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電話傳眞與多用途電子郵件間之轉送伺服器
A Gateway for Multimedia Phone/Fax and MIME Mail

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摘要

因爲傳眞和電腦網路的使用廣泛，各種整合兩者的系統陸續被發展，電子郵件和傳眞的結合便是其中的一種。電子郵件是電腦網路裡最常使用的文字傳送系統，幾乎在每一台連接Internet的電腦都有它的影子。如果電子郵件和傳眞能彼此交換訊息，則可以加強它們傳遞的能力。國立中央大學分散式系統實驗室發展出一個整合MIME電子郵件和傳眞的雙向多媒體訊息傳遞系統。藉由Remote Printing Experiment的幫助，使用者可以從Internet寄送信件到電話網路。我們的系統更進一步讓使用者可以從電話網路寄多媒體訊息到Internet。同時在加拿大的Ottawa大學也發展了一個稱爲Fax-MIME gateway的系統，在Binary File Transfer (BFT) 的協定下，可以從電話網路寄多媒體訊息到Internet。然而，BFT在目前還沒有被廣泛的接受，因此大多數的傳眞機並不支援這項標準。對使用者而言仍然只能單向傳送訊息。相反的，我們的系統提供多個入口：電話、Group 3傳眞機和電腦，讓使用者可以經由電話網路傳文字、聲音和圖形到Internet上。我們的系統有下列特性：
- 提供雙向訊息傳送；
- 遵循現有協定並和其他系統相容；
- 提供一個方便而友善的使用者介面，像是語音導引或幫助；
- 定義一套通用的定址方式。

最後，我們相信我們的系統眞正符合使用者的需求：雙向多媒體訊息傳遞、簡單友善的介面和一套透明而完整的定址方式。

關鍵詞: 電子郵件,多媒體,傳眞,電話,PSTN, Internet, MIME, Group 3

Abstract

Since both facsimiles and computer networks are used widely, various systems integrating them are developed. One of these application areas is the integration of the e-mail and facsimiles. The e-mail is the most popular textual delivery system on computer networks, and almost installed on each computer connecting with Internet. The message exchange between the fax/phone and e-mail will enhance their messaging capabilities. In the Distributed System Laboratory at the National Central University, a new system with the MIME (Multipurpose Internet Mail Extensions) mail and fax/phone has been proposed to fill the request for the transmission of bi-directional multimedia messages. With the help of the Remote Printing Experiment, a user can send messages from Internet to the Public Switched Telephone Network (PSTN). Furthermore, our system extends their work to make users send multimedia messages from PSTN to Internet. In the meantime, the Fax-MIME gateway developed by University of Ottawa in Canada also has the ability of bidirection MIME messaging with the Remote Printing Experiment and the Binary File Transfer (BFT) protocol support. However, BFT is not adopted widely by the fax machine manufacturers as Group 3, so most fax machines don't support this standard, and the message transmission of this gateway is still a single direction for most end-users. By contrast, our system offers multiple contact points: telephones, Group 3 fax machines and computers to transmit messages containing text , image or audio to the Internet recipients through PSTN.

Our system has the following properties:
- Provide bidirection multimedia messaging.
- Be conformable to the current protocols and existing systems.
- Provide a user-friendly interface, such as voice

interface response or voice help.

- Define a universal addressing scheme.

Finally, we believe that our system meets a real user need: bidirection multimedia messaging, a simple and user-friendly interface, and a transparent and complete addressing scheme.

Keywords: PSTN, Internet, E-mail, Multimedia, Fax, Phone, MIME, Group 3

1 Introduction

The growth of fax usage in the 1980s and 90s has been dramatic since Group 3 standard was proved, and now there are more than 14 million facsimile units in use throughout North America [21]. Obviously, facsimiles have become the most popular form of text communication on the Public Switched Telephone Network (PSTN).

