Chapter 16

INTERNET-BASED UNIFIED MESSAGING SYSTEMS

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Abstract

In this chapter we present unified messaging systems, their evolution, architectures, enabling technologies, standards, and commercial systems and products. Unified messaging systems provide a single mailbox for all messages including voice, fax, e-mail, data, and video. Benefits of unified messaging systems are tremendous – they provide improved productivity and much more efficient communications then conventional messaging systems, and bring a positive cultural change among their users. In addition, Internet-based unified messaging systems use the Internet telephony instead of long distance for sending and retrieving voice and fax messages. We describe key technologies and various architectural approaches to unified messaging. Case studies of two commercial unified messaging systems are presented as well.

1. INTRODUCTION TO UNIFIED MESSAGING

1.1 HISTORY

Today, messaging is a strategic and mission critical necessity. Messaging has truly become an infrastructure upon many future applications will be built.

Traditionally, telephone networks, with voice and fax messages, have been most popular ways to communicate. However, recently Internet based technologies, including e-mail messages and World Wide Web, have introduced a new way to communicate, create, and exchange messages. According to the Electronic Messaging Association (EMA) study, the number of active e-mail users is expected to grow from 54 million in 1996 to 108 million in the year 2000. Clearly, electronic messaging has followed the path of the telephone and the fax machine in changing from a rudimentary tool for exchanging information among a selected group of researchers into an indispensable component of every day life. Electronic messaging is now an integral part of the worldwide information infrastructure, with applications in business, education, commerce, and interpersonal communications.

In a traditional company, these three different messaging methods (voice, fax, and e-mail) are independent. Faxes are typically sent and received via fax machines, while voice messaging resides on a voice mail system, which has no connectivity to other systems. E-mail messaging system is the part of computer and communication system and typically consists of text messages.

The main drawback of this "unconnected" messaging approach is that it requires three separate user interfaces. This approach also requires separate administrative and support functions, and consequently is of a higher cost.

Once upon a time, for communication purposes and exchange of messages everyone had two phone numbers (home and business) and a mailing address. Today, corporate America has been arming employees with cellular phones, pagers, e-mail, Internet access, and other communication tools so they can stay closer to customers and effectively communicate and exchange messages. According to the recent study, the average Fortune 1000 worker now uses an average of six communication tools [9].

Today, electronic messaging industry consists of five different segments: (1) electronic mail, (2) voice processing, (3) paging, (4) computer-based faxing, and (5) electronic data interchange.

Electronic mail is the largest segment, and according to EMA's market research survey, accounts for about 50% of total electronic messaging. Voice processing, the second largest segment, comprises of voice mail systems, voice response systems, automatic call distributors, and other voice processing systems. Service providers typically supply voice processing technology to subscribers through a private network.

The paging industry includes subscriber-based paging services and paging equipment. Computer-based faxing consists of facsimiles sent and received through a personal computer bypassing a stand-alone fax machine. This industry segment includes fax-capable modems, fax boards and chips, and fax software. Electronic data interchange (EDI) allows companies to electronically exchange business documents, purchase orders, and invoices.

Technological breakthroughs over the last decade have made electronic messaging both feasible and affordable, thereby allowing for the rapid expansion of the industry. The impact of the Internet and related technologies on electronic messaging has been tremendous. Internet technologies have provided new links between different messaging technologies.

In order to resolve the problems occurred due to this dramatic growth of different messaging technologies, a new approach referred to as unified messaging has emerged. The basic idea behind unified messaging is to allow users to receive and retrieve different messages (e.g. voice mail, fax, and e-mail) from one interface device, such as a PC or phone. The unified messaging can be achieved by integrating two worlds, the world of computers with the world of phones, as illustrated in Figure 1. The phone network deals with phone calls, faxes, and voice mail. It usually uses proprietary voice systems, which are not flexible and expensive. The computer world deals with e-mail messages, World Wide Web, and Intranet. It is typically based on open computer architecture.

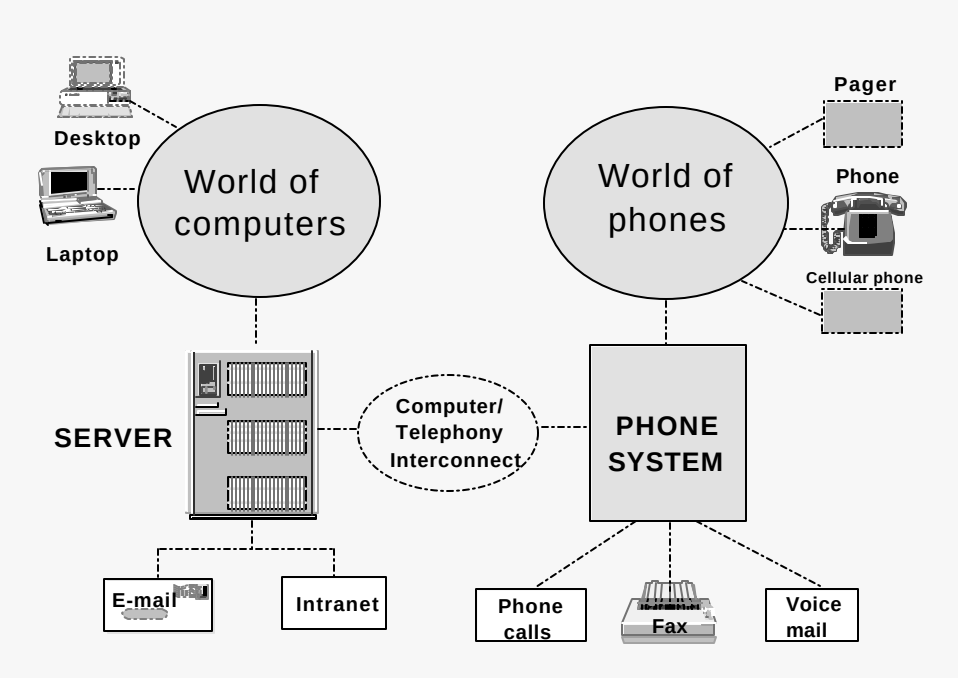


Figure 1. The foundation of unified messaging: integration of the computer world with the phone world.

By integrating these two worlds, the user can receive and send all messages either via his/her PC or portable computer, or via phone, cellular phone, or pager.

1.2. MESSAGE STATISTICS

In this section we present message statistics, reported by the Institute for the Future/Gallop Organization in the article published in April 8, 1997. This statistics illustrates the exponential growth of messages that an average business user must handle per day.

Table 1 shows an average size of e-mail, voice mail and fax messages and required storage. Table 2 shows a typical statistics for an average business user.

Table 1. Average Size of Messages
(Source: Institute for Future/Gallop Organization, article WSJ April 8, 1997).

MEDIA UNIT STORAGE	SIZE/UNIT [KB]	AVERAGE NUMBER OF UNITS	AVERAGE SIZE [KB]
E-mail (message)	24	1	25
Voice mail (sec)	5	45	226
Fax (page)	35	2.5	88.5

Table 2. Message Statistics for an Average Business User
(Source: Institute for Future/Gallop Organization, article WSJ April 8, 1997).

MESSAGE TYPE	MESSAGES PER DAY	NEW MESSAGE STORAGE [MB]	NUMBER OF ARCHIVED MESSAGES	ARCHIVED STORAGE [MB]
E-mail	13.6	0.33	100	2.44
Voice mail	11.2	2.47	15	3.31
Fax	8.8	0.76	30	2.59
TOTAL	33.6	3.56	145	8.34

From the presented statistics, which are from 1997, it is obvious that the large number of various messages arrived every day (total 33.6 per an average business user) makes the message management and manipulation a complex task. Unified messaging is the only answer to efficiently handle all messages.

1.3 DEFINITIONS

Unified Messaging (UM) is a new, hot concept and for various people means different. In order to better understand unified messaging, let us analyze the evolution of messaging from segregated to unified messaging [32].

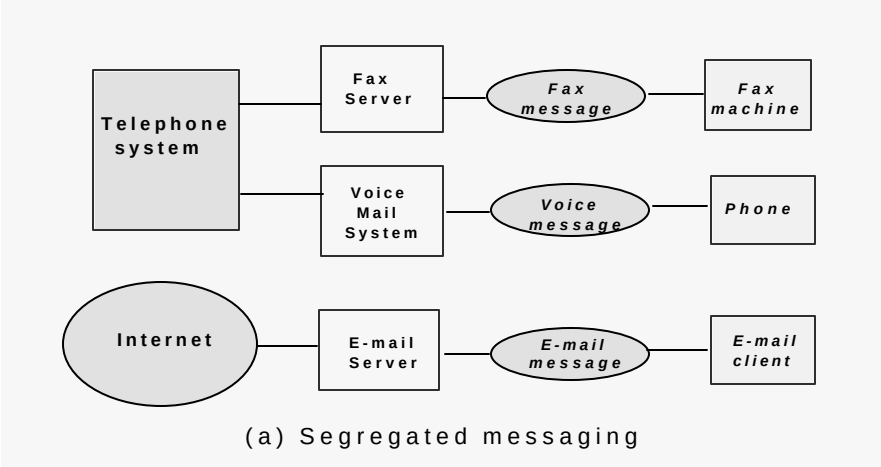
The first generation of messaging systems, referred to as ***segregated messaging***, is shown in Figure 2a. Voice and fax messages are received through the telephone network and a PBX exchange, while e-mail messages are received via a computer network. Voice messages are retrieved using a touch-tone phone, and faxes are stored and printed when desired. Email messages are sent and received through an e-mail server using an e-mail client.

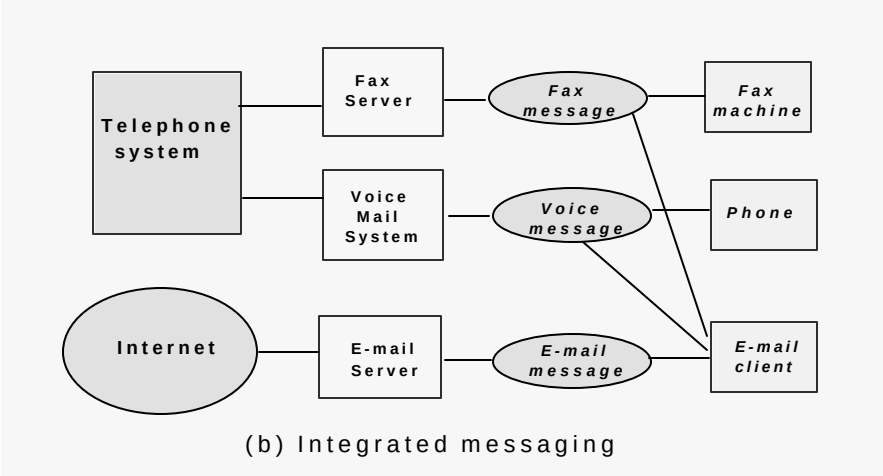
In the second generation of messaging systems, referred to as ***integrated messaging***, voice, fax, and e-mail messages can be retrieved through the e-mail client, as illustrated in Figure 2b. The three different messages are managed and administrated separately. The flexibility of integrated messaging is limited.

Finally, the third generation of messaging systems, referred to as ***unified messaging***, assumes that there is a single mailbox for all messages, as illustrated in Figure 2c. The unified messaging allows local and remote access to voice mail, faxes, and e-mail through the e-mail client, phone, or a Web browser. There is a central management and administration of all messages regardless of their type.

According to the [47], the following definition of the unified messaging system can be used:

> *A Unified Messaging System (UMS) provides a single, multimedia mailbox for all messages: voice, e-mail, fax, data, and video. This mailbox is accessible from a PC, phone, or laptop computer. In addition the UMS enables the originator to easily create and send a message of any type and provides intelligence for managing messages.*





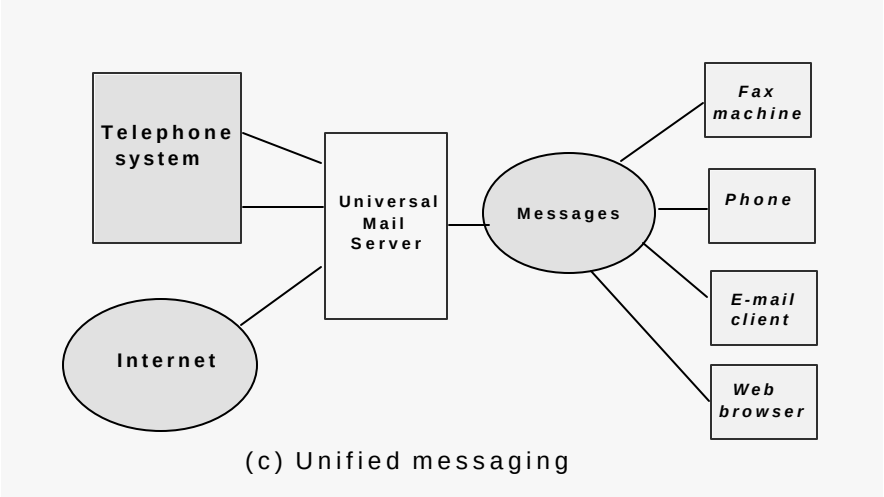


Figure 2. Evolution of messaging systems: from (a) segregated messaging systems to (b) integrated messaging systems, and (c) unified messaging systems.

