed public key cryptography for all security and access control. Private keys are stored in physical Notes ID files; users assign passwords to these files to protect their private keys. Once the physical User ID file is distributed to a user, the administrator loses all direct control of that ID. If an attacker gets a copy of a user's ID file, and gets the password to it then they have effectively stolen that user's identity. It does no good for the user to change their password at this point – *passwords are not global – they only apply to the local ID file*. Changing a password only changes on your local copy of the ID file. The attacker still has full access to the user's private key in his copy of the ID file.

If such a compromise is ever suspected, then the user must be issued an entirely new ID (a whole new “identity”). The old ID cannot simply be deleted centrally – *because the attacker has physical possession of it*. Instead the old ID must be “Denied Access” to all servers and databases in the organization. This task sounds especially daunting – although administrators can alleviate the burden somewhat if they plan ahead and carefully follow Lotus' advice to maintain a central “Terminations” or “Deny All Access” group in every database by default. However, it's not necessarily just your own organization you need to worry about – the ID must also be Denied Access on any external servers or organizations which have cross-certificate trust with your organization – or else the attacker may have access to resources in those other organizations.

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### Protection from “disgruntled former administrator” attacks

One of the biggest security risks in Notes results from the fact the Lotus uses the same distributed ID file mechanism with the top-level “Certifier” IDs as well. These IDs are used to create all of the other user and server IDs. An administrator with access to the Certifier ID could create new ID files at will that match existing user IDs, allowing them access to any resource in the organization. Needless to say, Lotus has strict recommendations on how to try to make your Certifier ID file secure. To their credit they have also added new features in version 4.0 that can help safeguard the Certifier ID: so-called “missile silo” keys, where two or more separate people must give their passwords to use the Certifier ID, and optional Public Key matching – where an ID is checked against the Public Name & Address Book to make sure it's not an unauthorized duplicate of an existing user ID. Still, it's up to the administrators to use these optional new features to keep their system safe.

One can argue that in any system the top-level security administrators must be trusted to a very large extent. This is true – but in Notes, the biggest problem is what happens *after* they leave the company. A disgruntled or untrustworthy Certifier admin could easily make copies of the Certifier ID file (as well as all user ID files if they made backups) and store them at home for a “rainy day.” If that person leaves the company, the new Certifier admins can change the password on the

Certifier ID, but again, it's too late – this only changes the password on their local copy of the ID file – it changes nothing on the attacker's copy of the ID file. This is a worst-case compromise scenario – a new certifier ID must be issued, as well as new IDs for all servers and users that were certified with the old Certifier ID. You must practically re-install the system at this point.

Again, Exchange Server and Windows NT Server guard against this scenario by simply allowing all passwords to be globally reset. Even if an attacker did have the correct password at one time, this hole can be quickly sealed by changing it centrally. Any “backdoor” logon accounts the former admin may have created can be quickly found and centrally deleted.

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### **Complete security policy management**

Because Exchange Server uses the underlying logon/security facilities of Windows NT Server, it automatically inherits the security policy management features from NTS. Customers tell us they want to be able to set consistent security/password policies across all their systems. Windows NT Server (and therefore Exchange Server, or any BackOffice app) allows the following password and user policies to be managed:

- min password length
- min/max password age
- password uniqueness (can't re-use last 'N' passwords)
- valid logon hours
- valid logon workstations

Of these, Lotus Notes only supports minimum password length on Notes ID files.

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### **Intruder detection and account lockout**

Exchange Server supports (via Windows NT Server) the ability to detect when an “intruder” is trying to break into the system by repeatedly trying multiple passwords. This activity can trigger an alert to an administrator. Further, the system can be configured to automatically lock out *all access* to the specific account after 'N' bad passwords to prevent dictionary/password attacks on the system.

Lotus Notes uses distributed public-key security, which provides no intruder detection or lockout facilities, leaving Notes ID files potentially vulnerable to dictionary attacks.