The e-mail is the most popular textual delivery system on computer networks, and almost installed on each computer connecting with Internet. Since both facsimiles and e-mail are used widely, various systems integrating them are developed. The message exchange between the fax/phone and e-mail will enhance their messaging capabilities. In addition, it provides another way to share the resource each other. Customarily, the message exchange between PSTN and Internet is through modems [27]. Two ways are used widely: the virtual terminal and SLIP/PPP [26, 23] but they are problematic. They are complicated and manual. Users usually must have the experience of using and setting up network. In addition, it is difficult to build connection because of frequent busy lines. By contrast, the integration of facsimiles and e-mails provides another choice to exchange messages without these disadvantages. Furthermore, it is easier and simpler.

The original Internet e-mail is based on the Simple Mail Transfer Protocol (SMTP) [11, 24]. It was not suitable for the transmission of multimedia messages because of many shortages including limitation of mail length, content based on 7bit ASCII code, no content type and so on [13]. Therefore, the Multipurpose Internet Mail Extensions (MIME) [19, 18] was proposed to satisfy this request in June of 1992. It builds on SMTP by standardizing additional fields for mail message headers that describe new types of content and organization for messages. The MIME makes users able to exchange multiple-media mail messages over the Internet.

In the Distributed System Laboratory at the National Central University, a new system with the MIME e-mail and fax/phone is proposed to meet the requirement of bidirection multimedia messaging (Fig 1). Our system automatically transmits mail messages to the fax machine of destination with the help of the Remote Printing Experiment [6, 5, 4, 3] . Furthermore, it permits users send multimedia messages from PSTN to Internet by using popular telephone sets, Group 3 [7, 8] fax machines and personal computers.

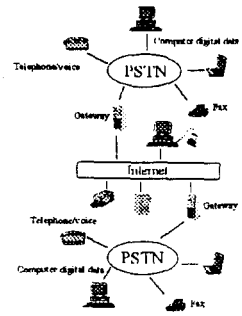

Figure 1: Our service environment

In the meantime, the Fax-MIME gateway [21, 22] was developed by University of Ottawa in Canada. Their system also has the ability of bidirection MIME messaging with the Binary File Transfer (BFT) protocol [9] support. However, BFT is not adopted widely by the fax machine manufacturers as Group 3, so the message transmission is still a single direction for most end-users. By contrast, our system offers multiple contact points: telephone sets, Group 3 fax machines and computers to transmit messages containing text , image or audio to the Internet recipients through telephone lines.

In our paper, the related work is introduced in the next section. This discussion is about two systems: the Remote Printing Experiment and the multimedia Fax-MIME gateway. The addressing problems and their available solutions are discussed in section 3. Section 4 specifies the design issues and system architecture. Our implementation and experience are discussed in section 5. Finally, we summarize our conclusion and outline future research plans.

2 Related Work

There are two research projects based on the MIME mail and facsimiles: the Remote Printing Experiment and the Multimedia Fax-MIME Gateway.

The Remote Printing Experiment. It was proposed by C. Malamud and M. Rose in October of 1993. In this system, Internet users are admitted sending electronic mails to remote printer servers, then the servers transmit the messages to the Group

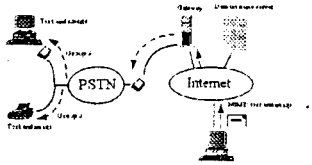

Figure 2: The Remote Printing Experiment

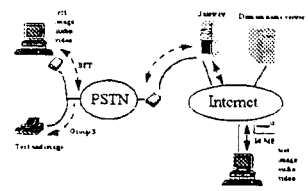

Figure 3: The Fax-MIME gateway

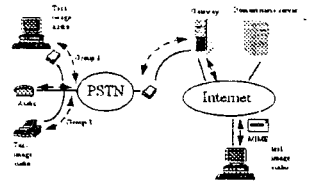

Figure 4: Our system uses traditional telephone sets, fax machines, and computers to provide multimedia messaging

3 fax machines of destination via PSTN (Fig 2). The critical points are that the MX of DNS [16, 17, 20] is applied in the routing problem, and mail messages are based on the MIME standard. With DNS, the Internet message-handling infrastructure can route the message to a remote printing server automatically. According to the telephone number encapsulated in the mail address, the server could send the message to the assigned remote printer (fax machines). When the transmission is finished, an acknowledgment will be sent back to notify users.