1.4 BENEFITS OF UNIFIED MESSAGING

Today, with a growing number of professionals working from home or on the road, e-mail and voice mail have become the standard modes of communication. In traditional systems, users must use a variety of devices – phone, facsimile, and computer – to receive or send all their messages. In addition, the number of received and sent messages is growing rapidly. A Gallup poll from 1997 [10] reported that an average office worker gets 178 messages a day. Today, this number must be much higher.

Unified messaging systems are designed to solve this problem, both in small and large organizations. They provide a new approach in storing, managing, retrieving, and distributing messages. Each subscriber has only one mailbox for all his/her messages. Messages in the mailbox can be viewed, listened to, stored, and retrieved by a personal computer, the telephone, or a pager, regardless of the form in which they were created. In addition, unified messaging services provide subscribers with an intelligent control over the reception and processing of the incoming messages. Figure 3 illustrates how messages can be sent and collected from the single mailbox in an advanced UM system.

In an UM system, the users can view documents or faxes, listen to voice messages, create new messages, and manage information in the way that works most productively for them. Therefore, one of the most important benefits of unified messaging is ***improved productivity***.

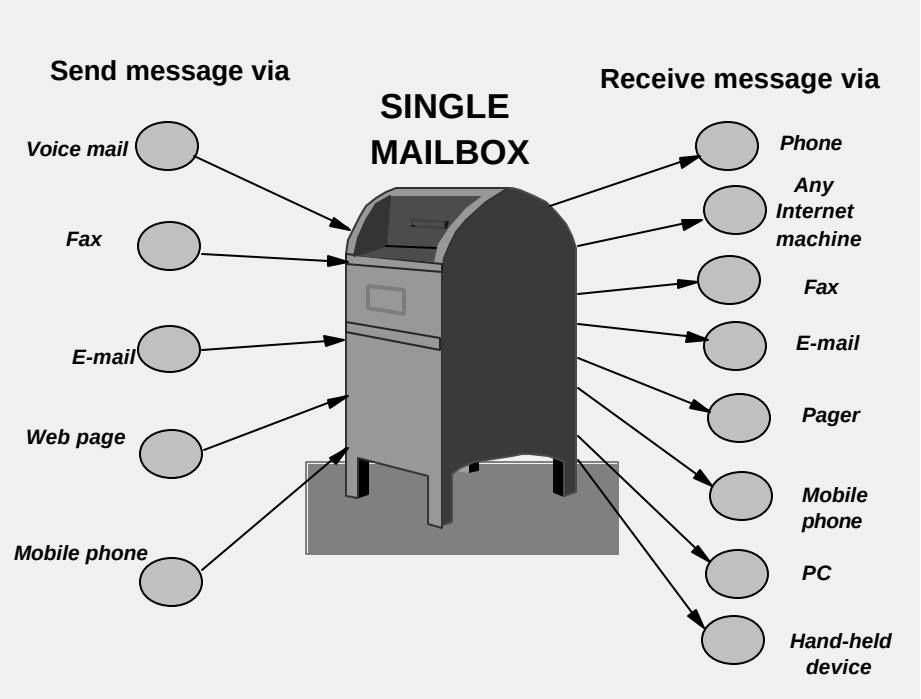


Figure 3. Single mailbox is the heart of unified messaging systems.
Methods how to send and receive messages.

Figure 4 illustrates the screen from Lucent's Octel Unified Messenger, on which different type of messages (e-mail, voice, and fax) are presented to the user on a single screen.

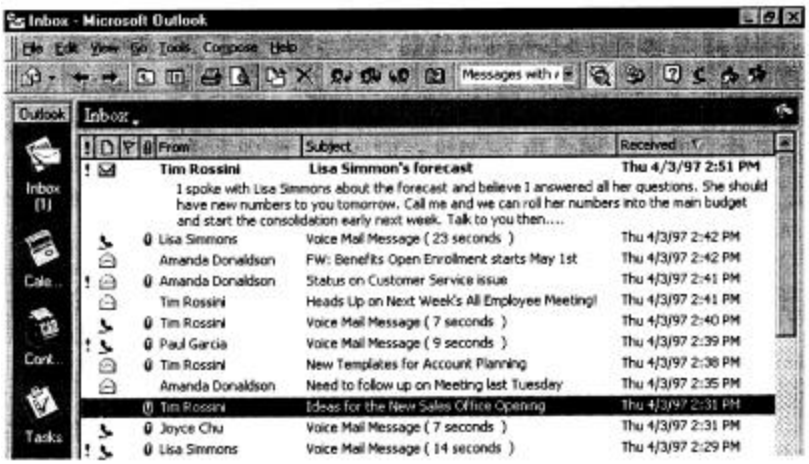


Figure 4. User's screen – example from Lucent's Octel Unified Messenger.

According to the Report from Lucent-Microsoft roundtable on unified messaging, held in Boston on September 9, 1998, the customer organizations that have deployed UM felt that the key benefit is that employees are better connected and comfortable with the UMS. These companies also indicated that UM has brought a positive change in culture within their organizations. In addition, unified messaging has improved internal and external communications among employees.

A study performed by PulsePoint Communications indicates that the most direct unified messaging saving derives from *use of the Internet telephony* instead of long distance for sending and retrieving voice and fax messages [9]. In addition, UM eliminates extra phone lines for fax or answering voice messages.

For the whole enterprise, a unified messaging system allows the company to *streamline communication administration, maintain security of company's messaging directories, simplify networking connections, and reduce communication and administration costs*. Network administrators can also work from a single screen – setting up e-mail, voice, and fax messaging capabilities.

The unified messaging systems also break the geographical chains. They assign an address to a person, not a location like in conventional telephone systems. As a consequence, the message can be routed to the subscriber regardless of his/her location.

In summary, the benefits of unified messaging systems are tremendous and it is obvious that over the next several years a number of large enterprises and medium- and small-size corporations will upgrade their traditional systems to unified messaging systems.

2. TECHNOLOGIES FOR UNIFIED MESSAGING

2.1 KEY COMPONENTS OF UM SYSTEMS

The unified messaging system is based on a single universal mailbox (UMB) for all messages. The universal mailbox (or universal message box, or universal in-box) is the heart and the main component of an UM system. However, according to Zimmer [12], there are the other three key components of future, advanced UM systems: intelligent post office, intelligent network, and intelligent services, as shown in Figure 5.

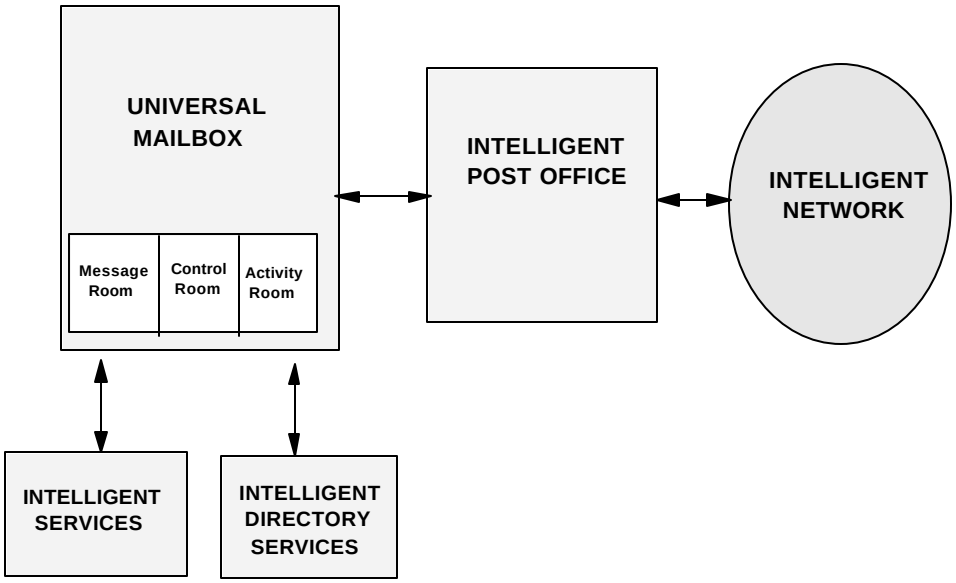


Figure 5. Key components of an advanced UM system [12].

The universal mailbox allows the user to receive all messages of different types from one location. A variety of interface devices can be connected to the single UMB (as illustrated in Figure 4), such as telephone, fax machine, PC, pager, mobile phone, or hand-held device. The single access interface provides additional functionality in creating new messages, referred to as *cross messaging*. Cross-messaging enables a message created by the originator in one medium to be converted to another medium. For example, an e-mail text message can be retrieved from a phone using text-to-speech conversion. Or, text from a fax letter can be converted to speech using optical character reader technology.

In addition, a multimedia message may contain attachments in other media. For example, text e-mail could have video, voice, data, or fax files attached; a voice mail could arrive bundled with a fax message.

According to Zimmer, the universal mailbox can be broken into three sub-components, or three rooms: the message room, the control room, and the activity room. The message room handles all the messaging needs for the users. It stores the incoming messages and notifies the

user of new messages. The message room handles all types of communication: voice, fax, e-mail, video, sound, and others.

The control room comprises of controls that help the user in managing messages. The control room deals with personal directories, security and privacy of messages, and provides the user with other services such as news, stock, weather, information services, etc.

The activity room handles interactive services, such as access to public directories, various information services, such as on-line searches, on-line magazines, Internet and Web, and others.

Intelligent post office provides routing capabilities for messages. For example, according to the user's request, some messages can be routed directly to the user, while some other, less important messages, can be directed to an assistant.

Intelligent network has the main function to locate subscribers as they travel. For this purpose, it provides a single address for each subscriber for all communications.

Intelligent services are to be built on the top of unified messaging systems. First generation of services includes business-to-business activities and consumer services, such as customized newspapers, electronic shopping, and others.

2.2 ARCHITECTURAL APPROACHES TO UNIFIED MESSAGING

As we discussed in Section 1, there are two main approaches in implementing unified messaging: integrated messaging and true unified messaging. In integrated messaging, a single logical mailbox is presented to the user, however in reality there are multiple mailboxes on one or several servers. In true unified messaging, all messages are stored in a single mailbox.

From the user's point of view, these two approaches may look similar. However, there are significant differences that affect the design and operation of the system.

From the commercial point of view, integrated messaging approach looks more appealing, because of the needs to preserve existing infrastructure – large number of e-mail and voice mail systems are already installed. The unified messaging approach usually requires a new infrastructure, but, on the other hand, it is more flexible and easier to design and operate.

There are several architectural approaches in designing integrated and unified messaging systems [9, 26]:

- Separate clients/separate servers architecture
- Single proprietary client/separate servers architecture
- Universal access messaging
- Integrated messaging architecture
- Unified messaging architecture

Separate clients/separate servers architecture, shown in Figure 6a, allows visual access for voice and fax messages on the user's PC. This approach is proposed by voice mail vendors several years ago to give users a way to easily view their voice and fax messages using a PC-based graphical interface similar to interfaces used to view and menage e-mail messages. This architecture is also referred to as *integrated desktop architecture*.

This approach allows a low cost upgrade to an existing voice mail system, however it does not unify e-mail and voice mail into a single architecture. As a consequence, multiple systems must be managed and administrated separately. Most voice mail vendors today offer a product built on this approach.

Single proprietary client/separate servers architecture, comprises a single client that integrates all media, but the servers are separated, as illustrated in Figure 6b. There is no interaction between the message store servers, since the integration is done at the client level. The PC client is connected to both servers, and appears to the user that there is a single mailbox. This approach, supported by PBX companies, relies on a specialized PC application that controls the desktop telephone and displays voice mail and e-mail messages in a single application. For the user, this approach offers a single view of all messages as well as the ability to access advanced PBX features, such as transferring and forwarding calls. However, this approach does not unify e-mail and voice mail systems. It requires separate systems, separate directories, and separate administration. This approach is sometimes referred as to *integrated client architecture* and is supported by PBX vendors, such as Nortel.

Universal access messaging architecture is based on "one access" rather than "one mailbox" approach, as illustrated in Figure 6c. This approach assumes multiple mailboxes for each type of messages, however the user can access all mailboxes with a single device – this is why this architecture is referred to as one access messaging. This approach does not require changes in the existing message infrastructure. Logica supports this approach, and the device that provides universal access to various mailboxes could be a digital mobile phone.

Integrated messaging architecture consists of separate voice and e-mail networks, but provides a bridge between the two networks. It appears to the user as one mailbox. The voice mail system is connected to the LAN, and specialized synchronization software, which runs on each e-mail server, routes and controls message traffic between these two messaging systems, as illustrated in Figure 6d. The message systems are separate

Integrated messaging architecture uses the e-mail interface to display all messages – voice, fax, and e-mail. However, the messages continue to be stored in separate voice and e-mail systems. System administrators continue to support and maintain two different networks, mailboxes, and directories. Forwarding messages back and forth across the LAN may generate a significant amount of background traffic on the network. Active Voice and AVT support this approach.