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## **CONNECTIVITY**

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### **Universal transfer agent for both replication and mail routing**

Only Microsoft Exchange Server takes full advantage of store-and-forward messaging architecture for its replication services. The Exchange Message Transfer Agent (MTA) already provides sophisticated least-cost routing, dynamic re-routing, automatic traffic balancing, and very high throughput. This robust backbone is ideal for a Public Folder to send its replication changes to other replicas, ensuring guaranteed and efficient delivery. With this backbone already in place – the Administrator's job becomes enormously easier. Creating additional replicas on new servers is a simple point and click – Exchange Server automatically handles the details of distributing replication changes to the new servers over the existing routing topology.

In this way, the Exchange MTA can distribute and replicate any data type - not just messages but also BBS postings, documents, forms, applications, directory changes, and group scheduling data. With these capabilities, the MTA might better be termed a *universal transfer agent* which provides a single mechanism for *fault-tolerant replication and message routing*.

Although Lotus Notes has a built-in Mail Router process – it's curiously unused for database replication. Instead, Notes database administrators must set up point-to-point replication



“connection documents” from every server to every other server that contains a replica, in a mesh topology. These many-to-many relationships quickly become unmanageable, and so in most larger Notes systems, administrators are forced to manually simulate a store-and-forward messaging backbone – by creating a “hub and spoke” replication topology. Spoke servers have to replicate their changes to a central hub server, which then consolidates and replicates the changes back out to the spokes. Timing becomes very critical; great care must be taken to ensure that all the spokes have finished replicating before the hub starts sending changes back out.

Note also that the Exchange MTA can route over X.400 or SMTP, as well as directly between Exchange Servers – this means that Directory and Public Folder replication can also take place over these *industry standard* store-and-forward protocols. Notes replication can only take place over direct network connections between two Notes servers.

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### **Built-in X.400 support**

Microsoft Exchange Server is shipping with built-in native support for the X.400 (both 1988 and 1984 certified) messaging protocol via the Microsoft Exchange X.400 Connector. This means Microsoft Exchange can plug into existing X.400 backbones, or it can serve as an X.400 backbone itself. Connections to other X.400 systems can be made via TCP/IP, TP4, and X.25.

Lotus Notes has not yet shipped their X.400 MTA for Notes 4.0. As of this writing it is still in early Beta testing. This gateway will be provided as an extra-cost option for Notes 4.0 servers. Lotus has said that this new gateway will not provide TP4 connectivity – a potentially large problem for many standards-based customers.

To get X.400 connectivity today with Notes 4.0, customers must have a Notes 3.x server, and use a gateway designed for use with Notes 3.x – such as the Lotus Message Switch (aka Softswitch EMX) or another 3<sup>rd</sup>-party X.400 gateway.

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### **Built-in SMTP/MIME support (Internet Mail)**

Microsoft Exchange Server is shipping with the built-in Internet Mail Connector (IMC). The IMC provides native, built-in support for SMTP/MIME (Internet mail). Native SMTP/MIME support in Microsoft Exchange allows use of the Internet as a messaging backbone to send and receive rich-text, high-fidelity messages and attachments.

Lotus Notes has not shipped a native SMTP MTA for Notes 4.0. As of this writing it is still in early Beta testing. This gateway will be provided as an extra-cost option for Notes 4.0 servers.

To get SMTP/MIME connectivity with Notes 4.0, customers must have a Notes 3.x server, and use either the existing Lotus SMTP gateway for Notes 3.x, the Lotus Message Switch (aka Softswitch EMX) or another 3<sup>rd</sup>-party SMTP gateway. Note that existing Notes 3.x SMTP gateways do *not* allow for backboning, or *encapsulation* of rich Notes data across the Internet, although this is planned for their future gateway.

Another dimension of Internet Mail support is client support. Since the Microsoft Exchange Client is a “universal inbox” built entirely around the open MAPI architecture – it can natively talk to a variety of email systems, including SMTP/POP3 mail servers – not just to Microsoft Exchange Servers.

The Lotus Notes 4.0 client, on the other hand, does not support MAPI at all – it is not a universal mail client. It is written to the proprietary Lotus Notes API, and can only connect to Lotus Notes servers.