A user doesn't need to know the location of the server, and the delivery procedure is transparent and easy. Furthermore, the system is compatible with the existing systems, and users don't need to modify their mail system and to install new applications. At last, the multiple content: text and image (postscript and tiff) are supported. However, the Remote Printing Experiment is not perfect. It doesn't have the ability of bidirection messaging. This means that it only permits transmission from Internet to PSTN. Also, the content types are not enough. Our system enhances the Remote Printing Experiment to provide the transmission of bidirection messages, and additional voice communication services.

The Multimedia Fax-MIME Gateway. This system was developed by the university of Ottawa. It uses the Remote Printing Experiment to route mails to the remote fax machines from the Internet sites. But the Fax-MIME gateway has the ability of bidirection MIME messaging with BFT support. In other words, it permits users transferring messages from PSTN to Internet and from Internet to PSTN (Fig 3). Further, the gateway supports many content types including video, audio, text and image. By using BFT, it also provides the Internet file transfer and news services.

In messaging mode, the gateway would provide the Internet users with the access to fax machines that are not connected to the Internet by using the Remote Printing Experiment. In a typical scenario, this would allow an Internet user to send multimedia documents to a personal computer with BFT support at home. At first, users send MIME messages by e-mail to the fax-MIME gateway over the Internet. In order to transmit the messages to the assigned recipient, the gateway encapsulates the MIME messages into a BFT body with appropriate headers and faxes it out. If the fax machines corresponding to the telephone numbers don't support BFT, the gateway sends the recipient only those content types supported by Group 3 fax machines, (for instance, tiff, text, and postscript).

In order to send MIME documents to the Internet user over PSTN, the user agent with BFT support encapsulates the message in a BFT body, describing the recipient's Internet address and other attributes in the BFT header. The fax-MIME gateway decapsulates the BFT messages and uses the e-mail address in the BFT header to mail the MIME message to the recipient. Similarly, the file-transfer and news services are based on the same procedure.

However, Their gateway also meets several problems unsolved. First, it doesn't have the ability of bidirection messaging on the current telephone communication environment based on telephone sets and Group 3 facsimile machines. Their services such as messaging, FTP, and news are only available under BFT support. This means that the user agent on PSTN without BFT support merely receives the messages whose content types are only text, postscript or tiff, and no message can be transmitted to the gateway through telephone lines. Second, the additional software and hardware have to be installed in the user agent because BFT is not the popular standard, most fax machines don't support it yet (Fig 5).

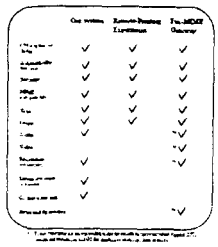

Figure 5: The characteristics of our system, the Remote Printing Experiment, and the Fax-MIME gateway

3 Problem Overview & Available Solutions

This section describes several problems which the designers will meet as integrate the phone/facsimile and e-mail, and their available solutions.

3.1 Addressing

When the researchers try to integrate the facsimiles and e-mail, they could not avoid considering the addressing problem. In many instances, the fax gateway is blamed that it can't identify the correct recipient, and the fax must be printed out and distributed manually. In a word, the issue is how the system knows the location of recipients between two heterogeneous networks, then transmit messages automatically. This is a key point of the system design. The addressing problem could be discussed from two viewpoints: phone/fax-to-mail and mail-to-phone/fax.

1. Phone/fax-to-mail. In this mode, systems have to make sure that the incoming messages are distributed to the right users on networks. The problem can be divided into two parts: how to get the address information from PSTN, and how to convert the intermediate address to the recipient mail address.

How to get the address information from PSTN. There are many ways in which incoming messages are routed to users on networks. In a typical scenario, the gateway, a PC or workstation connecting with Internet and PSTN, first has to be able to get the address to identify the intended recipient on Internet. There are six possible methods which we recommend getting address from PSTN: DID, DTMF, CND, TSI, OCR, and VR.

(1) *Direct Inward Dialing (DID).* [14, 15] A special type of phone line (trunk) provided by the phone company which associates multiple phone numbers with a single telephone line and which send a signal down the line when a call arrives which indicates which number was used to place this call. Therefore, DID could be used with fax modems to provide routing of inbound faxes. Each user is given a different fax number but all of the calls come in on the same DID trunk. The fax modems decodes the signal from the phone central office which indicates which number was dialed and uses this number to route the incoming fax to the recipient.