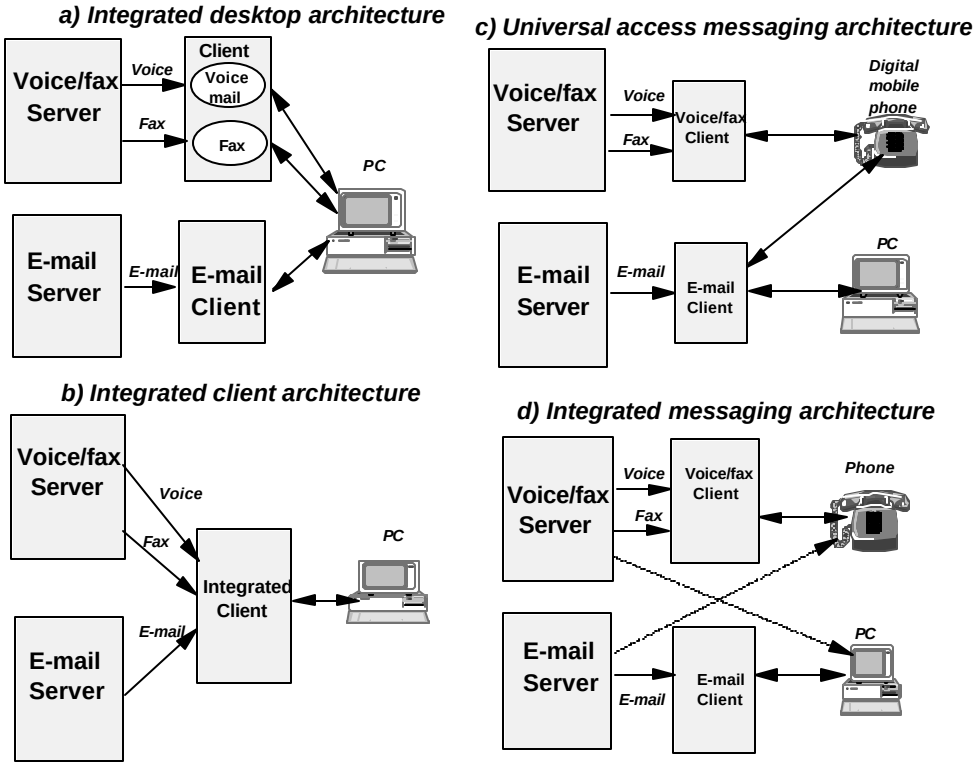
Unified messaging architecture, shown in Figure 6e, uses a single, unified mailbox and a single directory for all messages. The voice/fax messages are taken from the voice mail server and moved to the common server, which holds e-mail messages. The user can receive the messages using computer or phone. System administration tasks are significantly reduced, because there is only need to support, configure, and maintain one messaging system. Lucent's Octel Unified Messenger supports this approach.

2.3 TECHNICAL CHARACTERISTICS OF UM SYSTEMS

There are a number of technical issues to be considered when evaluating technical characteristics of commercial UM systems. These issues, listed in Table 3, are discussed next.

2.3.1 Centralized Versus Distributed UM Architecture

A very important architectural issue in designing or implementing a unified messaging system is choice between centralized and distributed server architecture.



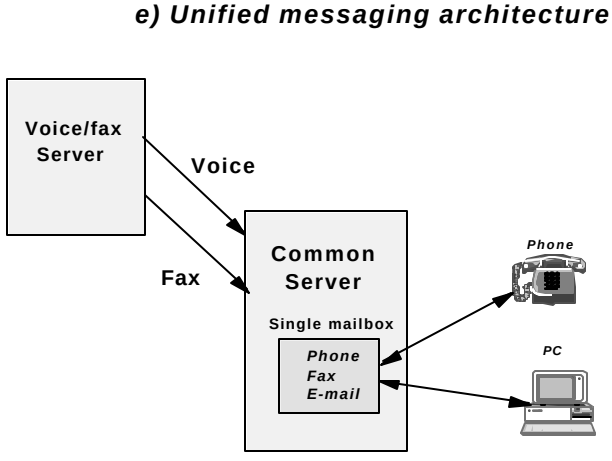


Figure 6. Various architectural approaches in integrated and unified messaging.

In a centralized architecture, a single server is used to store all messages of different media types. The centralized architecture provides simple administration, and there is no issues related to replicating and synchronizing information on different servers. However, the centralized system, based on one server, may cause a complete communication blackout if a hardware problem occurs. Lucent's Octel Unified Messenger, described in detail in Section 4, applies centralized server architecture.

Table 3. Technical Issues in Designing and Implementing Unified Messaging Systems

TECHNICAL ISSUES
Distributed versus centralized architecture
Open versus proprietary systems
System scalability
IP-based versus PSTN-based systems
Fault-tolerant UM systems
UM systems for different size networks
Ability to integrate the system with existing messaging systems

The distributed architecture is based on separate servers each handling a particular type of media. In such system, if one of the system fails (for example voice mail system), the user can still receive other media types – in this case faxes and e-mail. Nortel's Symposium Messenger uses a distributed server architecture.

2.3.2 Open UM Systems versus Proprietary UM Systems

All participants in our survey have agreed that the standards play a crucial role in selecting and implementing UM systems. An open UM architecture is built on industry standards and facilitates the integration of components from a variety of vendors. In contrast, proprietary systems require purchases from specific vendors and don't allow the flexibility to swap components based on economic factors.

One of the main issues in implementing UM systems is the integration of existing e-mail and voice mail systems. For a service provider offering unified services, the coexistence and interoperation of a variety of telephony and computer systems is necessity. An e-mail message may consist of a number of different types of messages (text, voice, and video), and therefore it heavily depends on standards, such as SMTP and MIME (see Section 3). These standards assure the interoperability among different components of the e-mail message.

However, commercial voice message systems are usually proprietary – they use proprietary hardware, protocols, and data formats and they are designed to interact only with the same type of systems.

Therefore, the developers and integrators of UM systems must include formats and media conversation facilities to ensure proper handling and interoperability of all messages [7]. For example, a voice message must be converted in the appropriate audio format in order to be presented in an e-mail client. In addition, complex synchronization mechanisms are needed to ensure the consistency of the various mailboxes involved.

In order to resolve these interoperability problems, the Electronic Message Association has launched VPIM initiative – the Voice Presence for Internet Mail [8]. The issues addressed by VPIM include the use of SMTP and MIME to transport messages across systems and the ability to exchange messages with e-mail systems. VPIM also addresses issues related to integration of voice and non-voice mail systems.

In summary, open UM systems are based on industry standards and an open API (Application Programming Interface) for interconnections. Proprietary UM systems use proprietary hardware and are not based on standards.

2.3.3 IP-Based Versus PSTN-Based UM Systems

In a typical unified messaging system both worlds, the telephone word and the computer world, are connected. The voice messages and the faxes are sent and received through the conventional phone long distance network, sometimes referred to as Public Switched Telephone Network (PSTN). All messages (voice messages, faxes, and e-email messages) are then collected on a single unified messaging server. The UM server contains a voice board that translates analog to digital voice messages and vice versa. This system, shown in Figure 7, is referred to as the PSTN-based UM system.

All members of the expert panel agreed that the Internet is getting more and more important for unified messaging. Possible benefits of the Internet for the UM systems include:

- The Internet can be used as a universal interface
- The Internet can be used for message retrieval via Web browsers
- The Internet can be used for quickly subscribing for the unified messaging service through the Web.

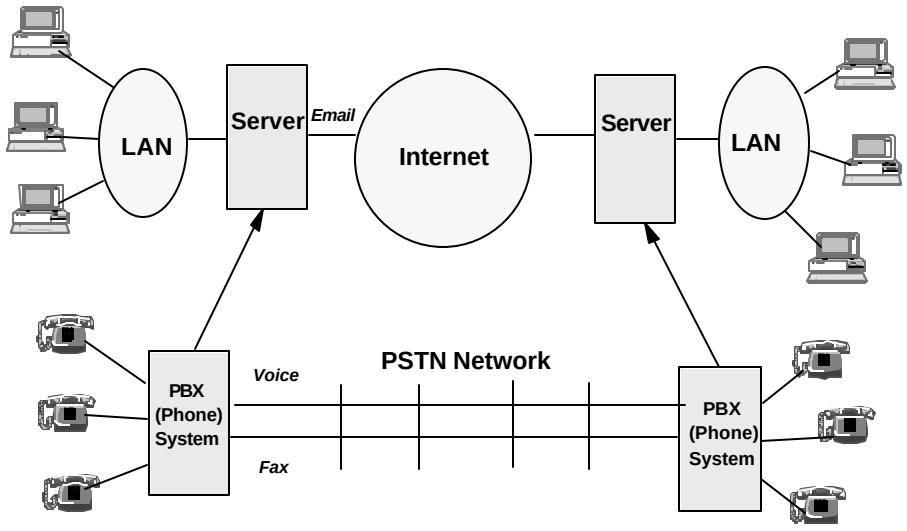


Figure 7. The PSTN-based UM system. The phone network is used for sending voice messages and faxes, while the Internet is used for sending e-mail messages.

The UM systems may use the Internet not only for sending e-mail messages, but also for voice messages and faxes – the Internet becomes a universal interface for all messages. In such system, referred as the Internet-based UM system, the Internet telephony is used instead of long distance phone network for sending and retrieving voice messages and faxes. Besides saving in long distance charges, this approach eliminates additional phone lines for fax and answering voice messages.

In an Internet-based system, shown in Figure 8, telephone messages and faxes are sent from one UM server to another over the Internet. An example of commercial system that uses this approach is CallWare's Viewpoint UM system.

The Internet has another important function in UM systems. It can provide remote access to the UM server and to all messages stored in the user's mailbox. A Web browser provides the access to the messages. This functionality can be very beneficial for mobile users, who can retrieve and send their messages from the hotel or airport using a public computer, a laptop, or a hand-held device.

Finally, the Internet can be used for quickly subscribing for the UM services through the Web.

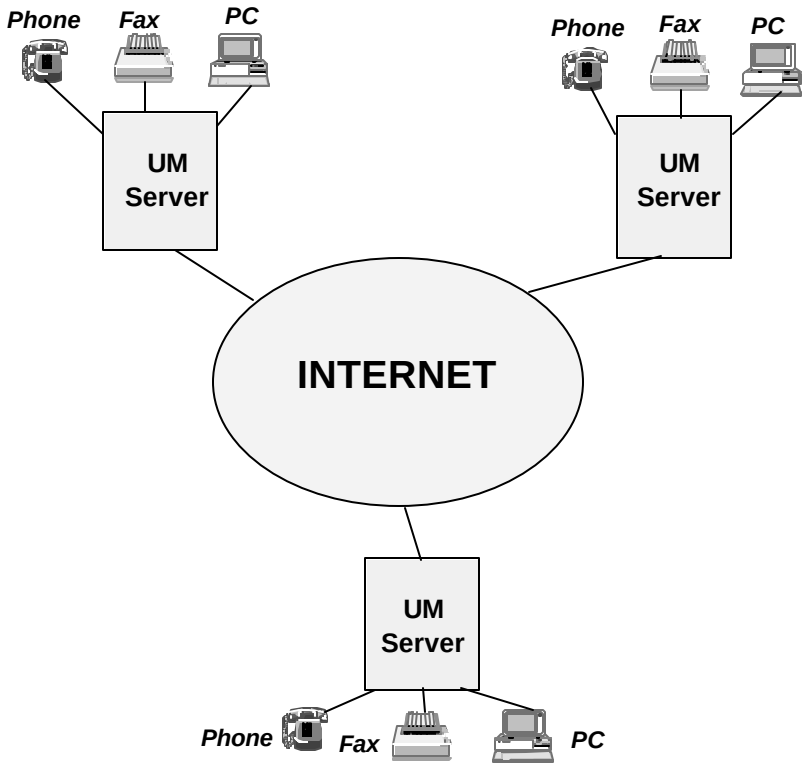


Figure 8. The Internet-based UM system.
The voice messages and faxes are sent over the Internet.

2.3.4. Fault Tolerance Issues in UM Systems

An important issue in true unified messaging systems is fault tolerance. A non-fault tolerant UM system is based on one server with a single mailbox. In this centralized-managed system, voice messages and incoming faxes are stored directly into the server's message database – a single mailbox, as illustrated in Figure 9a. In this system, if the server goes down, the complete communication system will crash. The faxes will get lost and the callers will not be able to leave voice messages.

Therefore, contemporary UM systems must embed fault tolerance in their designs. One of the possible solutions, applied by Interactive Intelligence (see Section 4), is based on a connector process, as shown in Figure 9b [32]. The connector process resides between the main server and the processes that collect and send voice messages and faxes. The connector process creates copies of all voice messages and faxes, creates and manages the queuing of incoming voice messages and faxes, and sends them to the server's message store. In order to provide full fault tolerance, the connector process must run on a separate machine.