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### **Limit outgoing/incoming message size per user**

In Exchange Server, administrators can specify a default limit for maximum incoming and outgoing message sizes. Administrators can also get more granular and specify different limits on a per-user basis. For example, a 1 MB limit on maximum message size might be imposed by default, perhaps

in order to avoid saturating some low-bandwidth connections between sites. If a particular user in the Graphics department needs to be able to transfer 20MB graphics files via email – the administrator can raise the limit for that user only.

Lotus Notes 4.0 has no ability to limit the incoming or outgoing message size. Users can attach arbitrarily large files to messages – which may wreak havoc on a company's network bandwidth without some controls.

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## **END-USER ARCHITECTURE**

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### **Built-in Group Scheduling**

Microsoft Schedule+ is an integral, built-in part of Microsoft Exchange Server. As expected, meeting requests and responses are sent via email and appear in the user's Inbox. The Exchange Directory is used for looking up both users and conference rooms. As with the rest of Exchange, a single logon to your Windows NT Server account gets you access to all authorized resources.

Lotus Organizer is a separate product, which is not part of the Notes 4.0 product. It is "loosely coupled" with the Notes address book, and can use Notes Mail to send meeting requests, but the integration appears to stop there.

Lotus has announced plans to integrate Scheduling directly into the Notes user interface in a future release, and has begun demonstrating early versions of this capability, although it is definitely not part of the Notes 4.0 release.

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### **Calendar data uses server store and replication**

In Exchange, users' calendar information is stored natively in the Exchange Server information store, leveraging its backup, restore, recovery, and security features. Free/busy information is stored in a Public Folder and distributed via Exchange Server's fault-tolerant replication system.

With Lotus Organizer, users' calendars must be stored on a separate file server; no calendar data is stored in the Notes database. Organizer makes no use of Notes' replication facilities for distributing data – enterprise-wide lookup of users' free/busy times is not possible without direct LAN connectivity between all file servers. Also, a separate Organizer server process (the "Scheduling Agent") must be set up and maintained.

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### **Local replication of mail, calendar, and groupware data**

Microsoft Schedule+ (a built-in part of Exchange Server) has complete support for mobile users, including automatic bi-directional replication of calendar information, off-line meeting request creation, and an off-line replica of the Global Address Book.

Organizer has only rudimentary support for off-line or mobile clients, requiring users to manually copy and merge calendar files between laptop and server.

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### **Mail-optimized Rules engine with infinite loop prevention**

Microsoft Exchange Server provides intelligent Auto-Assistants, including an Inbox Assistant and Out-of-Office Assistant, which run on the server to process the user's incoming e-mail according to rules they set up. These Assistants are optimized specifically for incoming e-mail, the most common customer requirement for "rules" processing. The rules are executed *synchronously* with e-mail delivery. The initial e-mail delivery to your Inbox and the processing of the rule will occur nearly instantaneously. This avoids user confusion and problems caused when a user sees a new mail arrive in their Inbox, only to have it later disappear – perhaps while they're working on it.

More importantly, the Exchange Server rules engine has built-in safeguards to prevent infinite mail loops or storms from happening. Users can safely set up any combination of forward, auto-reply, or other rules without fear of causing “mail loops.”

Lotus Notes 4.0 supports the use of “Agents” – which are a potentially powerful tool for processing messages automatically. Unfortunately, the Notes 4.0 Agent technology appears to be optimized for custom Workflow application development, rather than the common case of incoming e-mail rules. For example, even though one of the Agent trigger events is “When new mail has arrived” – this action will not be performed simultaneously with e-mail delivery to the user’s Inbox. Instead, it will be run by default whenever that Agent is next scheduled to run on that server – typically 5 to 10 minutes later. Users can become confused when they see mail arrive in their Inbox, only to later get moved somewhere else by a rule.

Of greater concern is the ease with which Notes 4.0 end-users can create infinite “mail loops”. Two users only need to setup Agents which send mail to each other upon arrival of new mail; once the agents are enabled they will cause each other to send mail back and forth infinitely (or at least until their databases fill up). This is a serious concern that could cause some administrators to disable users’ access to agents.