(2) *Dual-Tone MultiFrequency (DTMF).* [15, 12] A method of signaling in which is a combination of two frequencies, each from a group of four, are used to transmit numerical address information. The two groups of four frequencies are 697 Hz, 770 Hz, 852 Hz, 941 Hz, and 1209 Hz, 1336 Hz, 1477 Hz, and 1633 Hz [15]. The frequencies are transmitted to the network each time a digit is dialed. The standard 0 to 9 digits are catered for, plus and #. Some fax modems also cater for the use of A, B, C, D, Q, and S. Users enter the address by using the touch-tone telephone.

(3) *Caller Number Delivery (CND).* [28, 29] This technique is very convenient. This is a kind of service available from phone companies. With this service, the phone company sends the calling party information along with ring signal to the called party. The major part of this information is the telephone number of the calling party or caller ID. The fax gateway read the caller's telephone number which is furnished during call setup for Group 3 fax transmissions, and attempts to match it with the numbers entered into a routing table by various recipients.

(4) *Transmission Subscriber Identification (TSI).* [7] This method is the least expensive method of identifying fax recipients. TSI is option signal during call setup which indicates the following facsimile information fields which is the identification of the transmitting station. These fields shall be the international telephone number including the telephone country code, area code and subscriber number. If a table is created in advance, the gateway could search for the recipient matching with the telephone number of the caller.

(5) *Optical Character Recognition (OCR).* Since the incoming fax is a kind of image, some designers try to use OCR to identify the recipient. By using OCR, the fax gateway is able to get the address of recipients directly from the incoming fax. Most products rely on standardized cover pages, which means that senders have to type in the recipient's name in a special panel so that it can be scanned easily.

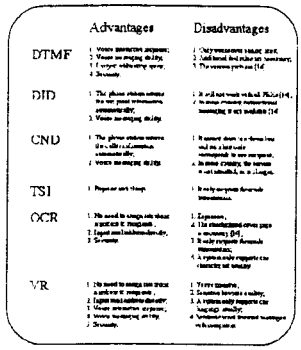

Figure 6: Various technologies to get the recipient information

(6) *Voice Recognition (VR).* It is practicable that the fax gateway can directly identify the recipient from the sender's voice through telephone lines. By VR, the gateway could decide whether the gateway receives fax messages or not. It can monitor senders and has a better security ability. Also, VR supports the transmission of voice and facsimile.

How to convert the intermediate address to the recipient mail address. This problem comes from the limitation of the above technologies which only permit users entering a series of numbers except OCR and VR. The incoming number, called intermediate address, cannot express the mail address which contains alphabets. Therefore, the conversion of the intermediate address into the recipient address is necessary. Several available methods are introduced here. *The simplest is to create a symbol table in the gateway.* The gateway searches the table for the mail address based on the intermediate address, then sending the incoming messages to the recipient on Internet. Another method is using the aliases table of mail system. The detail is the system manager adds the user UID and user name pair to the aliases table in the host of destination. Then, the gateway can send the incoming messages out directly, and the messages will be forward to the recipient according to the aliases table of the host of destination.

Another method is to modify the mail system to make it accept the digital address. For instance, let's suppose that the gateway asks users for the host IP address and user UID of the recipient. If the mail system of the host of destination can identify the mail address composed of user UID and IP address, the incoming messages will be send to the Internet recipient. Therefore, the table in the gateway will not needed.

2. Mail-to-phone/fax. Unlike the previous situation, the special hardware support is not necessary. And we focus on finding a suitable gateway automatically for the successful transmission of mails. The word, "suitable", means making the communication cost lowest. This problem can also be divided into two parts: how to find the location of gateway and how to pass the telephone number of destination to the gateway.