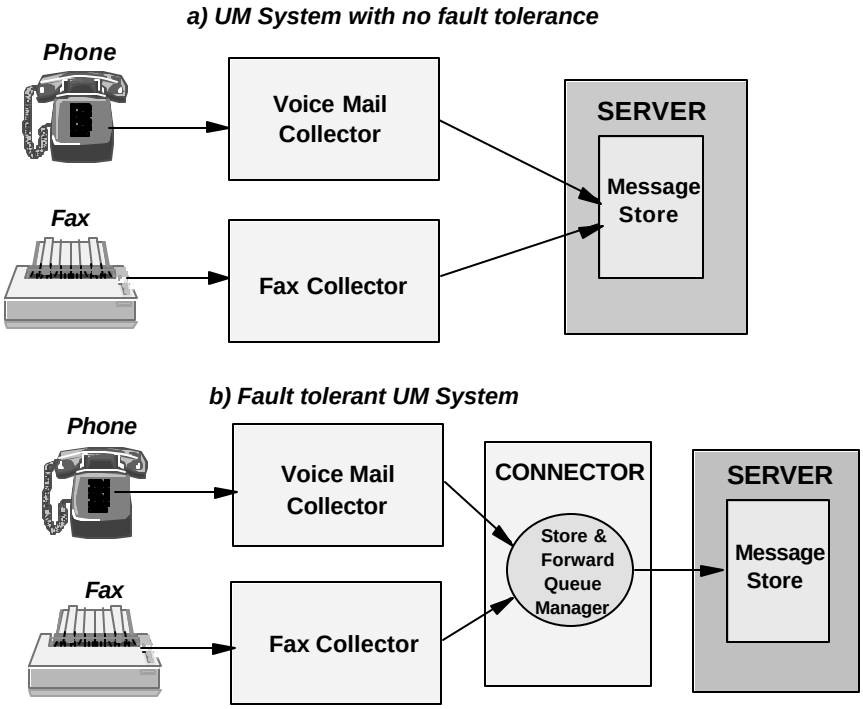


Figure 9. (a) The UM system with no fault tolerance. If the server goes down, all voice messages and faxes will be lost. (b) The fault tolerant UM system. Connecting process, which runs on a separate machine, receives and collects voice messages and faxes.

In this fault-tolerant UM system, if the main message server goes down, the connector process will continue receiving and collecting the voice messages and faxes. When the message server comes back up, the queued voice messages and faxes will be sent to the server's message store, and therefore it will be no data loss.

This approach provides a high degree of fault tolerance. It also allows greater scalability, since the rate at which new voice messages and faxes arrive is no longer depend on the rate at which the server can receive them.

When designing or purchasing a contemporary UM system, the goal should be to eliminate any hardware related single point of failure as well as provide a manageable, well performing, supportable, and reliable software system [34].

Hardware related single point of failure can be eliminated by incorporating (a) RAID disks, (b) hot swap power supplies, (c) clustered servers, (d) dual networks, and (e) multiple Internet service providers and switch links, as illustrated in Table 4.

Reliable and manageable software can be achieved by using (a) active system monitors, (such as HP OpenView, Java or SNMP monitors), (b) redundant processes, (c) autostart and scaleable process within a single server and across multiple servers, (d) performance monitoring capabilities for optimum performance tuning, and (e) lodging capabilities for security.

Table 4. Hardware and Software Techniques to Achieve Reliable, Fault Tolerant UM Systems

Hardware Techniques	**Software Techniques**
RAID disks	Active system monitors
Hot swap power supplies	Redundant processes
Clustered servers	Austostart and scalable process within a single server and across multiple servers
Dual networks	Performance monitoring capabilities
Multiple Internet service providers and switch links	Lodging capabilities for security

2.3.5 Scalability Issues

A unified messaging system is scalable, if it is capable to continue performing adequately as the load on the system increases. The most common measures of load are: (a) data size, (b) transactions per second, (c) calls processed per second, and (d) the number of active users in the system. [30]. The main question is when the system bottleneck is reached, does the system have scalability beyond this point? These bottlenecks can occur at three places: (a) network (Internet or internal network), (b) processing (voice, fax, and data processing boards or system processors), and (c) storage.

Scalability is a very critical issue, because software systems that work at one level of demand or size may not work equally well as that demand or size increases. For a service provider, this may mean having to limit the number of users in the system, perform expensive upgrades to expand proprietary systems, or let the quality of the services they provide deteriorate.

Unix systems can use cluster systems that provide failover and in some cases load sharing capabilities. Unix-based UM systems can take advantage of scaleable servers that employ symmetrical multiprocessors and multiple memory backplanes.

2.4 ENABLING TECHNOLOGIES FOR UM SYSTEMS

The main technological component of a unified messaging system is a Universal Communication Server (UCS). The USC provides and manage live communications (such as phone calls, phone conferences, Internet access, Internet calls and conferences), as well as all messages including voice mail, e-mail, and faxes, as described in [33].

The USC is typically located at the edge where the Internet and telephone networks come together, as illustrated in Figure 10. When located at the edge, the UCS can provide both telephone and Internet based services, and seamlessly connect these services together. The basic requirements of an UCS can be divided into the following groups: (a) media connectivity and conversion, (b) application services, (c) storage and indexing, (d) scalability and reliability, and (e) configuration and management [33].

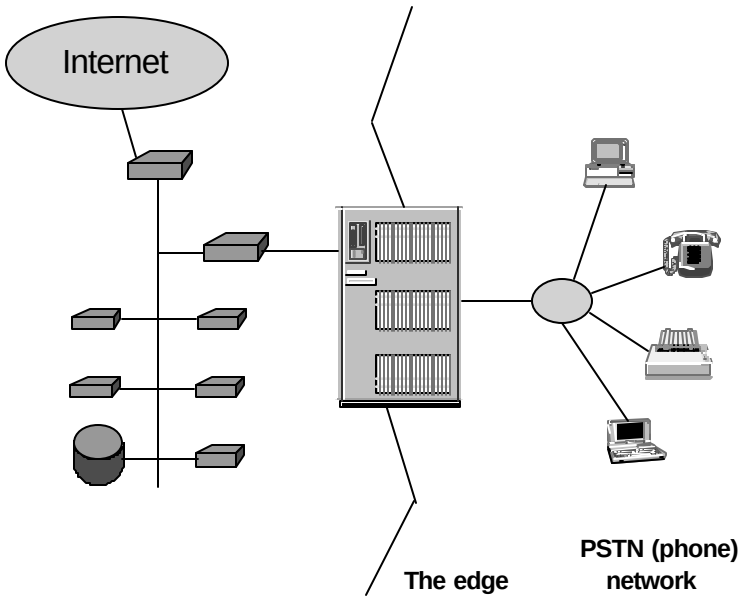


Figure 10. The Universal Communication Sever is located at the edge between the Internet and telephone networks.

Regarding to media connectivity and conversion, a contemporary UCS typically provides the following ports: ISDN digital phone ports, Ethernet IP ports, and WAN IP ports, as well as provides support for voice, fax and modem calls, and voice, image, and fax conversion.

Application services of the UCS include telephony, e-mail, and Web-based services. Storage and indexing functions include message storage and indexing, account information, and directory and PIM data access.

Regarding to scalability and reliability requirements, the UCS provides modular distribution, performs load balancing, and supports automatic fail over and self-healing functions.

Configuration and management functions of the UCS include IP configuration, PSTN configuration, application configuration, account configuration, and universal system management.

The current technology assumes that the UCS is designed based entirely on Internet standards and that should include SNMP and Java-based management tools. It should integrate with existing mail servers, telephony gateways, and networks. It should support traditional voice and fax, IP voice and fax, paging, and V.34/V.80 modem connectivity.

The USC should also allow software-based DSP function modules to be added at any time in order to support new connection or conversion types. The USC should allow software-based service modules from different vendors to run on the same hardware at the same time, receiving incoming calls, e-mail and Web requests as appropriate. The USC should be scalable from dozens to tens of thousands of ports.

One of the main requirements for the unified messaging to become effective and accepted by the users is the ability to perform content conversation from one medium to another medium – this is referred to as cross-messaging [10]. With content conversation, the users using a phone to access their mailboxes can read e-mail messages via text-to-speech conversation, or can send them via fax to a fax machine.

The current content conversation technologies allow the originator to create the message in one medium, and this message can be later converted to another medium. The following content conversation functions are feasible today and are implemented in some commercial UM systems:

- E-mail text message converted to voice in order to be retrieved by a phone
- Text from fax read by an optical character reader and converted to text or speech
- Voice mail converted to text
- Speech recognition
- Various media to fax conversation.

All these enabling technologies are available today and related products are offered by a number of companies.

With the speech recognition facilities the user can remotely over the phone manipulate and manage his/her messages. The typical voice commands include: Read, Repeat, Save, File, Acknowledge, or Forward any message received.

At the Lucent-Microsoft executive roundtable on unified messaging [29], those users who already used text-to-speech retrieval UM systems indicated that there are still problems with this technology, particularly in the following areas:

- Poor voice quality of the text to speech conversation,
- Difficulty of having to step sequentially through messages, and
- Difficulties in dealing with messages that have attachments.

2.5 ACCESS TECHNOLOGIES TO UNIFIED MESSAGING

From user's point of view, the main goal of unified messaging systems is to simplify the process of generating, accessing, and managing messages. There are four types of accesses associated with unified messaging systems: (a) desktop access, (b) phone/fax access, (c) Internet access, and (d) wireless access.

Desktop access allows access to unified messages (voice, fax, and e-mail) from desktop computers using enhanced e-mail clients. Message filtering, sorting, and prioritization are important features for desktop access.

Phone/fax access allows remote access in situations when computers are not available. Users have the ability to review a message list and select specific messages for playback from a remote phone. Voice mail messages are played back exactly as they were recorded, while e-mail messages can be played back using a text-to-speech conversion system. Besides message review, users may have limited message management options. They may remove messages from the mailbox or reply to e-mail messages with voice messages that are delivered as e-mail.

Internet access allows mobile users with a laptop or with access to a public computer (in a hotel or airport) to review and manipulate messages in their mailboxes through a Web browser. The functionality provided by Web-based clients includes the ability to retrieve, review, delete, and forward messages.

Wireless access allows mobile users with hand-held devices and cellular phones to access and manipulate their messages. Speech recognition technology plays a crucial role in wireless access allowing hands free operation.

2.6 OTHER FEATURES OF UM SYSTEMS

There are a number of other appealing features of UM systems, listed in Table 5. Some of these features are described next.

Table 5. Other Appealing Features of UM Systems

OTHER FEATURES OF UM SYSTEMS
Real-time features
Cross-messaging features
Confidentiality of fax messages
The ability to save and archive all messages
The ability to redirect all messages with a single mouse click
The ability to process messages
The ability to be notified
Intelligent agents for UM systems

Real-time features of UM systems include:

- Real time conformation of fax delivery
- Real time confirmation of email delivery
- Notification of incoming calls with caller ID
- Notification of incoming calls with caller profile

Cross-messaging enables a message created by the originator in one medium to be converted to another medium. Cross-messaging technologies have become more and more sophisticated and are presently important components of many commercial UM systems.

An important future trend is to integrate *intelligent agents* in UM systems. These intelligent agents will allow new, intelligent functions and enhanced services. They can be classified into the following groups [35]:

- Intelligent categorization of mail
- Intelligent notification process
- Automated mail routing
- Automated response management
- Automated broadcasting of messages

Intelligent categorization of mail can include a variety of criteria for categorization specified by the user. These criteria can be based on source, subject, size, content, and priority.

Intelligent notification process can include selected mail and the user can select the notification path. In addition, a number of different notification devices can be selected, such as pages, cellular phones, home/office phones, and desktop computers.

Automated mail routing can be based on source, subject, size, content, and priority. ***Automated response management*** includes automated greetings, which can be based on source, subject, size, content, and priority. Finally, ***automated broadcasting of messages*** can be based on source, destination, and subject of the messages.

In summary, the additional features preferred by the expert panel include: (i) the ability to be notified through a wireless device when important messages arrive, (ii) the ability to save and archive all messages, and (iii) the ability to process messages, e.g. reply as soon as they arrive instead of waiting to go back to the office or home.

3. STANDARDS FOR UNIFIED MESSAGING

Standards are clearly very important to customers, however, in the case of unified messaging the technology is still so relatively new that customers really don't know what standards to ask for and what they need fur future interoperability [29]. Vendors of unified messaging products and services are still free to test and experiment with new features and options, and they are not tied to any particular model of implementation including standards.

However, as the use of unified messaging becomes more pervasive, vendors will be increasingly pressured to demonstrate to customers that their products can inter-operate with a large variety of products and technologies on the market, which also means that they confirm with industry standards. According to the expert panel survey (see Appendix A), standards will play a big role in selecting UM systems.

According to [33], both service providers and customers need unified messaging standards. Service providers need unified messaging standards to:

- Allow new products and services to integrate with old ones,
- Allow all services to me managed with the same tools, and
- Make services more attractive to customers.

Customers need unified messaging standards to:

- Allow new products and services to integrate with old ones, including products and services from different vendors and providers,
- Use their personal favorite clients with new services, and

- Use new services without installing new clients.

Standards are mostly needed between building blocks of a unified messaging system. The building blocks of unified messaging systems include client software (in e-mail clients, Internet clients, and Web browsers) and various servers in the system (edge, application, and back-end servers).

In this section, we briefly introduce a variety of standards, which, in our opinion, will play important role in unified messaging systems. We also describe in detail a few standards, which according to our expert panel, will be crucial for the future of unified messaging. We also introduce Microsoft Exchange Server, which has become the server of choice for a number of unified messaging systems – therefore it has been de facto standard for UM servers.

Table 6 gives an overview of a variety of standards that can be applied in unified messaging.

