TELECOMMUNICATION METHODS

INTRODUCTION - THE ENVIRONMENT

In the "Age of Information", the technologies which enable communication between humans have assumed an almost surrealistic profile. This environment may be due, in part, to the tremendous complexity which enshrouds many specifications for digital communications between machines. It is this unforgiving complexity which demands an unprecedented level of worldwide collaboration between technologists, equipment manufacturers, and researchers to develop open standards, protocols, and formats so that machines can "communicate", thus allowing humans to "communicate." It is this complexity which has also confounded the business and marketing of technology with an ever-deepening stream of acronyms, cryptic terminology, and system architectures. The purpose of this chapter is to provide an overview of several of the major communication technologies which, having been formally standardized, having become "de-facto" standards via widespread popularity, or having been accepted simply as "part of life", have emerged as powerful and necessary means of communication between humans.

One of the most mainstream examples of communication technology is the common telephone. Telecommunication technology and some of the concepts, acronyms, and architectures which comprise this extremely complex subculture are discussed in several of the sections that follow. From Plain Old Telephone Service (POTS) and Facsimile transmission (FAX), to the emerging "Converged Communications" environment, these technologies and their rapid deployment play a central role in all "high tech" communication and in the development of the "information superhighway." A brief discussion is presented of (a) the salient points of standards and system architectures for private telecommunication networks, (b) interfaces with public providers, and (c) basic concepts related to voice, video, and data communications via circuit-switched or packet-switched networks.

A second tremendously important technology in the expanding scope of communication is the "language of the Internet." The orderly, organized, and open standardization of the suite of protocols which are the building blocks of the Internet phenomenon is briefly discussed, and several of the primary protocols are highlighted which allow for seamless communication between humans using computers. The purpose of this discussion is not to provide the reader with a "developer's understanding" of TCP/IP or to delve deeply into the structure of particular protocols. Rather, an attempt is made to focus attention on several user-level protocols which have had significant impact on the rapid development of human-computer-human communication, enabled tremendous functionality or new innovation, or have matured to a point where they permit "high-level" classification for the benefit of non-technical users. Included in these classifications are electronic mail (text and non-text formats, system concepts, and underlying technologies); the Hyper-Text Transport Protocol (HTTP) and its accompanying user-interface via the Hyper Text Markup Language (HTML), and the World-Wide Web (WWW).

MAINSTREAM INFORMATION EXCHANGE

Electronic Mail (email) and facsimile transmission (fax) are increasingly becoming the medium of choice for efficient communication of business and engineering information, as well as personal interactions. Although "softcopy" may never completely replace "hardcopy", the convenience, rapidity, and repeatability of electronic memoranda, facsimile and electronic document interchange, and broadcast messaging have re-structured the way humans communicate. In addition, the Internet phenomenon of "the web" has revolutionized storage, dissemination, and access for textual, graphical, and pictorial information. With the continuing evolution of "network computing" and increasing interactivity of web-pages, the once-serene research environment of the Internet has given-way to mass commerce and hypertext chaos.

Electronic Mail

Numerous Internet Requests for Comment (RFC's) document the format of email documents, attachments, and transmission protocol syntax. These documents are archived along with other Internet standards by the Network Information Center (NIC) at http://ds.internic.net or by the Internet Engineering Task Force (IETF) at http://www.ietf.org. Of the many RFC's, there are primarily two technologies used to enable the transport, storage, and retrieval of electronic mail. As is the case with most Internet-class protocols, these technologies are divided into "client" and "server" functions. On the "server" side, the Simple Mail Transport Protocol (SMTP) is a well-developed member of the Internet Protocol (IP) suite which has long been responsible for the transport and storage of electronic messages. On the "client" side, where varied user interfaces and capabilities are required for retrieving messages, a single standard isn't as clearly delineated. However, the decentralization of computing resources from "mainframe" to "workstation" environments has produced a need for much more sophisticated, network-aware interfaces between users, workstations, and mail repositories.

Bulk-Mail Transport

The usefulness of SMTP lies in its capability to transport electronic mail between "bulk storage" computers and then allow distribution of the mail to appropriate users. SMTP is defined in RFC 821 and uses a request-response protocol based around the "usual" IP requirement that all protocol content be clear-text, human-understandable strings formatted according to the American Standard Code for Information Interchange (ASCII). Responses to the commands are also text lines, starting with a 3-digit code to indicate the result of the command and finishing with arbitrary text for informational purposes. Although this "open" format for Internet protocols is tremendously convenient for development, etc., it has been the source of innumerable security

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breaches in distributed computer systems. For example, it is well-known that SMTP servers traditionally "listen" on TCP port 25 for incoming connections. It is a fairly simple matter for an unscrupulous user to connect with the server and use SMTP-commands to exploit security weaknesses in the implementation of the server software. It is also straightforward to "snoop" the clear-text email transactions entering/leaving TCP port 25.