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### **Universal mail client can access multiple email systems**

Microsoft Exchange is fully MAPI 1.0 compliant at both the client and the server. MAPI 1.0 (Messaging Application Programming Interface) is a published, industry standard. Applications written to MAPI 1.0, such as the Microsoft Exchange client, can be used against any back-end messaging service that has a MAPI 1.0 Service Provider (driver) available for it. This means for example, that the Exchange client can be used directly with an SMTP/POP3 mail server, with online services like CompuServe or the Microsoft Network – or even with other LAN-based mail servers, like Lotus Notes or Lotus cc:Mail.

MAPI 1.0 provides a comprehensive set of interfaces for accessing and manipulating messages, folders, address books, forms, and properties. Information in Microsoft Exchange Server mailboxes, Public Folders, Forms Libraries, and the Directory Service are all accessible via MAPI.

The Lotus Notes 4.0 client has no support for MAPI. All Notes clients are strictly limited to talking with Lotus Notes servers. To their credit, Lotus has shipped a MAPI driver for their Notes Server 4.0 – this enables MAPI clients such as Microsoft Exchange client to work against the Notes Server for mail access. However, to date, Lotus has not announced any intention to support MAPI in the Lotus Notes client.

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### **Supports native vs. “simulated” Web browser**

Microsoft Exchange client today takes advantage of the Microsoft Internet Explorer – today’s hottest Web browser, and also supports other popular browsers, such as Netscape Navigator™. Whenever a URL web link appears in the text of a mail message Exchange automatically converts the text into a hot-spot that can be single-clicked to immediately invoke your Web browser, and jump directly to that web page. Conversely, the Microsoft Internet Explorer 2.0 has a “File.Send” command which launches Exchange and embeds an Internet Shortcut in a new mail message. Netscape Navigator 2.0 also has an explicit option to use the Microsoft Exchange client for email. Customers can take advantage of the latest technology in the fast-changing web browser world.

Lotus’ strategy for Web browser client integration is Notes-centric, and doesn’t leverage customers’ existing investments in web browsers. Notes 4.0 includes application which *simulates* a Web browser – called Lotus Notes Web Navigator. This application provides a server gateway which translates HTML-based Web content into native Lotus Notes documents on request. Notes clients can then browse the translated documents, which look and act like native Notes documents (double-click on links instead of single-click). Although it can translate most basic HTML elements – the Web Navigator cannot handle advanced Web features like Java, Frames, or RealAudio™. In the rapidly changing world of Web browsers, the Lotus “simulated” web browser and the Navigator

gateway will be hard-pressed to keep up. Additionally, the process of translating HTML documents to native Notes format can be slow, making Web Navigator performance visibly worse than using a native Web browser.

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## **MICROSOFT OFFICE INTEGRATION**

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### **Native document and property storage**

The Microsoft Exchange client supports *direct* drag and drop of documents from the file system into the information store, without having to first “attach” the document to a note. Further, if the documents use OLE Compound Storage format (as do Microsoft Office documents) – then all OLE properties in the documents are automatically stored in the Exchange information store as database properties – both Standard and Custom properties. For example, if you have an Excel worksheet with a bottom line called “contract amount,” you can define the cell that contains the contract amount as a field. The benefit to the user is that the important information in the worksheet can be “hoisted” in a way that it can be viewed from within Microsoft Exchange without having to open the Excel worksheet – the original app needn’t be running for this “property exchange” to take place. Changes to the original worksheet are reflected directly in the Microsoft Exchange folder.

Lotus Notes requires that all files and documents first be “attached” to a note or a form before they can be stored in a Notes database. In order to store the document’s properties, the original application must be running, and it must support the proprietary Lotus F/X (field exchange) protocol.

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### **Post documents directly into Public Folders**

Microsoft Office documents can be directly saved into Exchange folders as an alternative to the file system, via a standard *Post to Exchange Folder* command found in all Microsoft Office 95 applications. Like the drag/drop example above, all of the document’s properties are saved, as well, and immediately available for use in views, sorting, etc.