Table 6. Standards for Unified Messaging

STANDARD	TYPE OF INTERFACE	BRIEF DESCRIPTION
POP3	Client-server	Used to retrieve messages from the application or back server
IMAP	Client-server	Used to retrieve, move, search, and flag messages
ESMTP	Client-server	Used to send voice, fax, and video
SMTP	Server-server	Defines the exchange of information among a large class of e-mail servers
MIME	Sever-server	Defines the exchange messages, which are non-textual objects
VPIM	Client-server	Defines the exchange of voice and fax messages between voice mail systems
LDAP	Application	Standard directory access protocol
ACAP	Application	Standard user account and configuration protocol
H.323	Multimedia communications	Defines multimedia communications services in a packet-switched network (LANs, WANs, Internet)
MAPI	Internet fax client	Used to send fax as e-mail message

3.1 MICROSOFT EXCHANGE SERVER

An e-mail server is the central component of a unified messaging system. It contains unified mailboxes and supports basic administration functions. All messages, including voice mail, fax, and e-mail, are all stored as e-mail messages. An e-mail server must support POP3 and/or IMAP4 standards.

Today, 96% of Fortune 50 corporations have already standardized on one e-mail system, versus only 4% that are either currently evaluating message platforms or have chosen a platform, but have not started the deployment phase (Source: Microsoft Exchange Server).

Microsoft Exchange Server has emerged as the leading messaging platform within Fortune 50 corporations - 52% of Fortune 50 have already standardized to Microsoft Exchange. Lotus

Notes is the second most popular platform with 24% of the Fortune 50 choosing is as the preferred messaging system. The other messaging systems include HP OpenMail, Netscape, and others, as illustrated in Figure 11.

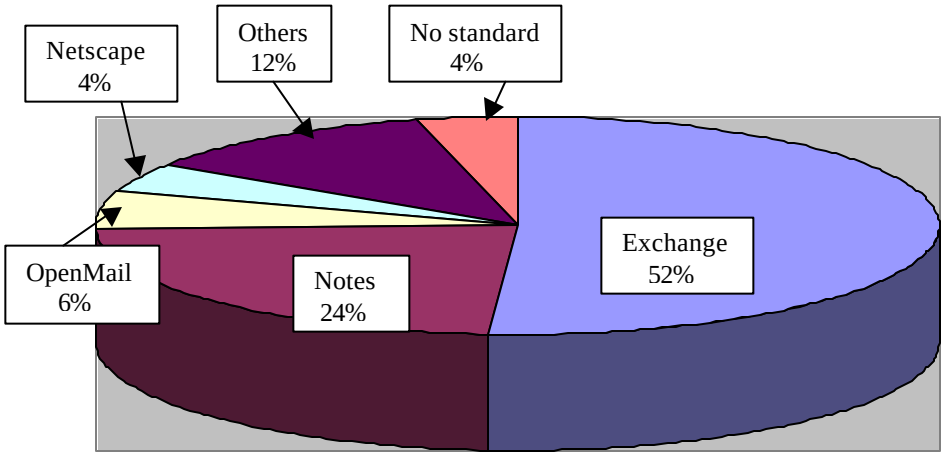


Figure 11. Most popular messaging systems within Fortune 50 corporations.

The Microsoft Exchange Server, used by several UM vendors including Lucent Technologies Octel Unified Messenger, was designed for both voice and data. It features high scalability to support thousands of users per server and tens of thousands of users in a single enterprise. It provides very high performance and implements Internet standards.

The Microsoft Exchange Server also provides high availability and fault tolerance through supporting clustering approach. It also provides high reliability with transaction-based store to ensure message delivery. Finally, it also features high security assured by single Exchange and Windows NT logon, password expiration, and support for the latest encryption standards.

The Microsoft Exchange Server supports a number of standards, such as SMTP, POP3, IMAP, LDAP, and HTTP.

3.2 CLIENT-SERVER INTERFACE STANDARDS

This section briefly presents two standard protocols for client-server exchange of messages: POP3 and IMAP.

3.2.1 POP3

The Post Office Protocol – Version 3 (POP3) is supported by a majority of present commercial e-mail servers. The goals of POP3 are:

1. To minimize resource requirements on the server by supplying only very simple access methods to messages stored in the user's mailbox.
2. To minimize implementation complexity on the client by supplying only the smallest sufficient functionality for the majority of environments.

It is designed as an asynchronous (off-line) remote message access and manipulation mechanism [7]. The user maintains a mailbox in a remote server that provides the store-and-

forward capabilities needed to send and receive messages. At the request of the user, a Pop3-enabled e-mail reader connects to the POP3 server, identifies the users, and copies messages to the local machine. Once in the local machine, messages are processed and manipulated only by the e-mail client.

POP3 operates over TCP connections. A POP session consists of three parts:

- Authorization
- Transaction
- Release and update.

The server receives the commands from the clients, which consist of a keyword and zero or more arguments. During the authorization state, the server validates the user's identity via USER and PASS commands. If the authorization is successful, the session continues with the transaction state, during which any combination of commands can be issued. The following list comprises possible commands:

STAT – list the number of messages in the mailbox
LIST n – provides information about n-th message
RETR n – retrieves the n-th message
DELE n – marks the n-th message as deleted
NOOP – has no actions (used to verify the state of the server)
RSET n – marks the n-th message as unread
QUIT – ends the session.

Following the QUIT command, the server enters the update state, where it removes all messages marked as read, releases the mailbox lock, and releases the TCP connection.

POP3 has several drawbacks that typically fall into two areas:

- Inefficient use of the network
- Inability to support decentralized operations.

Although POP3 is highly optimized for efficient implementations on host systems, its use of the network is not optimal with respect to latency. The typical POP session consists of at least 4+2N round-trip interactions, where N is the number of messages retrieved. This includes three round-trips to exchange greetings, one round-trip interaction to release the session, and two round-trips for each message [1].

POP3 also limits access to a single mailbox during any given session. However, some users may decide to utilize multiple machines to process their mail. POP model of centralized operations, in which all processing is done on a single client, is not adequate for these operations.

Additional drawback is that POP3 clients must download messages to the local machine before they are available for reading. In addition, POP3 does not recognize differences in the structure of the messages. In particular, it does not provide information on whether a particular message contains attachments or not.

3.2.2 IMAP

The Internet Message Access Protocol (IMAP) is more advanced than POP3 as a client-server interface protocol. The key feature of the current version of IMAP protocol, called IMAP4, is the ability to manipulate messages stored in a remote e-mail server. Like POP3, IMAP4 can

operate in off-line mode, in which e-mail client connects to the server and copies the messages to the local machine. However, it also supports on-line and disconnected modes.

In on-line mode, messages remain stored in the server and can be accessed from multiple e-mail readers. For example, a user can read the same mailbox from the office, home, or a remote Web browser without worrying about leaving messages copies in the server and the local machines.

Other features of IMAP4 include its ability to allow concurrent access to a mailbox, support multiple mailboxes, and use system-defined and user-defined flags.

IMAP session consists of four parts:

1. Exchange greetings
2. Select and manage a mailbox
3. Manage and process messages
4. Release the session.

IMAP has a considerably richer command set than POP.

3.3 INTERNET STANDARDS

The Internet is definitely becoming more and more important for unified messaging. Two established Internet standards that allow exchange information among e-mail servers are SMPT and MIME. VPIM initiative is a new effort to establish an Internet standard for exchanging voice mail and fax messages between e-mail servers.

3.3.1 SMPT

The Simple Mail Transfer Protocol (SMTP) defines the specification for establishing connections and messages exchange among e-mail servers on the Internet. It operates over TCP connections and it is strictly mail transport protocol that does not describe the structure of the mailboxes.

SMPT is characterized by a set of text commands interpreted by the e-mail servers involved in a transaction. A single SMTP transaction consists of three steps:

1. First, the sending host issues a MAIL command that includes the identity of the sender and the reverse path that is used to report errors.
2. Then, a series of RCPT commands are sent, each of which identifies a message recipient.
3. Transaction begins with a DATA command, followed by one or more fixed-length text lines containing the message.

The SMTP is limited for exchanging textual information.

3.3.2 MIME

The Multipurpose Internet Mail Extensions (MIME) standard was designed to overcome the limitation of SMTP and to enable the exchange of non-textual objects including:

- Textual message bodies in character sets other than ASCII,
- An extensible set of different formats for non-textual message bodies,
- Multi-part message bodies, and
- Textual header information in character sets other than ASCII.

The basic idea in MIME is the structuring of the message into multiple components and parts, each of which can be encoded and processed separately. MIME protocol includes type descriptors, which define media type and subtype identifiers. Type descriptors define the general class of data, such as text, image, audio, video, etc.), while subtype identifier specifies the characteristics of the media, typically its format (JPEG, GIF, MPEG, AVI, etc.).

3.3.3 VPIM

The Voice Presence for Internet Mail (VPIM) is the initiative, launched by the Electronic Messaging Association, with the goal to establish a standard for the exchange of voice and fax messages between voice mail systems over the Internet [8]. The VPIM specification [28] is a proposed standard and has been submitted to the Internet Engineering Task Force (IETF), which is the governing body for Internet standards.

VPIM includes basic messaging capabilities of creating, forwarding, and replying to voice and fax messages over any TCP/IP network. VPIM is strictly a server-to-server protocol that does not include the interaction between voice mail systems and their clients. It includes the use of SMPT and MIME to transport messages across systems. VPIM also provides the exchange of messages with e-mail systems. This is enabled through format transformation functions and advanced directory servers that provide the address lookup and routing services needed to deliver the message to the appropriate mailbox.

The deployment of VPIM is likely to be gradual. According to Elliot [8], the companies will first use VPIM gateways to connect existing internal voice mail systems together, then perhaps to link them more tightly with remote sites, mobile workers, and trading partners.

Figure 12 illustrates how existing voice mail systems and networks will connect to TCP/IP Intranets or to the Internet via VPIM gateways on SMTP hosts. These gateways consist of software modules or adjunct standalone systems. Figure 12 also shows new voice messaging systems, which will include native VPIM and SMTP routing of VPIM messages, and will support directory address lookup. E-mail and other client-server applications can support VPIM-based MIME constructs in the same way they currently support other MIME parts.

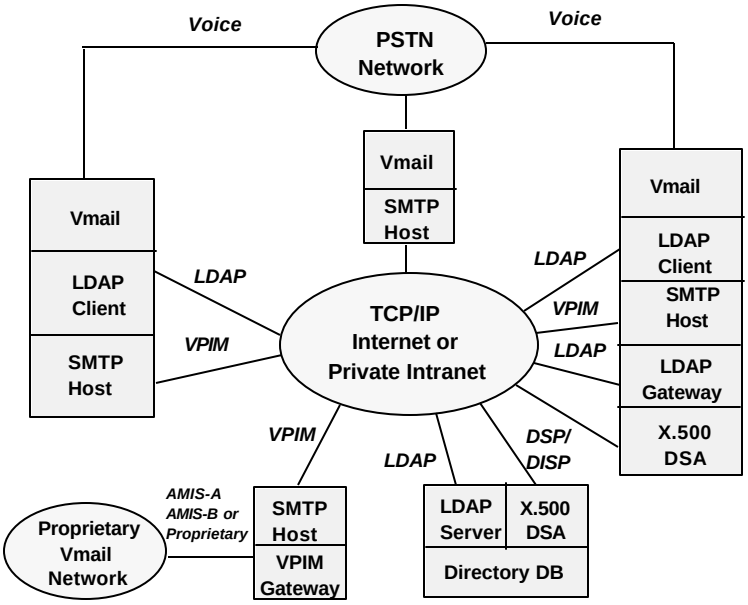


Figure 12. The VPIM-based world of voice mail systems and networks.

Nearly all major messaging vendors are supporting the VPIM standard. Many UM vendors Nortel, Lucent, Centigram, AVT and others, have committed to developing VPIM compliant networking products.

Because VPIM uses the Internet as the backbone for transmission of the voice and fax messages, this has strong benefits in the area of cost savings. By using the Internet for the routing of the network traffic, separate and dedicated digital lines between systems do not need to be purchased, installed, and managed. In this case, the Internet provides the pipe, and VPIM defines the communication structure for the networked messages.

4. UNIFIED MESSAGING VENDORS AND PRODUCTS

There are many vendors who offer unified messaging products and services. Table 7 presents the selected ten UM vendors and their basic products and characteristics.

Table 7. Overview of UM Vendors and Their Products.

VENDOR	UM PRODUCT	BASIC CHARACTERISTICS
Lucent Technologies	Octel Unified Messenger	• Based on Microsoft Exchange client/server architecture • Single mailbox for all messages
Interactive Intelligence	Enterprise Interaction Center	• Distributed client/server architecture running on Windows NT servers
Mediagate	iPOST	• Distributed architecture based on three communication servers • Single mailbox for all messages
Big Sky	Unified Messaging Assistant	• Supports Internet-based and Notes-based architectures • Voice server for Windows NT
Applied Voice Technology (AVT)	CallXpress	• Runs on Windows NT server
Amteva	Unified Messaging Plus	• Internet-based architecture • Based on an access server and Unix systems
Active Voice	ViewMail	• Runs on Microsoft Exchange server • Uses voice server for voice messages
Centigram	OneView	• Runs on PC Window desktop
CallWare	CallWare Unified Messenger	• Runs on Novel GroupWise and Microsoft Exchange • Based on either Netware or NT server
Ericsson	UMS 8000	• Wireless UM system • Based on Unix and Windows NT operating environments

In this section we present two unified messaging vendors and their products and services – Octel Unified Messenger and Interactive Intelligence Unified Messaging system.

