PC-Based Digital Facsimile Information Distribution System

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Abstract
This paper describes an information distribution system that merges the personal computer (PC) and facsimile technologies to enhance and expand the capabilities of existing stand-alone facsimile machines. The goal is to identify and develop mechanisms to reliably dispatch or receive a page of text or graphical material to or from any place worldwide within one minute. To allow universal compatibility, the system is designed based on the CCITT recommendations for Group 3 fax apparatus. Automated sending and receiving processes are devised in a user-friendly, menu-driven environment to minimize human intervention. The information dispatching mechanism is integrated with existing PC wordprocessors, graphics editors, and image databases. In addition, the system software is implemented at the application layer of an OSI LAN model as a fax server to provide a cost effective solution for information exchange that rivals existing document delivery systems.

1: Introduction

Facsimile, or fax for short, is the method by which written documents or photographic materials are converted into electrical signals, transmitted over telephone lines to reproduce as duplicates at the receiving end. A fax system consists of the mechanisms to transform the graphical materials to electrical signals suitable for transmission over telephone lines, a modem that transmits the signals to the receiving station, and the mechanisms to record and replicate the original documents. One can think of the fax system as a "remote copier machine" or an "instant mail facility." Although the basic principle of fax communication was known as early as 1843 [1], its real use for business communication did not begin until 1970 [2]. This was the direct result from the lack of any form of standard protocols for fax equipment.

The International Telegraph and Telephone Consultative Committee (CCITT) realized the need for such standards and developed the Group 1 Fax Recommendation in 1968. Even though Group 1 units generally worked better than the earlier fax systems, they were slow (requiring four to six minutes of transmission time for an A4 size document) and the copies produced were of poor quality. Few manufacturers adopted this standard. The CCITT Group 2 Recommendation came eight years later, in 1976, to improve the performance of Group 1 machines.
Although Group 1 and Group 2 fax standards had triggered the worldwide acceptance of fax communication, their analog transmission techniques were inherently slow and produced low-resolution copies. It was until 1980 when the CCITT developed the Group 3 Recommendation for digital facsimile, that marked the new era of fax communication. In fact, the first digital facsimile system made its debut [3] eleven years before the Group 3 standard was recommended. During this time, different coding techniques were developed to improve the performance of digital facsimile. Among the many coding schemes, some of them are one-dimensional (1-D) run-length codes; e.g., Bl-code [4], Truncated Huffman code [5] and Modified Huffman code [6], which utilize the statistical dependency of adjacent pictures within individual scan lines. Other more complex schemes; e.g., Kalle-Infotec code [7], Dacom code [8], Kokusai Denshin Denwa code [9] and TUH-code [10], which also exploit the line-to-line dependencies in a picture are denoted as two-dimensional (2-D) coding [11].

The standardization of Group 3 digital facsimile apparatus resulted in universally compatible fax systems that are reliable, efficient and produce high quality copies. Consequently, the fax growth rate was doubled in 1987 and in 1988, making a worldwide population of over fourteen million Group 3 digital fax apparatus by the end of 1989 [12]. It was predicted that this number would be tripled by the year 1992.

As the demand for fax communication increases, the cost of stand-alone fax units drops substantially. However low-end fax units still lack the useful features such as regular (instead of thermal) paper output, fax broadcasting to a group of recipients, automatic resending upon error, etc. Even high-end fax units may not be suitable for use as networking fax-stations or electronic document storage devices. The solution is to employ computer-based facsimile systems (see Figure 1). Similar systems were used in the design of document delivery systems such as the ARTEMIS [13] and the request for quote (RFQ) system utilized by the Houston Lighting and Power Company with proven success.

A stand-alone fax unit can only be regarded as an information transmission facility but not an information distribution system. To make a fax unit as a complete information distribution system, the components to convert, store, maintain and distribute facsimile information must be incorporated into the design. A PC-based fax adapter employs the programming power and the mass storage facilities of the personal computer (PC). This allows the PC to provide all the necessary components to emulate the advanced features of a Group 3 fax apparatus. These components permit documents generated by any computer application to be converted and transmitted as fax documents in a robust fashion. Furthermore, massive storage is required to handle the storage requirement for incoming fax documents. The system must also have the ability to route the received fax documents to their intended readers automatically.

The facsimile information distribution system (FIDS) described here is implemented at the application layer of an Open Systems Interconnection (OSI) LAN model [14] as a fax information server. As shown in Figure 2, the FIDS is a gateway that provides fax services to users across the OSI LAN and the PSTN. Each authorized user is assigned a subdirectory on one’s local workstation to store facsimile documents. Each of these subdirectories is treated as a personal fax-mail box. All incoming and outgoing fax documents are routed to or from their owners’ fax-mail boxes. Security levels and user-defined passwords can be ascribed so that sensitive materials can only be seen by the intended viewers. To provide services to document request from a remote stand-alone fax machine, the fax distribution system must be able to answer a user’s phone call automatically. The system then greets the caller by a digitized voice message and allows the request for fax documents by means of a touch-tone

Figure 2: The fax information distribution system acts as a gateway between the OSI LAN and PSTN.
telephone. By decoding the dual tone multifrequency (DTMF) [15] signals, the system is capable of accepting instructions and selections from the caller.