Where is the desired gateway on Internet? *The most popular solution is using symbol tables.* On many commercial systems, users usually have to remember the IP address of gateway, and they could send their messages to it, then transmitted out via telephone lines. However, it is not transparent and convenient to users. If the address of gateway is changed, they have to remember a new one. A better mechanism is using MX of DNS proposed by the Remote Printing Experiment. The detail as mentioned above don't describe here again. The methods about passing the telephone number of recipient to gateway is dependent on the approaches of finding the gateway. If the first approach to remember the address of gateway is adopted, the telephone numbers can be in many places, for instance, mail content, mail headers, or account name of mail address. If the system adopts the method of the Remote Printing Experiment, the telephone number can be encapsulated into the mail address.

4 System Overview

In this section, we describe our design issues, service overview and system architecture.

4.1 Design Issues

In solving the main addressing problem about incoming messages from the PSTN, our system adopts DTMF. There are several reasons for choosing it to gather the address information through telephone lines. First, it can work through voice communication. This makes our system offer voice messaging via telephones and a friendly user interface by the voice interactive response [10]. Second, DTMF leaves a large of space for us to define the dial rules fitting for our address scheme. Third, it is cheap and available for most existing PSTNs. Finally, users are familiar with dialup. Although, this technology is only available for analog communication environments, and can not be used on digital networks, such as ISDN. But this is not an important issue because there are a few Group 4 [25] fax machines used, and over 98% of fax machines are

produced based on Group 3 standard [25].

By using DTMF, the problem about getting address is solved. However, there is a problem unsolved: how the mail address is expressed with 12 keys ($0 \sim 9$, *, and #) on the keypad. As the above mentioned, modifying the mail system and using a symbol table are two solutions. Our system adopts symbol tables. In a typical scenario, the user inputs the intermediate address consisting of the IP address and user UID. Our system uses the symbol table in the host of destination (the mail aliases or user defined table) to convert the intermediate address to the recipient address defined by SMTP. Users are familiar with this scheme because it is similar to the address form of SMTP. This method is transparent since users can send their messages to the arbitrary gateway over PSTN, then transmitted to the Internet recipients. However, it is not customary to remember the user ID of recipient. Another shortage is the total length of address is too long to dial the right numbers easily. In order to solve these problems, the gateway creates the group table with the group number and mail address pairs. When the user inputs the group number to the gateway, the corresponding mail address can be found out with the table. The group number can be short enough to be remembered. Furthermore, a group number is able to correspond to several addresses, hence users could send their incoming messages to a group of recipients. By this way, the registration is necessary. If the recipient address doesn't exist on the group table or the table is not created by the gateway, senders cannot send their documents to the desired mailboxes by using the group number.

Because both methods have their advantages and disadvantages individually, we integrate them. The former is the main addressing scheme, and the latter is auxiliary. If users know the recipient user ID, they simply enter the complete address to the gateways. Or, if users merely remember the group number of some recipient or want to send their messages to multiple recipients simultaneously, they can enter the group number.

4.2 Service Overview

In the Distributed System Laboratory at the National Central University, a new system is developed to integrate e-mail and phone/fax, and it has the ability of bidirectional multimedia messaging is proposed. We use the Group 3 fax machines, telephones and computers as the base devices to build a complete service environment. The Remote Printing Experiment helps us to transmit Internet mails to the remote printer. Our gateway extends their work to reach the goal of bidirection messaging between Internet and PSTN. The interactive voice response and the DTMF decoding mechanisms allow our system to provide the following services.

The service styles are divided into 4 types: fax/voice to MIME mail, MIME mail to fax, store and forward fax, and polling MIME mail from fax machines.

Fax/voice to MIME mail: Users send their facsimile or voice messages to a gateway, then transmitted to the desired mail account. During the transmission of facsimile, the user puts his or her document transmitted ready and dials to a gateway at first. Upon the gateway answering the call, the user enters a series of numbers corresponding to the mail address of destination.