Simple electronic messages consist of separate functional parts ("envelope", "header", "body"), much like traditional postal communications. RFC 822 defines the basic header syntax for Internet email as a series of lines with `field: data` format. In keeping with common-sense, usual header fields in email transactions are `From, To, Cc, Reply-To, Subject`, and `Date`. The data contained in each header field must comply with syntax particular to that field. As a message traverses through a series of SMTP servers (or "Message Transfer Agents"), each server adds a Received field on the message with time/date and server identifier to aid in retracing the message's path (in the same fashion that documents are physically stamped to indicate handling) (1).

For messages which contain non-ASCII information (such as files created with word processors, spreadsheet programs, images, audio/video, etc.) the "usual" approach to handling clear-text email isn't applicable because the numeric values of the data bytes may not correspond to ASCII character codes. In these cases, the Multimedia Internet Mail Extensions (MIME) defined in RFC 1521 and RFC 1522 are used to augment the basic header information of RFC 822 and slightly restructure the message body. The MIME RFC's define a flexible, extensible, and reversible procedure for translating binary data into unique sequences of ASCII codes which comply with RFC 822. These "MIME attachments" can be included in email messages and easily transported by SMTP. MIME encoding uses a technique known as "base64" where groups of three adjacent 8-bit non-ASCII bytes are broken into four pieces, each having 6-bits. These 6-bit units are then represented as a valid 7-bit ASCII character compatible with RFC 822. The data resulting from a MIME-encoding procedure consists only of ASCII codes for letters, digits, and the symbols +, /, and =. The MIME extensions of RFC 1521 and 1522 define additional message header fields such as `MIME-Version, Content-Type`, and `Content-Transfer-Encoding` to specify the multimedia characteristics and standard representations for messages which have "complex" (i.e. non-ASCII) components. Any message which does not have a `MIME-Version` field in the header is assumed to be composed of clear-text only. The `Content-Type` header field is an extensible definition of basic document types, each of which may have multiple sub-types. The seven document types and subtypes defined in RFC 1521 are shown in Table 1. The `Content-Transfer-Encoding` header field is used to declare which type of binary-to-ASCII "packaging" was used to encode the binary data for transmission via SMTP. The simple ASCII-formatted "header" plus "body" plus "attachment" architecture of email is an important building block for transport of other application-level Internet messages. These important payloads span several areas, from the hypertext of the WWW to the basic signaling messages proposed for "next generation" telecommunications.

User Access to Mail

Electronic messages are separated by an SMTP server (often called a Message Transport System, or MTS) based on user-specific criteria. In a multi-user environment, this criteria is often the "username" of the person to whom a message is addressed. Electronic mail destined for a specific user is collected in that user's "mailbox" for the user to access at some later time. The modern decentralization of computing resources based on Internet Protocols (among others) and highly capable (portable!) workstations has made it impractical to maintain complete MTS services on personal computers. As a result, the methods by which end-users access their electronic "mailboxes" have undergone a dramatic paradigm-shift. There are three general modes for mailbox access as discussed in RFC 1733: "Online", "Offline", and "Disconnected." The primary difference among these modes is the location of the electronic messages after the user has accessed (or "read") them. "Online" and "Disconnected" access modes maintain a master copy of messages in a mailbox on the MTS and differ in the use of a local "cache" copy of the messages (Disconnected mode) versus true remote manipulation (Online mode). "Offline" access entails fetching several messages from a server to some local storage, then deleting the fetched messages from the server. Of these access modes, two specific approaches, standardized in multiple RFC's, are dominant (2).

POP mail

The Post-Office Protocol (POP) is a very popular realization of an "Offline" access paradigm. POP is an application-specific message access protocol which is intended to move mail in a store-and-forward fashion from a repository (mailbox or server) to a single destination. Originally, the POP protocol was useful in the on-demand delivery of electronic messages from an MTS to a personal computer where the messages were read, archived, edited, deleted, and manipulated locally by the end-user. After several revisions, the current POP specification (POP3) is documented in RFC 1939 and provides for user authentication as well as some remote mailbox manipulation. Note that passwords are transmitted in clear-text to correspond with the format of Internet text messages defined in RFC 822. This is a significant security hazard, and has been addressed in several ways, most notably through the use of a "secure socket" approach (RFC 2595). POP3 sessions are TCP connections which progress through several states. These states are described by the usual command/response pairs of text-based Internet protocols. After initiation and establishment of the TCP session between client and server, the client must successfully proceed through the AUTHORIZATION state where username/password are validated. Properly authorized clients proceed into the TRANSACTION state where any combination of POP3 transaction commands may be issued to manipulate the user's mailbox, retrieve messages, and so on. When the POP3 client terminates the transaction sequence, the session enters the