Lotus Notes doesn’t provide a similar standard direct “save to database” feature – although with some effort, macros or Lotuscript custom code could be written to accomplish this.

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### **Use Word Processor as message editor**

The Microsoft Exchange client is architected in a modular fashion to allow replacement of various components. An excellent example of this is the ability to use Microsoft Word for Windows 95 as the text editor in Exchange. Users then get full use of Word’s advanced editing features, such as AutoCorrect, AutoFormat, tables, thesaurus, etc.

The Lotus Notes 4.0 client does not support this ability to use your office suite’s word processor as an alternate editor.

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## **ADMINISTRATION AND DEPLOYMENT**

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Microsoft Exchange provides a rich set of administration tools aimed to ease the management of the messaging infrastructure. These tools are built into Microsoft Exchange Server and ship in the box, at no additional cost.

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### **Single seat administration**

Microsoft Exchange Server provides a built-in dedicated-purpose administrative program, which can be used to centrally manage an entire Exchange enterprise-wide from a single point – over

either LAN or dialup connections. It provides the ability to create/modify users, change server and gateway settings, and point and click to distribute Public Folder replicas to servers around the enterprise. Administration can be done both on individual servers as well as on logical groups of servers called "Sites." Configuration changes made to a Site are automatically made to all servers in that Site.

The Exchange Server Administrator program also provides sophisticated, proactive monitoring capability. Server health and statistics can be monitored enterprise-wide, and a variety of actions can be taken automatically in response to events. An automatic "escalation path" for these actions can be defined. For example simply trying to restart a service the first time a problem is detected, notifying an administrator via pager the second time, or even automatically shutting down and restarting the server remotely if it's still down a third time.

Lotus Notes provides a "Server Administration Console" built into each Notes client, which administrators use to create users and modify server settings, as well as configure basic server and statistical monitoring. Although this tool can remotely administer any server on the network, it typically is used to point at and manage one server at a time. This built-in tool does not provide any global view of how database replicas are distributed – individual connection documents must be examined to determine that.

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### **Central link and mail delivery monitoring**

Microsoft Exchange allows administrators to proactively monitor multiple aspects of the messaging network. These monitors provide both a reactive and proactive tool in diagnosing and troubleshooting problems (real or potential) within your e-mail infrastructure. Especially useful are Link Monitors, which allow you to monitor the actual flow and elapsed time for messaging delivery enterprise-wide. Link monitors work by bouncing test mail messages against the target servers and measuring delivery time.

Microsoft Exchange Server provides this enterprise monitoring out of the box at no additional cost, as part of the Exchange Administrator program.

Performing this same task in Lotus Notes requires the purchase of Lotus NotesView (which also requires HP OpenView to run). Lotus NotesView is a 16-bit application which runs on top of HP OpenView for Windows 3.1. Lotus NotesView retails for \$5,995 for up to 150 servers, and \$3495 for up to 10 servers. HP OpenView has a list price starting at \$1495.

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### **Message tracking and query**

Microsoft Exchange provides administrators with end-to-end message tracking. Many administrators have told us this is the "Saved my Job" feature. If a user complains that "I sent a message to Jane Smith, and she claims she never got it" – the administrator can easily query for the message in question, and see its tracking history graphically displayed, including every server, MTA, or connector that ever touched the message. Most importantly, they can determine whether the message was in fact ever delivered, if it's "stuck" in a queue, etc. – and resolve the problem.

Lotus Notes does not provide a message tracking center like Exchange. Instead, it provides a simplistic message "tracing" feature. At the time that trouble is suspected, a "trace" can be set on subsequent messages that will show the path taken by those messages. This might help find some types of problems, but at that point *it's too late* - it doesn't help you locate a missing message that was previously sent.