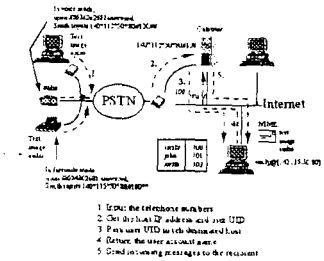

Figure 7: Fax/voice to MIME mail from fax machines or telephone sets

Let's suppose that a user, named Smith, wants to send a facsimile message to his friend Emily whose mail address is emily@[140.115.50.80] and her user UID is 100, and there exists a gateway, whose telephone number is +886-3-4262681. Smith simply puts his document on the paper cap of the fax machine and hangs up the phone, then dials +886-3-4262681 to the gateway. After the call is answered, he starts to enter the number 140*115*50*80#100** and presses the start button on the fax machine. The gateway will send the received facsimile message to Emily's account in the form of MIME mail over Internet (Fig 7).

Our system also supports the group transmission of fax/voice mail. A user can send their fax/voice messages to a group of recipients simultaneously. It is convenient and useful for users to transmit messages to hundreds of recipients (Fig 8). For instance, Smith wants to send facsimiles to his partners, Tom, Mary, John. He simply create a table with their addresses in the gateway. Let's suppose that the group number of the table is 4508. After putting the document on the cap, he dial +886-3-4227151-4508** to the gateway. Once getting the

group number 4508, the gateway will search the table and send the incoming messages to the recipients listed in the table: Tom, Mary, and John.

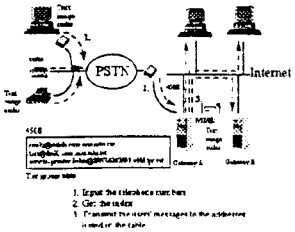

Figure 8: Group fax/voice mail

MIME mail to fax: If the Internet users desire to transmit mail messages to fax machines, the system has to choose one of the available gateways. The assigned gateway will fax the mails out. One of the method to find the gateway is using domain name servers to bind fax gateways. It is proposed by C. Malamud and M.Rose. The MX resource record defined by DNS is used to register all fax gateways. A user can send a mail to a special address composed of telephone numbers. Then, the mail will be routed to the fax gateway by DNS (Fig 9). For instance, if Smith wants to send his messages to the fax machines, whose number is +886-3-4262681. He

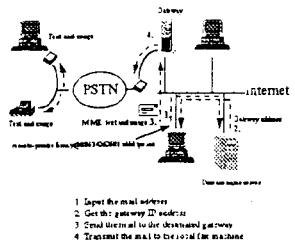

Figure 9: MIME mail to fax

simply mails his messages to the address, remote-printer@ 1.8.6.2.6.2.4.3.6.8.8.tpc.int or remote-printer@88634262681.iddd.tpc.int. When the facsimiles are given to Emily, the address becomes remote-printer.Emily@1.8.6.2.6.2.4.3.6.8.8.tpc.int or remote-printer.Emily@88634262681.iddd.tpc.int and the cover sheet will contains the recipient name Emily. The mail will be automatically routed to a suitable fax gateway, then sent out over PSTN. One of the advantages of this mechanism is that it is compatible with the existing systems and straight forward for users. Another advantage is the way follows MIME standard and supports tiff. postscript, text data formats. Please see the

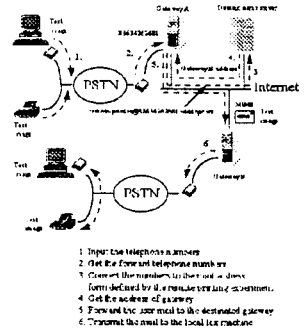

Figure 10: Store and forward fax

Remote Printing project for the detail.

Store and forward fax: Our fax gateway also provides the store-and-forward function. Users send their facsimile documents to a fax gateway, then forward to another gateway via Internet, and the final gateway transmits the messages to the destination on PSTN. By this way, users save their communication cost. (Fig 10).

For instance, let's suppose that Smith wants to send his facsimile to +886-3-4262681. He simply hangs up the phone and dials to a gateway. When the connection is build, he inputs the number 886-3-4262681** and presses the start button. The gateway transmits the number string to the mail address, remote-printer@88634262681.iddd.tpc.int, and mails the incoming message to this address. Another gateway on the Internet will receive the mail and send it to the fax machines whose telephone number is +886-3-4262681 via the PSTN.

Polling MIME mail using fax machines: This service allows a user to get their MIME mail by using a fax machine. Therefore, users could read their mail at home, and it is not necessary for them to sit in front of terminals. The user dials to a gateway. (Fig 11).