The establishment of a fax call may be realized either manually, if a system operator is in attendance, or automatically. This establishment is described by the procedures for call setup during Phase A of any fax transmissions. Different fax services are provided by the fax server depending on how the fax call is initiated. These services can be classified into four types; LAN user initiated fax transmission, LAN user initiated fax reception, PSTN user initiated fax transmission and PSTN user initiated fax reception. These services are discussed in the remaining sections. Sections 2 and 3 describes fax transmission and reception services provided directly to LAN users respectively. Fax services that can be accessed by PSTN users are discussed in Section 4. Future enhancements and the conclusion are given in Section 5.

2: LAN user initiated fax transmission

When a LAN user desires to transmit a fax document, the first step is to access the fax server's fax/phone database. This database stores names of contacts and companies, telephone and fax numbers, home and office addresses, and specific remarks. The next step is for the user to select a particular person from the list of names to be the recipient of the fax document. If the recipient's name is not on the list, the user can choose to add it to the database. Any updates of the recipient's record can also be done at this time. After the selection, the system asks for the files to be sent as fax documents. These files can be ASCII text, graphics (e.g., stored in PCX or TIFF graphic formats), or T.4 fax image files. Depending on the file types the user selects, the graphics conversion module will automatically convert each one into the T.4 Group 3 fax format. At this point, the user is asked to begin fax transmission immediately or schedule the process for a later time. The user may decide to send the fax at late night when the phone rates are low. Either way, a fax job description file containing information about the senders station identification (ID) number, the destination fax number, time of job submission, files involved in the transmission and the scheduled time for transmission is prepared. This job description file along with all the converted T.4 fax documents are now sent to the fax server to be serviced. Once the fax server obtains these files, it schedules to transmit at the requested time. If too many requests are needed to be serviced at any time interval, the server sets up a queue table. Each request is serviced according to their time of arrival as recorded in the queue table. If two or more jobs arrive at the exact same time, then the workstation ID number is used to decide which one get serviced first. The workstation with the smallest ID number is served with the highest priority.

The fax/phone database also allows the user to categorize a number of stored names into specialized groups. These groups are useful for group fax broadcasting. With the broadcasting feature, the user only needs to select a specific group to be the recipient of a fax document. Selecting individual members of the group is not necessary. Imagine you need to send the same notice to two hundred branch managers of an organization. With the group selection feature, you just need to pick the group named "Manager" and start sending the document immediately. The time savings between making one selection and two hundred selections are tremendous. This is provided when you add each manager's name into the database, you have also assigned each one with the group name "Manager". You can assign up to three group names to each person's record in the fax/phone database. The user may optionally choose to temporarily remove certain members from the specified group for a particular fax transmission. When the transmission time comes, the server automatically searches for the fax number of the people belonging to the selected group. A list of the names of each recipient in the group is generated in alphabetical order. The server then delivers the fax document in sequence according to this list.

3: LAN user initiated fax reception

Fax polling services are handled the same way as group fax broadcasting. Except in this case, the user wants to receive documents from various people rather than sending to them. A group of people is selected by the user to be polled at a particular time. The group names is submitted to the fax server for polling service. For secure polling, a extra file containing specific Remote Terminal Identification (RTI) numbers of each polled machine is also submitted as part of the fax job. These numbers are passwords for accessing individual polled fax units. The RTI numbers are obtained from the people at the remote sites. This RTI file is encrypted so that the passwords can be kept confidential. At the specified time the server calls each person in the group for obtaining certain fax documents. Once the documents are received, they are routed to the fax-mail box of the user who initiated the job. A message file is send to the users workstation to notify him or her that the polling service is done. A log file is also sent, as in all fax services, to keep tack of what documents are received from which polled unit. In addition, all errors occurred during the service are recorded into the log file.
4: PSTN user initiated fax Services

Obtaining fax services through the PSTN requires human interaction through voice communication. This method of establishing a fax call is designed for manual operation at both calling and called station. The original idea is to allow human operators to verbally identify and establish a fax transmission. However, in our facsimile distribution system, the human operator is replaced by a digitized voice prompt. This allows fully automated fax transmission on the receiving end.

Upon answering the phone, a digitized voice prompt greets the caller with the system's identification followed by a list of options for the caller to select. By using a touch-tone telephone, the caller can press the number corresponding to a desired selection. Through DTMF decoding, the system identifies the selected option and proceed with the appropriate fax services. This interactive voice response mechanism allows the facsimile distribution system to provide the following services (see Figure 3):

1. Deposit fax mail to a specify fax mailbox. A digitized voice message requests the user to enter the fax mailbox number. After the caller enters the number, it is repeated by the system for confirmation. An optional request for password may be included. After the confirmation, the system will then prompt the caller to switch his or her unit on line. The fax procedure then begins.