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### **Built-in Migration Tools**

Microsoft Exchange ships with tools that enable a straightforward and customer-controlled migration of user accounts, messages, attachments and calendars to a Microsoft Exchange environment. The migration tools that are provided with Microsoft Exchange include: Microsoft Mail for PC Networks, Microsoft Mail for Appletalk Networks, Lotus cc:Mail, IBM PROFS and

Office Vision/VM, DEC All-In-One, and Verimation MEMO. Microsoft Exchange provides a universal MAPI client, meaning it works against a MAPI backend, such as Microsoft Mail. Users migrating to Microsoft Exchange can take a controlled approach, migrating first clients and then servers.

Lotus Notes has announced plans to provide migration utilities for Microsoft Mail, Lotus cc:Mail, and Office Vision. These migration utilities will not be available until 2Q96, although the existing Notes 3.x-based tools may be used to migrate cc:Mail users in the interim. Additionally, the Lotus Notes client is not a universal mail client, meaning it runs only against a Lotus Notes Server. This means that there is no option to migrate clients to Notes first, and then migrate the servers later.

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### **Co-existence with legacy LAN-based email**

Microsoft Exchange supports a mixed messaging environment by enabling co-existence with legacy mail systems. The Microsoft Mail connector, that ships with Microsoft Exchange enables Microsoft Exchange Servers to connect directly with Microsoft Mail PostOffices. Microsoft Exchange Server can also replace existing Microsoft Mail MTAs for message routing in a Microsoft Mail environment. Bottom line: Exchange Server supports customer-controlled migration from Microsoft Mail; installing the first Exchange Server actually *improves* Microsoft Mail, with a more reliable and scalable MTA.

Lotus has not yet shipped the promised cc:Mail Connector for Lotus Notes 4.0, which is the key component of the Lotus Communication Server. As of this writing it is still in early Beta testing. This gateway will be provided as an extra-cost option for Notes 4.0 servers. In the interim, cc:Mail customers need to use the old LMEF (Lotus Mail Exchange Facility), which is an OS/2-based Notes 3.x gateway that routes mail between cc:Mail and Notes.

Furthermore, the specifications for the Lotus cc:Mail MTA for Notes 4.0 state that it will *not* directly connect to cc:Mail PostOffices – it only connects to cc:Mail Routers. This means that Lotus cc:Mail customers will have to continue to run and maintain their existing MS-DOS or OS/2 based Routers to service their post offices. The cc:Mail MTA for Notes 4.0 therefore cannot replace the old MS-DOS or OS/2-based cc:Mail Router infrastructure - it just adds another layer to manage. The customer benefit is questionable.

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### **User-Customizable Load Simulation Tool**

Capacity planning, hardware budgeting, and performance tuning are all critical aspects of a global messaging system deployment. Microsoft Exchange Server includes a sophisticated tool for simulating and measuring large user loads against actual running servers - *LoadSim*. Users can totally customize every aspect of the user and performance profiles in order to accurately model their real-world company environment. LoadSim works by simulating many dozens or even hundreds of Exchange client users on one or more “driver” machines. LoadSim is fully multi-threaded and multi-processor scalable to be able to adequately simulate large numbers of users. These “driver” machines then access one or more actual, running Exchange Servers, and measures response times across a wide variety of user activities. Extensive research and testing was done to ensure that the simulation tool uses the *exact* function calls and semantics of the real Microsoft Exchange client. Real-world production system measurements have confirmed the accuracy of the Load Simulator models.

LoadSim makes it easy to run even very large tests – simply say that you want *N* mailboxes split across *M* servers, and LoadSim will automatically create mailboxes distributed across those servers. Several default “user profiles” are included - based on actual research into customer usage patterns – such as light, medium, or heavy users. Load Simulator currently simulates 5 basic user tasks: Inbox task (“Read new mail”), the Browse task (“Read old mail”), the Send Mail task, the Schedule Plus task, and the Public Folder task. LoadSim also accurately reflects the load imposed on the server by background tasks – such as mail routing between servers, updating indexes, and Distribution List expansion. All aspects of the user profiles used are customizable – you can feed in *your* actual user data and measure the results:

- work hours, spikes in usage (first thing in the morning, lunch time, etc.)
- # of messages sent/received/replied per day
- % of messages with X recipients, to DLLs, etc.
- size of messages, attachments – or compose *actual* Exchange messages, save them, and use them in the test.
- # and depth of user's mail folders
- # Calendar appointments made
- Public Folder posting, browsing, reading behavior, etc.