4.1 OCTEL UNIFIED MESSENGER

Lucent Technologies Octel Unified Messenger is the currently the most popular UM product on the market. It runs on the Microsoft client/server messaging system, Microsoft Exchange

Server, described in Section 3.1. It is based on a scalable, open architecture and can support thousands of users.

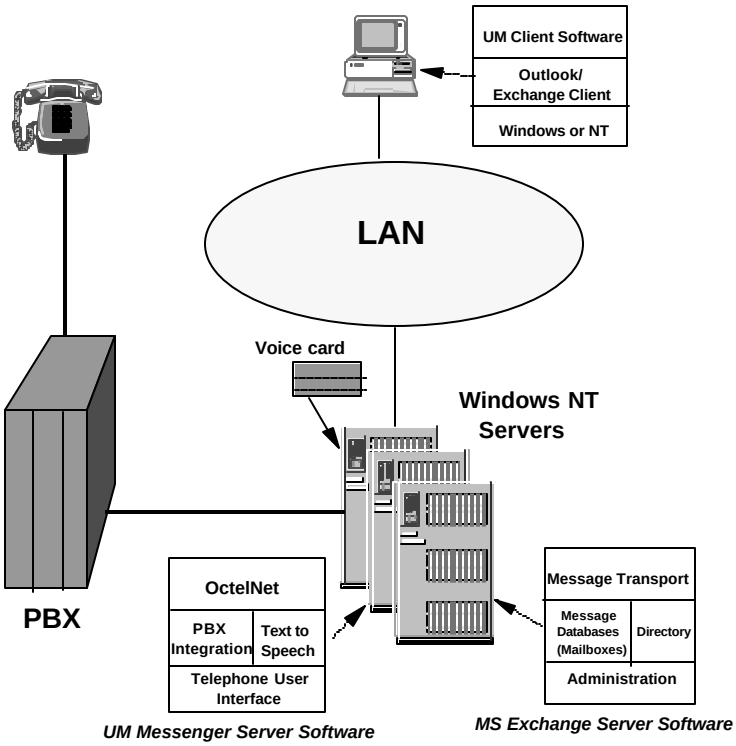


Figure 13. The architecture of the Lucent Technologies' Octel unified messaging system.

The UM system consists of the following components, as shown in Figure 13 [26]:

- The Microsoft Exchange server,
- The Unified Message server,
- LAN and PBX components,
- Personal computer clients, and
- Exchange-compatible fax servers and gateways to outside networks and the Internet.

The Microsoft Exchange Server is a powerful, high-performance e-mail system that serves as the repository for all user messages (see Figure 14).

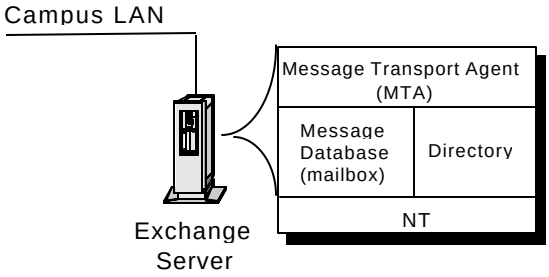


Figure 14. Microsoft Exchange Server and its software components.

Each Exchange server is also a high-performance LAN server. While a single Exchange server may contain the entire collection of Unified Messenger mailboxes in a workgroup, it typically acts as one of many Exchange servers and communicates with other Exchange servers on the local area network, on remote networks via WANs, and with other e-mail environments via the Internet. The Exchange Server contains the following components:

All user universal mailboxes.

Contents of all mailboxes. The contents consists of voice messages, e-mail messages, faxes, and other documents stored in the universal mailbox.

Directory. The Exchange directory manages addressing for the Exchange and the Unified Messenger system. Directory can also accommodate addressing for external destinations including fax numbers and e-mail addresses.

Message Transfer Agent (MTA). The MTA is the Exchange software that is used to transport messages between mailboxes and Exchange servers. It also replicates and replicates directories.

The Unified Message server software (Figure 15) runs on the Microsoft Windows NT server operating system. It serves as the integral connection between the LAN and the telephone network.

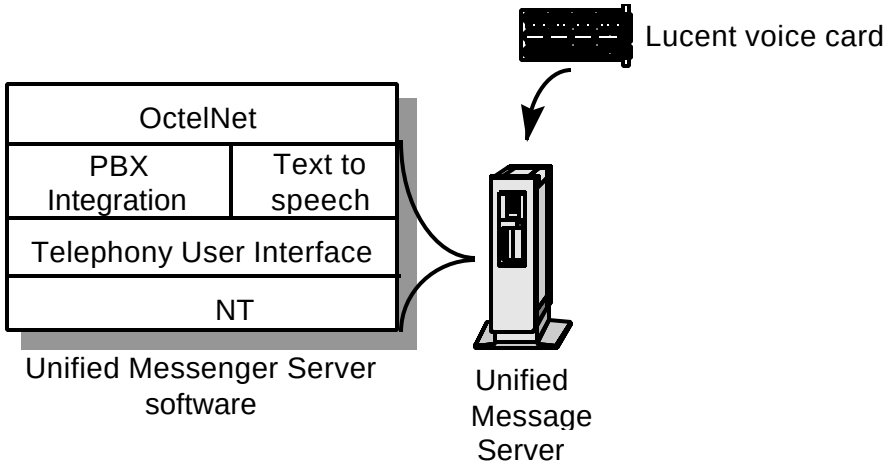


Figure 15. Software components of the Unified Message server.

The functions of the Unified Message server are to:

- Play and record voice messages
- Provide telephone answering services for individual users
- Compress audio messages in real time for storage on the Exchange server
- Retrieve audio messages from the Exchange server, decompress and play them in real time
- Interpret DTMF for mailbox manipulation and control
- Perform text-to-speech conversion for audio playback on text such as e-mail
- Exchange messages with users on existing Octel systems
- Forward incoming fax calls to an Exchange-compatible fax server
- Forward faxes and e-mail messages to an Exchange-compatible fax server for printing.

Figure 16 shows a typical user screen in the Lucent Unified Messenger system. Voice messages, stored on the Exchange Server, are available to any Exchange client software, such as Outlook. By clicking on the voice message icon, the message is retrieved from the user's mailbox on the Exchange server and staged for playback, as illustrated in Figure 17.

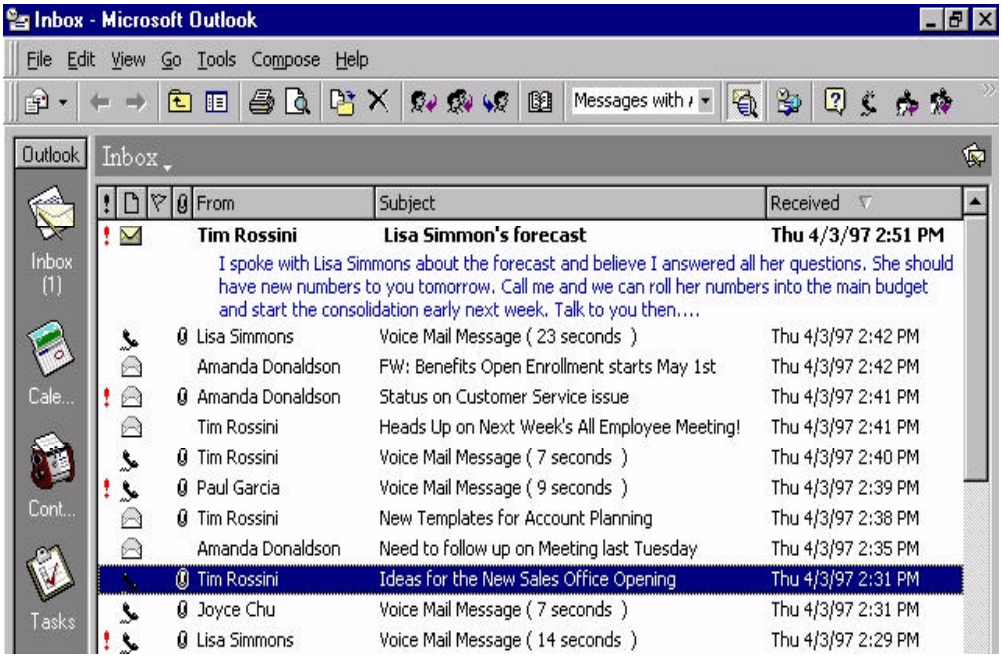


Figure 16. A typical screen of the Octel Unified Messenger.

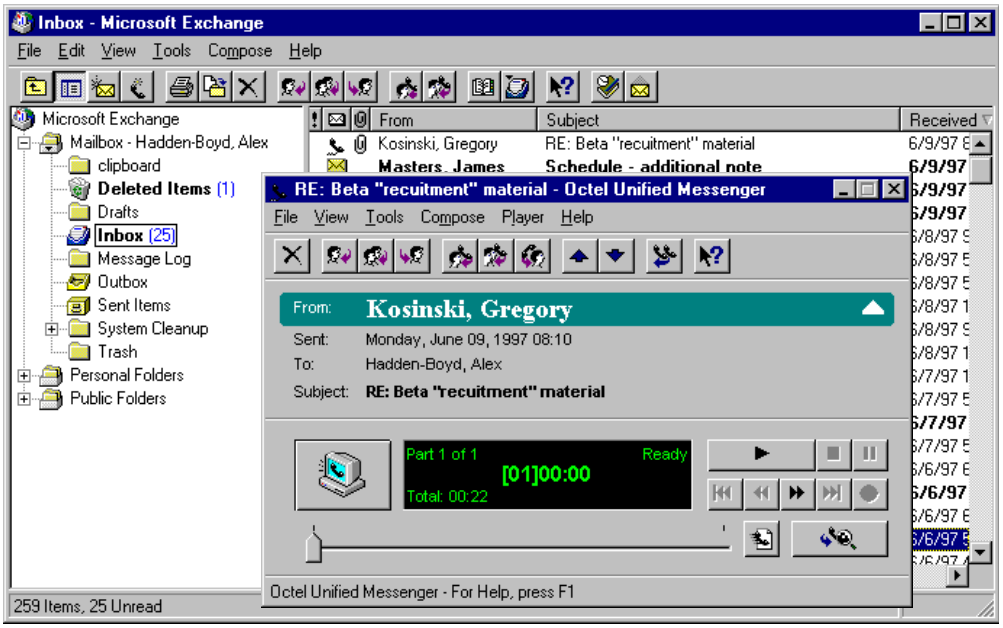


Figure 17. Voice messages are selected from the mailbox in the same way as e-mail messages.

Similarly, fax messages can be retrieved and presented on the screen, as illustrated in Figure 18.

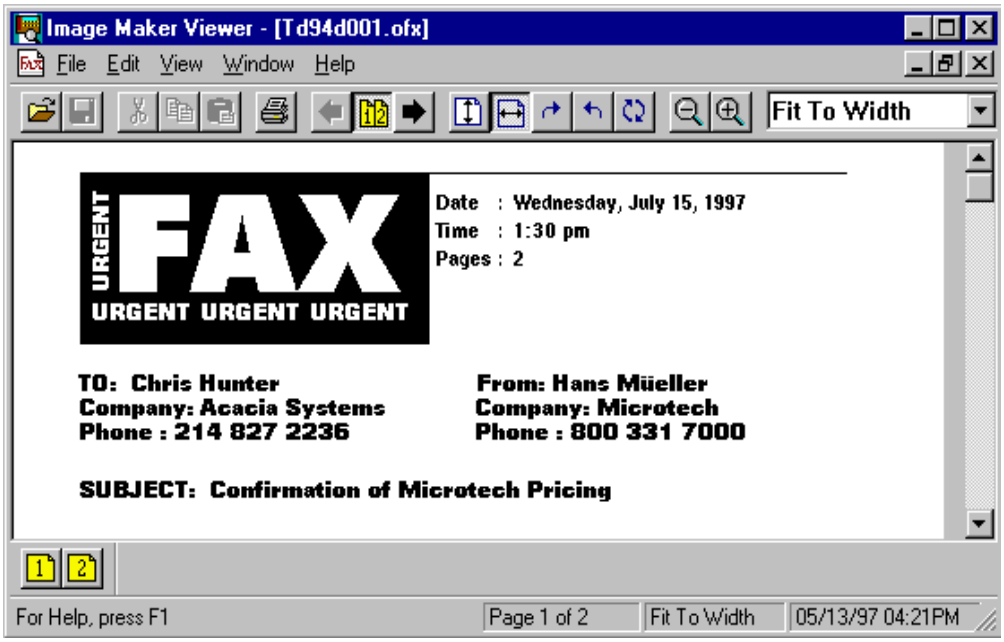


Figure 18. Fax messages are selected from the mailbox and presented on the PC screen.

Unified Messenger connections include both LAN interfaces and PBX integration. Exchange servers and Unified Message servers are high-end PC servers running Microsoft Windows NT and supporting standard LAN connections. Lucent voice processing cards, that contain digital signal processors (DSPs) to capture and compress voice data as well as to detect DTMF input, are located in the Unified Message server, as shown in Figure 15.