2. Store-and-forward fax documents. The user selects this function and deposit a fax document into the server. The fax distribution system then inquires the fax number of the destination and the time scheduled for the delivery. When the scheduled time is reached, the documents will be forwarded to the desired fax station. This facility is most useful for users who travel frequently. Its worth noting that this service involves two parts. The service is initiated by a user from the PSTN to deposit the document. However, when the time for forwarding the document is reached, it is the server that initiates the transmission to complete the job.

3. On-demand fax document retrieval service is provided to all users who can gain access to the public service telephone network. The user selects a particular document by a preset catalog number. The fax server searches its document database using the catalog number as the key. When the document is found, a digitized voice from the fax server prompts the user to press the start button on his or her fax machine to begin reception.

With voice capabilities, the system can be designed to handle voice mail as well. Voice messages are digitized by special A/D conversion circuits into binary files. These files are stored in specific subdirectories of local workstations. These subdirectories can be regarded as voice-mail boxes. The only difference between fax-mail and voice-mail is that the latter can only handle incoming messages. If a LAN user wants to send a voice message, special hardware for recording the message is required. It is not cost-effective to install voice-recording hardware in each and every workstation. To avoid the need for extra hardware, the user can call the information distribution server through the PSTN. By using the telephone and the fax modem circuits installed in the server, the user can now deposit a voice message into his or her own voice-mail box for future use.

5: Conclusion

This paper has demonstrated that a sophisticated information system can be constructed by combining the computation power and architectural flexibility of PCs with the advanced digital facsimile technologies of Group 3 fax apparatus. Since the system is implemented for LAN applications, users connected to the LAN may benefit from all the facsimile services without the cost of fax modem hardware for every individual work station. The automatic scheduling and routing services provided by the fax manager program simplifies the process of sending and receiving fax documents. The password protection option is essential for sending and receiving confidential documents. The broadcasting and polling
services are especially efficient to handle massive information disbursement and collection. The entailed error correction mechanisms allow the system to perform efficiently even under noisy telephone line conditions. With the application interface and graphics conversion modules, fax documents can be prepared by all commercially available wordprocessors, spreadsheets, desktop publishers or optical scanners. By using the same modules, fax documents received from other fax systems may be imported to graphics editors, character recognition programs or image databases for further manipulations. The included interactive voice capabilities permit users outside the LAN to access the system by using touch-tone telephones. Voice recognition mechanisms can be introduced to the system allowing even more users to gain access to the system through the PSTN. The transmission speed of the system can be improved by adding a CCITT V.17/V.33 compatible modem into the hardware. With the V.17/V.33 modem, the system will be able to send and receive fax data at speeds up to 14400 bps. The considerations on this upgrade are compatibility and cost of the hardware. Since CCITT has recently included the modem specifications V.17/V.33 as an option for Group 3 fax apparatus, few fax machine manufacturers have adopted this option. The majority of Group 3 fax machines operating today still support transmission speeds up to 9600 bps only. Fax machines capable of operation at 14400 bps will have to transmit at 9600 bps in order to be compatible with the rest of the world. This makes the extra hardware useless. By the same token, only a few chip manufactures produce modem integrated circuits that conforms to the V.17/V.33 specifications. Until public demand forces more manufacturers to produce such kind of fax modem chip, the cost of it remains high and the availability remains low. However, it will not be surprising to see the population of 14400 bps fax units grows rapidly within the next year.

To improve the performance of the system in terms of handling fax documents, a coprocessor can be incorporated into the fax modem hardware. With the coprocessor and sufficient local memory, all source coding (CCITT Recommendation T.4) and signalling (CCITT Recommendation T.30) functions can be performed directly by the fax modem interface. This enhancement turns a host-controlled interface into a self-contained intelligent peripheral. The intelligent fax modem allows the host computer to devote its computation power on scheduling and routing fax documents fully. The new system can be designed to run on a multi-tasking platform so that it can handle multiple telephone lines. For this purpose, more than one intelligent fax interface can be installed in a single host computer. A high speed data modem can also be added into the design for E-mail and binary file transfers. The only disadvantage here is the cost of the coprocessor, local memory, firmware, direct memory access (DMA) circuitry and other related circuits. The hardware will be more complex and the control program will be more complicated.

References
3. The first digital facsimile made its debut in 1969. This was the Dacom's Rapidfax 100 utilizing the single-line adaptive run-length coding algorithm patented by Donald Weber.
15. Dual-tone multifrequency (DTMF) dialing is the generic term for the widely used term Touch-Tone® dialing which is a registered trademark of the Bell System.