Table 1. RFC 1521 Document Types

Content Type	Subtypes	Interesting Notes and Constraints
Text	Plain Richtext	Allows for unformatted ASCII text or text with simple formatting commands (boldface, italics, indents, etc.)
Multipart	Mixed Alternative Digest Parallel	Allows for messages to be composed of multiple ‘‘chunks’’ of encoded data, each of which may be a different MIME type.
Message	RFC822 Partial External-body	Allows for messages to include other messages, for long messages to be broken into multiple pieces for transmission, or for messages to refer to external information.
Application	Octet-stream Postscript	Allows for transmission of data to be interpreted by programs installed at the recipient's computer. (Serious security problems are possible when transmitting executable programs.)
Image	JPEG GIF	Allows for inclusion of digital still images in email messages. (Base64 encoding is generally used.)
Audio	Basic	Allows for inclusion of digital audio clips in e-mail messages. (Base64 encoding is generally used.)
Video	MPEG	Allows for inclusion of digital video files in e-mail messages. (Base64 encoding is generally used.)

Table 2. Examples of ASCII Techniques for E-mail Emphasis

Situation	Example
Use all capital letters or bold font only when there is a desire to stress a point.	`I WILL NOT GO TO THE DANCE WITH YOU!` Capitalized or bold words, phrases, or sentences imply that the writer is shouting.
Insert the text description of emotions in angle brackets.	A joke, pun, or humorous statement could be followed by `<grin>`. Displeasure or sadness could be followed by `<frown>`, `<sigh>`, or `<sad>`.
Use visual symbols to indicate emotions. These “faces” are often called “emoticons” and have developed into a technological artform with a strong following.	Pleasure can be indicated by a “happy face” such as :) or :^) or :-), or a “wink” by ;-). Displeasure can be indicated by a “sad face” such as :<(or :^(or :-(.
Indicate underlined information with an underscore in the blank spaces surrounding the words being emphasized.	`The electrical circuits class uses the book_Basic_Engineering_Circuit_Analysis_ by J. David Irwin.`
Place a forward slash before and after words to be italicized.	`The paper will be published in the /IEEE Transactions on Education/ in the January issue of next year.`
Place an asterisk before and after a word or words to be emphasized.	`The LED should be *red* and not green.`

UPDATE state where the server finalizes mailbox changes, deletes retrieved messages from the mailbox, and closes the TCP connection. This flow of events is illustrated in Fig. 1. Several implementations of POP3 clients are available for personal computers. One of the most popular client interfaces is *Eudora*, which is developed and maintained at QUALCOMM, Inc. *Eudora*, like other POP3 clients, has user-interface features which implement convenient retrieval, local processing, manipulation, and storage of electronic messages. Some features which are not specified in Internet mail access protocols, but are important in managing large quantities of electronic mail, include hierarchical folder structures for archiving messages, automatic filtering and sorting of incoming messages, the ability to correctly and automatically handle (decode) MIME extensions, and seamless integration with the operating system of the local (personal) computer.

Internet Message Access Protocol (IMAP)

The Internet Message Access Protocol, described in RFC 2060, is a functional superset of POP which allows for much more sophisticated interactions between user (client) and mailbox (server). Additionally, IMAP provides a capability for the user's client software to retrieve the structure or “envelope” of messages without the need for downloading the entire message body. This approach is especially useful in reducing transmission time for users with

Table 3. Eight Guidelines for Electronic Mail

Always · · ·

1. Provide identification of sender early in the message, even if the return e-mail address includes sender's name.
2. Include a greeting (e.g., `John:`).
3. Correct spelling and grammar mistakes (use a spelling checker if one is available).
4. Avoid sarcasm, subtleties, slang, and colloquialisms.
5. Avoid the use of acronyms that may be unfamiliar to the reader.
6. Include a "goodbye" (e.g., `I look forward to receiving your reply`).
7. Provide contact information at the end of your message (e.g., postal or "snail-mail" mailing address, voice telephone number, fax telephone number, and e-mail address).
8. Do not send needless copies but do ensure that individuals that should be informed of your communication do receive a copy (in the business environment, do not send e-mail to someone in management outside of your unit without at least copying your unit manager).

The sender's image will also be enhanced if · · ·

1. Messages are brief.
2. Lines are no longer than 70 characters (to avoid strange line breaks introduced by transmission and receiving software).
3. Blank lines are inserted between paragraphs.
4. Quoted and forwarded email has the prior permission of the original author.

Table 4. Six Guidelines For Fax Cover Pages

Always include · · ·

1. The fax telephone number to which the fax is being sent.
2. The name of the individual to whom the fax is being sent.
3. The fax telephone number from which the fax is being sent.
4. The name of the individual transmitting the fax.
5. The voice telephone number of the individual transmitting the fax.
6. The total number of pages contained in the fax (including the cover page).