In addition, the Unified Message server includes a specialized connection to the PBX, called PBX integration. The PBX integration provides information about the calls as they are routed to the Unified Message server. The information includes who the call is originally intended for (called party), who placed the call (calling party), and what caused the call to be routed (no answer, busy).

According to Lucent study, the impact of the Unified Messenger on network traffic is not significant. Unified Messenger has an encoding rate of 32 Kbps, so for a 10 Mbps Ethernet LAN, one active port would use up about 0.4% of the bandwidth. This number is obtained by adding 32 Kbps plus 25% overhead divided by 10 Mbps. Similarly, 24 simultaneously active ports, all streaming data across the LAN, will use about 10% of the bandwidth capacity (24 x 0.4% = 9.6%). For more than 24 ports, there is a need for faster LAN of 100 Mbps.

The Octel UM system provides the interoperability with other Octel servers and systems as well as non-Octel systems. Because of Unified Messenger's support of OctelNet, Octel message server users can interoperate with Unified Messenger users. When a Unified Messenger system and an Octel server share the same telephone switch, some users want to configure their networking in such a way that the Unified Messenger system and Octel server operate like a single voice system. This can be achieved by using automatic mailbox forwarding, as illustrated in Figure 19.

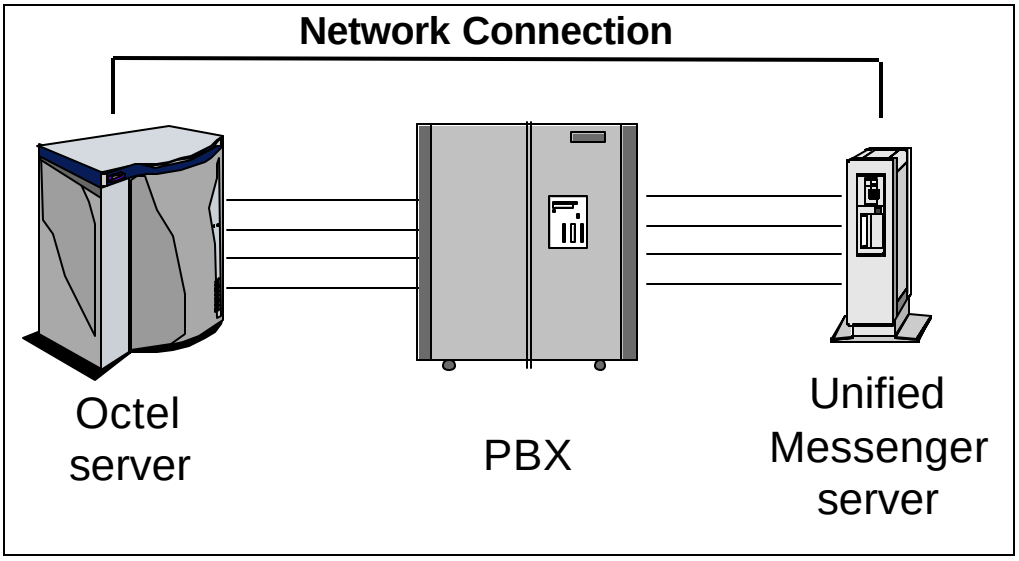


Figure 19. Messages received in the original mailbox on the Octel server are automatically forwarded to the mailbox on Unified Messenger over the network connection.

Unified Messenger users are notified of new messages through their PC client software.

With automatic mailbox forwarding, Octel message server users can continue to address messages to users on the Unified Messenger system the same way they address messages to the Octel server.

The interoperability with non-Octel users is achieved by implementing industry standards (see Section 3), including VPIM, SMTP and MIME.

The clients in the Octel UM system can be PCs or telephones. Client software resides on each client PC and it facilitates the sending and receiving of data between the client PC and the Exchange server. It also menages the display of all messages contained in the user's mailbox.

The telephone client can be used to record and listen to voice and e-mail messages. It also serves as an input device allowing the user to act on messages – reply to, forward, store, delete, print a fax, or request that an e-mail be faxed. E-mail messages are converted to speech through the text-to-speech feature. E-mail messages and attachments can also be converted to faxes for easy viewing.

In summary, Octel Unified Messenger is based on the Microsoft Exchange Server, which provides high scalability, high performance, high availability, high reliability, and high security. The UM system provides a single mailbox for all messages, including voice mail, e-mail, and fax. It allows users to access and manage all their messages from either a phone or a PC, anytime and from any place.

The system enables the reply to be in any medium of choice (voice, e-mail, or fax) regardless of the medium of the original message. The system allows users to store and organize voice and fax messages along with e-mail messages. E-mail and fax messages can be redirected from a phone or PC to any local printer or fax machine for printing.

For administration purposes, the Unified Messenger provides single point of administration and reduces cost by combining the administrative functions for voice and e-mail. In addition,

centralized management allows administration from any Exchange site for the entire enterprise. Scalable architecture can support small and large sites and enables organizations to grow to hundred of thousands of users. The UM system can be integrated with most major PBX systems.

4.2 INTERACTIVE INTELLIGENCE UNIFIED MESSAGING SYSTEM

Interactive Intelligence created Interaction Mail as the unified messaging system, which is the part of their Enterprise Interaction Center (EIC) software product running on Windows NT servers. The EIC is a distributed client-server application designed to integrate seamlessly with the Internet and World Wide Web, as illustrated in Figure 20.

The Internet capabilities of the EIC include (Source: Technical Overview of EIC [46]):

- The ability to remotely retrieve all messages, including e-mail, voice mail, and faxes.
- The ability to remotely administer, configure, and monitor the EIC.
- The ability to remotely supervise business interactions.
- The ability to remotely run and view reports
- The ability to make long-distance calls over the Internet and to hold, transfer, and conference these calls just like regular long-distance calls.
- The ability to route faxes over the Internet.

The heart of EIC is multi-threaded event-processing engine capable of handling many different types of communication events – incoming and outgoing telephone calls, e-mail messages, faxes, digital and alphanumerical pages, etc, as shown in Figure 21.

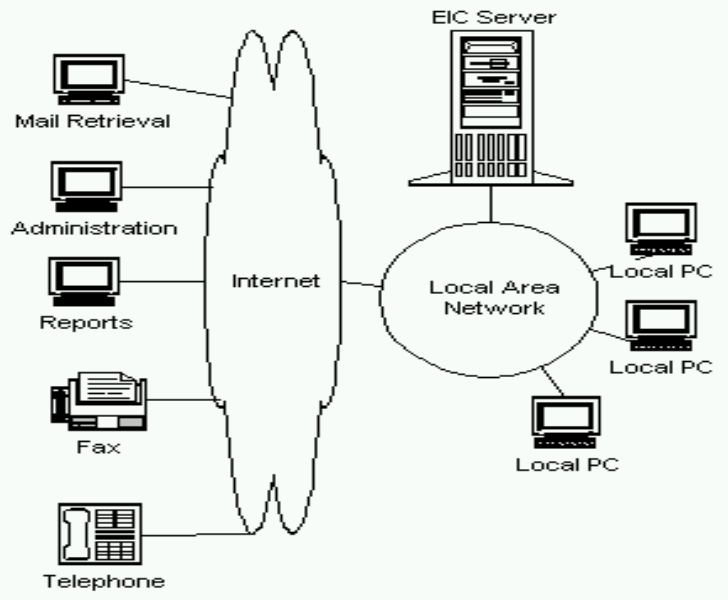


Figure 20. The Interactive Intelligence's unified messaging system is based on the EAC distributed client-server architecture.

The EIC can easily interface with popular e-mail systems, such as Microsoft Exchange and Lotus Notes, Web servers, such as Microsoft IIS, Netscape, and Apache, and database servers,

including SQL Server, Oracle, Sybase, and Informix, on a corporate network. The EIC can also interface to PBX systems or communicate directly with the telephone network via analog, T1, and ISDN PRI trunks. Configuration of the system for unified messaging based on the EIC server is shown in Figure 22.

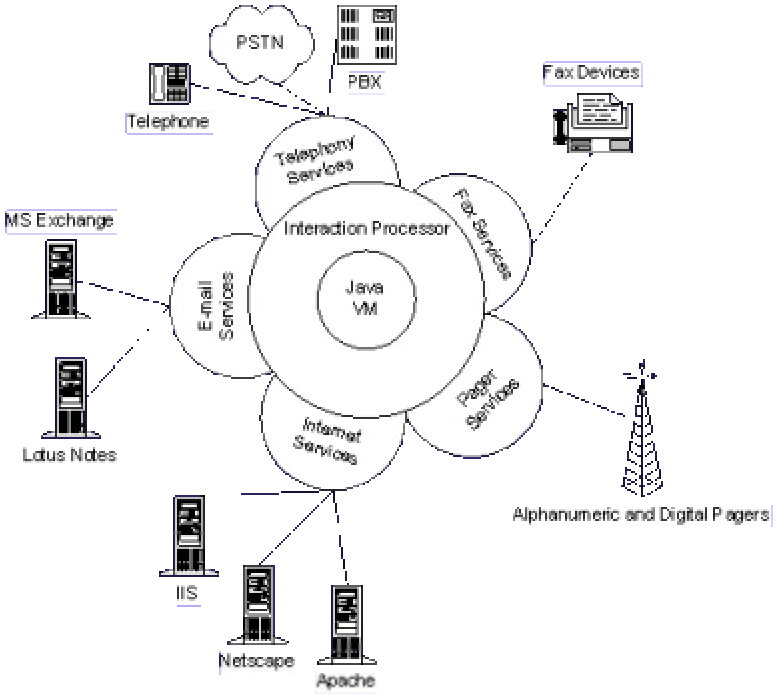


Figure 21. The EIC's Interaction Processor provides a single point of control for all communication events.

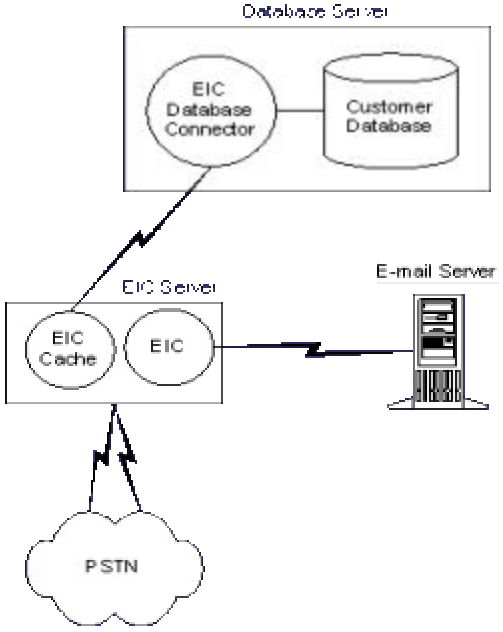


Figure 22. Configuration of unified messaging system based on the EIC server.

The system in Figure 22 consists of customer database, EIC database connector object, EIC cache object, and EIC server.

Customer database is a relational database stored on a high-capacity database server running one of the popular relational database systems (such as SQL Server, Oracle, Sybase, or Informix).

EIC database connector object (in the Microsoft DCOM format), located on the database server, handles communication with the customer database.

EIC cache object (also in Microsoft DCOM format), located on the EIC server, is used to cache information about a group of customers (e.g. 1-10,000 customers) for the unified messaging services to be provided to them.

EIC server is the server for the EIC applications and the EIC cache object. Incoming calls are routed to this server.

Microsoft Exchange or Lotus Notes mail server is where voice mail and faxes are stored. This makes it possible to provide access to these messages, as well as to e-mail messages, from a standard e-mail client (such as Microsoft Exchange or Outlook), or from a Web browser (e.g. Internet Explorer or Navigator).

PSTN trunks. Generally, several T1, E1, or ISDN PRI trunks are used to connect to the PSTN network. In some environments, it may be a PBX, which is located between the PSTN and the EIC server.

Interaction Mail is the software application for unified messaging, which allows users to access all their messages (e-mail messages, voice messages, and faxes) from a single mailbox (called "universal in-box) on their desktop PC. The screen capture in Figure 23 shows how Interaction Mail enables user's access to all types of messages.

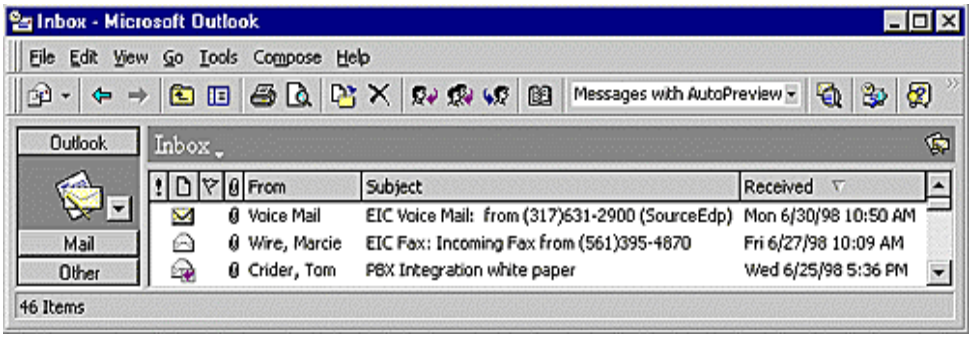


Figure 23. Interaction Mail allows users to retrieve all types of messages (e-mail, voice, and faxes) from a universal in-box.