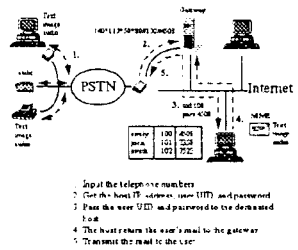

Figure 11: Polling MIME mail using fax/phone

Let's see an example, Smith wants to poll his mail from his account in the host via the PSTN. His mail address is smith@[140.115.50.80], his user UID is

100, and password is 4508. There exists a gateway, whose number is +886-3-4262681. Smith simply hangs up the phone and dials +886-3-4262681 to the gateway. After the call is answered, he inputs the number 140*115*50*80#100#4508 and presses the start button on his fax machine. The gateway analyzes the number string, and gets the mail from the desired account, which is smith@[140.115.50.80] in this example, then transmitted to Smith.

4.3 System Architecture

The system adopts client-server model, which the server is called fax gateway. As its name implying, it is responsible for the communication between the PSTN and Internet. It doesn't only act as a gateway but also an address converter and a service binder (Fig 12).

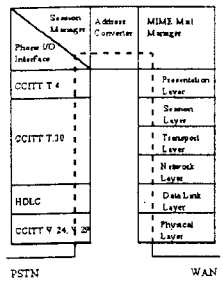

Figure 12: Our system acts as a gateway between the OSI WAN and PSTN

It consists of several modules. The MIME mail manager is responsible for message transmission. The incoming messages from PSTN are encapsulated into MIME mails, then transmitted to the recipients on Internet. Oppositely, the MIME messages from Internet are decapsulated into the forms for PSTN transmission.

When a user dials to a gateway, the phone I/O interface is triggered. The call is answered and keep up connection until the end of services. It is responsible for the communication between the gateway and PSTN users, the conversion of data formats and the date compression/uncompression.

The phone I/O interface has an important module: the DLE filter. The DLE filter, as its name implying, filters DLE shield codes from the incoming/outgoing data stream through telephone lines. When the user presses a key on the keypad, the telephone set generates a DTMF signal corresponding to the key, then sent to the gateway through telephone lines. The DTMF signal is converted to the DLE shield code by hardware support. To identify

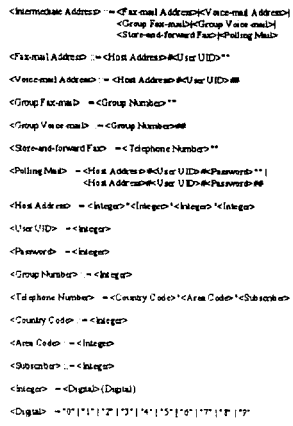

Figure 13: Dial rules

user's requirements, the gateway uses the DLE filter to get the DLE shield codes. In addition, before the data is transmitted out, the DLE filter filters DLE shield codes from the data stream. Since some DLE shield codes are considered as control codes, if they are not removed, the phone I/O interface will work abnormally.

The session manager plays a central role in tailoring the fabric of delivery services to fit the individual needs and preferences of users. Therefore, the session manager has to talk with users to know users' requirements. It consists of two components: the phone-session unit and voice notify base. The phone-session unit is responsible for negotiating with the PSTN users. When users in the direct-dialing mode, the gateway will receive a series of numbers coming from the users. After the DTMF signal is processed by the DLE filter, the DLE shield codes are sent to the phone-session unit and be parsed to identify the users' requests. If the users don't know our dial rules, the interactive-dialing will help them. After answering the call, the gateway plays a voice menu for users and tell them to select one option by pressing a number key. Then, the phone-session unit searches the voice notify base for a suitable voice notify according to the selection of users, then playing it. The voice notify is used to tell users the status of the system and what they should do next. These procedure may be repeated several times. During the question and answer, the session manager identifies what service users are interested in, and it will trigger other related modules to finish the service.

The address converter is responsible for converting the intermediate address to the e-mail address. Based on our dial rules (Fig 13), the intermediate address, which the user enters through telephone

lines, consists of numbers, "*", and "#", so it cannot express the e-mail address completely. The converter acts as an interpreter to describe the incoming intermediate address as the corresponding service type and generate the corresponding mail address.