Lotus has announced a benchmarking tool of their own, called Lotus NotesBench. Unlike LoadSim, Lotus has stated that the initial release of NotesBench will be non-customizable; it uses fixed Lotus-defined "user profiles" only. The entire purpose of NotesBench is quite different from that of LoadSim – it's designed strictly for running "apples-to-apples" tests between two or more different hardware platforms, to measure their relative performance. This is certainly valuable information (and LoadSim can do this quite easily) – but because it's not customizable, NotesBench does *not* allow real-world modeling of *your* messaging environment. This presents an obstacle for planning, budgeting, and deploying a real global messaging system.

## **CONCLUSION: MICROSOFT EXCHANGE SERVER'S KEY ARCHITECTURAL ADVANTAGES BEAT LOTUS NOTES 4.0**

Microsoft Exchange provides a complete messaging and groupware solution out of the box today. Powerful and reliable architecture, coupled with centralized administration and integration with the Windows NT Server directory and security enable Microsoft Exchange users to deploy a scaleable and dependable messaging and groupware infrastructure. This paper demonstrates that Exchange Server has a scalable, secure architecture that will meet customers' long-term investment needs.

<b>SUMMARY: Microsoft Exchange Architectural Advantages</b>	<b>Exchange Server 4.0</b>	<b>Lotus Notes 4.0</b>
<b>SCALABILITY AND RELIABILITY</b>		
Reliable data store with transaction logs	X	
Fast automatic recovery using transaction rollback	X	
Single-instance storage with automatic referential integrity		
Single-instance storage with per-user storage limits	X	
Live online backup to tape for 7 x 24 operation	X	
Incremental backup to tape	X	
Location-transparent replicas	X	
Automatic replica fail-over and load balancing	X	
Maximum application database size	16 GB	4 GB
Supports up to 1500 concurrent users on a single-Pentium server	X	
Supports up to 20,000 concurrent users on multi-processor servers	X	
<b>DIRECTORY SERVICE</b>		
Integration with Server operating system	X	
Single user logon to all network resources	X	
Single-step user account creation for networking, email, groupware, scheduling	X	
Directory scales to 5 million users	X	
Directory Links with automatic referential integrity	X	
Unified transfer agent for both replication and mail routing	X	
<b>CENTRAL SECURITY MANAGEMENT</b>		

Secure central deletion of user accounts	X	
Protection from "disgruntled former administrator" attacks	X	
Complete security policy management	X	
Intruder detection and account lockout	X	
<b>CONNECTIVITY</b>		
Universal transfer agent for both replication and mail routing	X	
Built-in X.400 support	X	
Built-in SMTP/MIME support (Internet Mail)	X	
Limit outgoing/incoming message size per user	X	
<b>END-USER ARCHITECTURE</b>		
Built-in Group Scheduling	X	
Calendar data uses server store and replication	X	
Local replication of mail, calendar, and groupware data	X	
Mail-optimized Rules engine with infinite loop prevention	X	
Universal mail client can access multiple email systems	X	
Supports native vs. "simulated" Web browser	X	
<b>MICROSOFT OFFICE INTEGRATION</b>		
Native document and property storage	X	
Post documents directly into Public Folders	X	
Use Word Processor as message editor	X	
<b>ADMINISTRATION and DEPLOYMENT</b>		
Single-seat Administration	X	limited
Central link and delivery monitoring	X	extra <sup>1</sup>
Message tracking and query	X	
Built-in Migration Tools	X	limited
User-customizable Load Simulator tool	X	

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<sup>1</sup> Requires separate purchase of Lotus NotesView (list price \$3495 for up to 10 servers, \$5995 for up to 150 servers). NotesView also requires a copy of Hewlett-Packard OpenView for Windows 3.1 (list \$1495 and up, from HP).