How the system works

In the following hypothetical example we will assume that a service provider offers unified messaging to 100,000 customers. The provider maintains a large database in which it keeps all its customer information. The system consists of ten EIC servers and five servers running Microsoft Exchange. Each EIC server is configured to handle 10,000 different customers. When EIC server 31 initializes, it downloads all the information it needs about customers 1-10,000 and keeps that information in its cache object. EIC server #2 does the same thing for

customers 10,001-20,000, and so on. Routing from the telephone company is set up so that the personal 800 numbers for customers 1-10,000 arrive on a set of twelve T1s, which are connected to EIC server #1. The personal 800 numbers for customers 10,001-20,000 arrive on a second set of twelve T1s, which are connected to EIC server #2, and so on.

When the call arrives from the PSTN over one of the twelve T1s connected to one of the EIC servers, the corresponding server answers the call and uses the dialed number to quickly look up customer information within the EIC cache object. It then plays the appropriate greeting and records the message from the caller. After compressing the message to 1K bytes per second, the appropriate EIC server sends it as an e-mail attachment into the pool of Microsoft Exchange servers where it is stored in the customer's mailbox.

If another caller sends a fax to the customer's personal 800 number, that call is too routed to the same EIC server, which recognizes the fax tones, captures the fax, and sends it to the Exchange server.

Sometimes later, this customer calls in to retrieve his/her messages. He/she can either dial a special number or simply dial his/her personal 800 number. The EIC server can require the customer to enter a pass code or can be configured to recognize the number from which he/she is calling and drop him/her directly into the message retrieval part of the system. The system present to the customer a menu of different options, which allow him/her to playback his/her voice mail messages or have his/her fax forwarded to his/her hotel. He/she can listen to e-mail messages using the system's text-to-speech capabilities.

EIC also offers a set of fax services for sending, receiving, viewing, and manipulating faxes without having to use a fax machine. The EIC server uses one or more Dialogic Gammalink fax boards for these applications. Users can access their faxes from an e-mail client, as illustrated in Figure 24. Users can also retrieve their faxes by phone and have them forwarded to a fax machine at a given phone number. The user can read a fax by using an optical character reader (OCR) or to be converted to voice by text-to-speech conversation system.

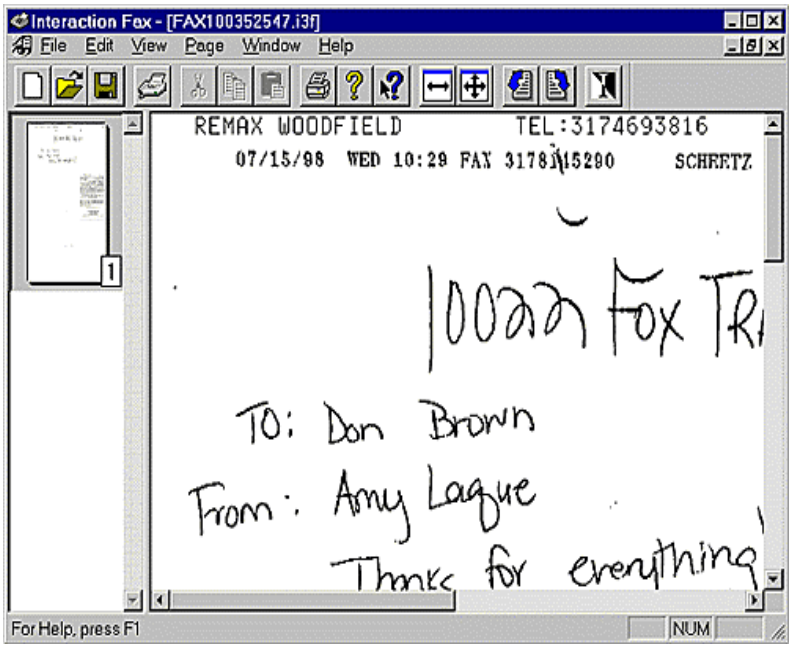


Figure 24. A screen shot from the EIC fax viewer.

Interaction mail uses a fault-tolerant approach by using a connector process. This process is located between Microsoft Exchange and the Interaction Mail processes, as presented in Figure 25. In order to provide full fault tolerance, it must run on a different machine on which Exchange Server runs. The functions of the connector processor are to creates local copies of voice messages and faxes, to handles the queuing of incoming voice messages and faxes, and to send queued messages into the Exchange message store.

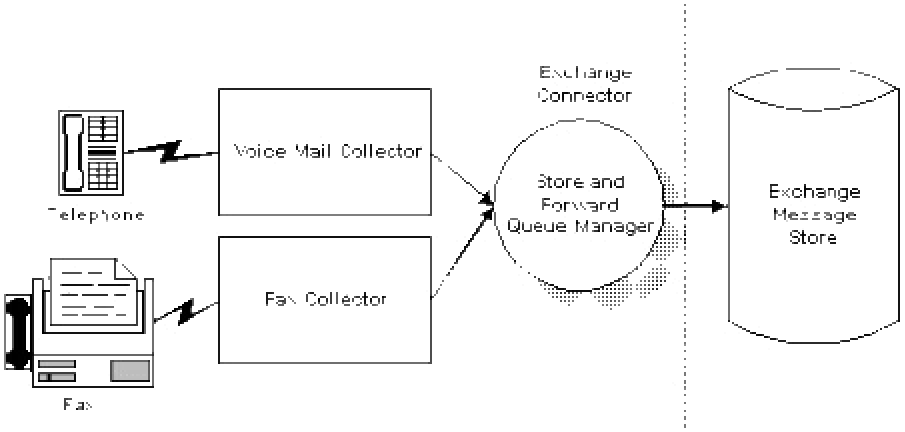


Figure 25. Exchange connector process, which runs on a different machine, provides fault tolerance.

If Exchange goes down, incoming voice messages and faxes are collected and queued. When Exchange comes back up, the queued voice messages and faxes are sent into the Exchange message store with no loss of data. Interaction mail can be integrated with most popular PBX systems e.g. PBXs from Lucent, Nortel, Siemens, NEC, Mitel, and Ericsson). This is accomplished by using the Simplified Message Desk Interface (SMDI) protocol, as illustrated in Figure 26.

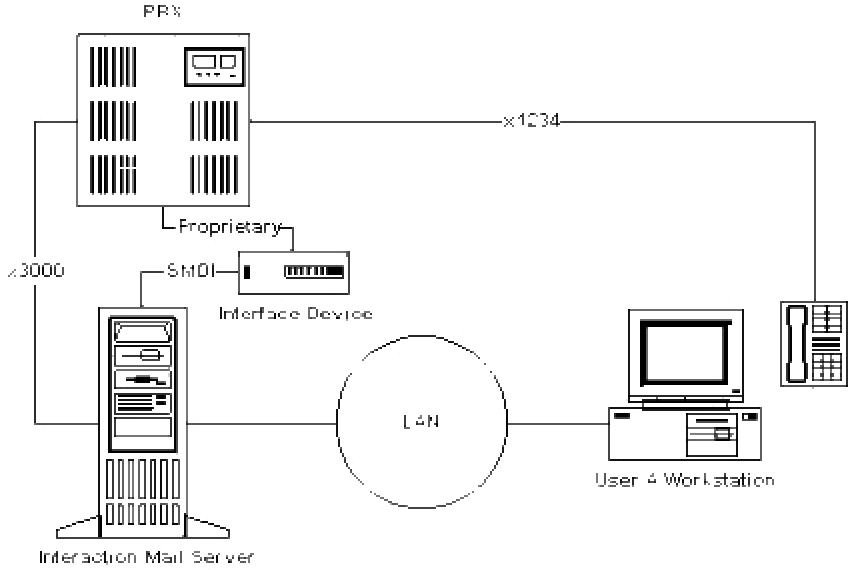


Figure 26. Integration of the EMS with popular PBX systems via SMDI protocol.

Interaction Mail can provide PBX users with integrated voice mail features without requiring any changes to the user's desktop. It provides cost-effective introduction of unified messaging into a legacy PBX environment.

5. CONCLUSIONS

Unified messaging is still in its infancy phase, but it is obvious that it will very soon enter the life of both consumer and business users. Unified messaging offers such a unique opportunity for improved productivity and long-term cost savings that it will definitely become a winning technology.

Generally, the electronic messaging perspective in the next Millenium [15]:

- Electronic messaging will continue to grow at phenomenal rates, as well as the Internet.
- Security will remain a very important issue. Digital signatures will become more prevalent.
- Messaging will become more sophisticated, and as such will become more of a business tool.
- Messaging management will become more important.
- Groupware or collaborative computing will be the next real infrastructure built on the messaging infrastructure.

The messaging industry started with *Call Answering*, and has moved to *Voice Messaging*, and it is currently moving to *Unified Messaging*. Many subscribers are using e-mail as a mainstream form of communications. They also use voice mail from their wireless service providers. Unified messaging provides users with access to respond to messages from a variety of networks from a single mailbox using any device.

What is the next step? One of the future trends is to provide users with flexibility to message however they like – to make messages configurable and highly personalized. This system incorporates the e-mail solution complemented with targeted telephony and Web user interfaces. This new concept is supported by PulsePoint Communications.

The vision of future unified messaging systems is that they will include a comprehensive solution, which will combine unified messaging services with other enhanced services. Such enhanced services may include call-initiation, access-control services, content and information services, and personal, time, and organization services [10]. Each new service should enhance and reinforce the benefits of other services.

There are several reasons that suggest that these additional services will be necessary. The most important of these reasons is increased competition, which will increase the pressure to service providers to deliver more value to the customers. The enhanced mailbox and related services is one way to add value and differentiate one's service.

Another reason to focus on enhanced services is that public networks are converging.. Due to the growing demand for greater bandwidth, the public switched telephone network (PSTN) and packet networks are combining, making enhanced mailbox services easier to build. Finally, client devices are becoming more intelligent. Personal computers provide great power for telephony communications and even wireless handset and telephone devices are beginning to have intelligence built in [10].

In summary, unified messaging and the universal mailbox will evolve to become the primary relationship driver between service providers and subscribers [10]. The universal mailbox will become the centralized network account where all services are delivered and managed. These services will include:

- Message management
- Incoming call management
- Billing
- E-mail
- Information services
- Fax services
- Personal assistant services,
- and much more.

The universal mailbox will be accessible from any chosen device – from wireless and wireline telephones to fax machines and personal computers. The computer telephone integration will provide true communication independence enabling subscribers to access and manage all their communications and information from anywhere at any time.

The adoption of UM systems have already began. Many companies, specifically small and medium-size, have successfully deployed unified messaging systems. However, the major deployment of UM systems is expected in the beginning of the next decade (from year 2000 to 2003).

Many companies indicated that they may take as long as 2 to 3 years to migrate to the UM system. Clearly, the migration process is typically longer for large-size companies. Therefore, it is important that vendors offer the right level of business planning and technical support along with UM products and services in order to enable the successful planning and implementation of the new system (conclusion from Lucent-Microsoft Executive Roundtable).

As the use of unified messaging becomes more pervasive, vendors will be increasingly pressured to demonstrate to customers that their products can inter-operate seamlessly with a large variety of products and technologies on the market. As a consequence, unified messaging standards will play a critical role in selecting a unified messaging system.

In order to be effective, a unified messaging solution should satisfy three key requirements [10]:

- Message access must be device-independent. A single mailbox should store messages of different types: e-mail, voice, and fax messages. The UM system should provide access to these messages from a variety of devices include wireline and wireless telephones, personal computers, and other devices.

- Unified messaging system should have an ability to perform content conversion, which is essential to satisfy the requirement of device independence. With content conversion, users can access their e-mail messages using a telephone (voice recognition and text-to-speech conversion), or they can send voice mail via fax (speech-to-text conversion).

- Unified messaging requires server-based storage and administration of all messages. This requirement has been a major challenge for service providers and UM vendors.

In our final analysis, the following conclusions can be made:

User's Perspective

- The main benefits of unified messaging are improved productivity, time saving, and improved accessibility.
- The recommended migration path is from traditional messaging systems directly to unified messaging systems.
- CLECs and Internet service providers should be selected for outsourcing UM services to users.

Vendor's Perspective

- Current target markets for unified messaging are SOHOs, small-size and medium-size companies.
- Early users of unified messaging are mobile professionals and home office people.
- Users are typically not aware of unified messaging technologies.
- Unified messaging will take off in the period 2000 to 2003.
- The expected revenues in year 2003 from unified messaging products and services are in the range $1-$10 billions and the number of UM mailboxes is between 5 and 100 millions.
- The most important characteristics of UM vendors are technical features of their products and their support systems.
- Internet is becoming more and more important for unified messaging.
- Standards play a big role in selecting unified messaging systems. Important UM standards are VPIM, IMAP, and SMPT.

Unified Messaging Products and Services

- The most important technical features of UM systems are that the system is using open protocols and standards, system scalability, and that the system is Internet-based.
- Cross messaging is important for unified messaging. The most important cross-messaging technology is text-to-speech conversation, which enables e-mail messages to be retrieved by the phone.
- Fault-tolerant solutions are important for unified messaging.
- Wireless access to the unified mailbox through digital telephones and pagers is important for unified messaging.

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