5 Implementation & Experience

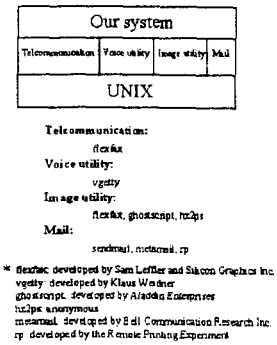

Figure 14: The relationship between our system and the applied applications

At the Distributed System Laboratory of the National Central University, our system prototype has been developed. The fax gateway is implemented on 486-PCs with ZyXEL fax modems which are connected with Internet and PSTN. The fax modems provide the fax/data/voice capabilities over telephone lines, and can detect DTMF signals then decode DTMF signals into DLE shield codes [28, 29, 1, 2]. The system is built on FreeBSD and Linux. In order to modify and port to different platforms easily, we use the C++ of GNU and C-shell script as our programming languages. Fig 14 describes the relationship between our system and other software. At present, it has been installed on a 486-PC at our laboratory to offer services to any user on Internet.

The gateway uses the mechanism of the Remote Printing Experiment to solve the mail routing problem. This makes the addressing procedure from Internet to PSTN transparent. It is not necessary for users to know the location of the gateway. Furthermore, our system has the ability of bidirectional multimedia messaging and supports audio, text and image content. During solving the problems coming from messaging through PSTN to Internet, DTMF is used to get the recipient information, and two symbol tables, one is the original mail aliases table and the other is a new table created for the group

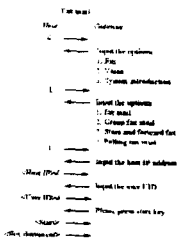

Figure 15: Fax mail

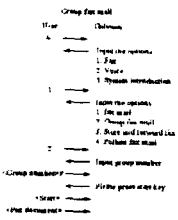

Figure 16: Group fax mail

transmission, are responsible for the address conversion. We combine these methods to establish a complete service environment.

In the previous section, we ever said that our gateway provides two kinds of user interfaces for the PSTN users. One is interactive-dialing for novices, another is direct-dialing for experienced users. Fig 15, Fig 16, Fig 17 and Fig 18 describe the procedure of interactive-dialing. Some initial feedback about our design is gathered. Users reacted positively regarding the system's ease of use and simple interface. In terms of functional extensions to the system, a few of users subject that more information is added into our voice notify base and the interruption during playing voice greeting is admitted. In our original design, users must hear of the total section of voice greeting in interactive-dialing mode. In the future, these suggestions will be considered when we improve our system.

6 Conclusion

We have created a basic prototype of our gateway, and released the source code on the FTP site at our laboratory, its host name is dslab.csie.ncu.edu.tw [140.115.50.80]. This gateway provides bidirection multimedia messaging in a traditional PSTN communication environment composed of telephones, Group3 fax machines. Furthermore, it offers users a user-friendly interface with voice interactive response to reach the goal of using without learning. As extensions to the effort, the resources and ser-

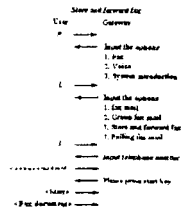

Figure 17: Store and forward fax

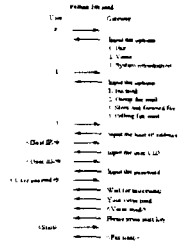

Figure 18: Polling mail

vices of the PSTN and Internet are shared with each other.

From our experience, we recommend the follows to the researchers interested in the integration of e-mail and phone/fax:

- Provide bidirection multimedia messaging.

- Be conformable to the current protocols and existing systems.

- Provide a user-friendly interface, such as voice interface response or voice help.

- Define a universal addressing scheme.

We believe that our system meets a real user need: bidirectional multimedia messaging, a simple and user-friendly interface, and a transparent and complete addressing scheme. Because DTMF applies to our system successfully, we plan to use it in other application fields in the future, and explore the possibility to apply other technologies mentioned in section 3 to the integration of e-mail and phone/fax.

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