Table 5. Most Important HTTP Requests

Request	Description
GET	Retrieve an object
HEAD	Retrieve the header of an object
PUT	Store an object
POST	Append to an object

Table 6. HTML <FORM> Tags

Argument of <FORM>	Description for HTML	Similarity to other languages (non-hypertext)
ACTION	Contains the URL that will process this form's data	Subroutine declaration, linking
METHOD	The http method used to format data for transmission (i.e., GET or POST)	Linking

Table 7. HTML <INPUT> Tags

Argument of <INPUT>	Description for HTML	Similarity to Other Languages (Nonhypertext)
NAME	Associates a name with the input field	Variable name
TYPE	Defines the presentation of the variable at the browser (see below)	Data type (object type)
SIZE	Number of characters for the field	Array length
VALUE	Default value of the variable	Initialization

Table 8. HTML "Data Types"

Allowable Values for tag <INPUT TYPE = " ">	Description
TEXT	A single-line text box (the default)
TEXTAREA	A multi-line text box
PASSWORD	A single-line text box where typing is not echoed
RADIO	A "radio" button (if several, only one can be selected)
CHECKBOX	A checkbox (if several, many can be selected simultaneously)

Table 9. Common speech compression algorithms

Std.	Pseudonym	Rate (kbps)	Main usage	Complexity
G.711	μ-law PCM	64	long distance telephony	Low
G.726	ADPCM	16/24/32/40	videoconferencing	Moderate
G.728	LD-CELP	16	videoconferencing	High
G.729	CS-ACELP	8/11.8	wireless & Internet telephony	High
GSM 06.10	GSM-FR	13	TDMA digital cellular	Moderate
GSM 06.60	GSM-EFR	12.2	TDMA digital cellular	Moderate
GSM 06.90	GSM-AMR	$<$12.2	TDMA digital cellular	Moderate
IS-733	QCELP13	$<$13	CDMA digital cellular	High
IS-893	SMV	$<$8.5	cdma2000 wireless	High
IS-127	EVRC	$<$9.6	cdma2000 wireless	High
RFC-3951	iLBC	13.3/15.2	Internet telephony	Moderate

Table 10. Common Digital Telecommunications Channels

Mnemonic	Rate	Description
DS0	64 kbps	AT&T Digital Standard, level 0
DS1	1.544 Mbps	AT&T Digital Standard, level 1
DS3	44.736 Mbps	AT&T Digital Standard, level 3
OC1	51.8 Mbps	Optical Carrier, level 1
OC3	155 Mbps	Optical Carrier, level 3
OC12	622 Mbps	Optical Carrier, level 12
OC48	2.48 Gbps	Optical Carrier, level 48

low-bandwidth network connections. During the parsing process on the server, user-specified criteria may be used to establish "selective fetching" of messages with certain body content, header content, and so on. This approach has increased functionality over purely "Offline" access protocols, such as POP, and provides a messaging technology which is more than adequate for contemporary needs. In IMAP-compliant client/server interactions, the server or MTS is implicitly the primary repository of electronic messages. Client software may retrieve/delete messages and manipulate the server mailboxes as if they were local, but the server always maintains the mailboxes. In short, the IMAP paradigm provides robust support for "Online" and "Disconnected" access to the mail repository, POP-equivalent support for "Offline" access, and an efficient, application-specific interface for message, mailbox, and client/server interaction. IMAP also provides the capability for an "Offline" user's message cache to resynchronize with the server (2).

An interesting example of "Online" electronic messaging is the Short-Message System (SMS) of wireless telephony. These "email-like" services were originally designed

Table 11. Seven Guidelines for Managing Telephone Conferences

Always include ...
1. Prior to the conference, a convenor should be identified who will be responsible for scheduling the call and all required facilities, including arranging a mechanism for initiating the call (i.e., having all participants called by an operator to initiate the call or having each participant call a central number to be connected into the call), identifying all individuals who will participate (along with the telephone number where they can be reached — if they are to be called), publishing an agenda for the conference that contains all "handouts" for the meeting and a list of all anticipated participants, selecting a secretary who will record the minutes of the conference, and identifying who will moderate the conference.
2. The call should begin with a roll call to identify the presence of each participant.
3. The moderator should then state the ground rules for discussion. For example, each participant could be limited to two opportunities to speak on each issue. A speaking time limit could be established to curtail long-winded speakers. Speakers could be recognized in a "roll-call" fashion.
4. When an agenda item is presented, the moderator should allow the presentation to be completed prior to entertaining questions and discussion. Questions and discussion should be tightly controlled by the moderator if the number of conference participants is large.
5. Each agenda item not concluded by a vote should be concluded by a statement from the moderator that summarizes the results of the discussion, identifies specific action items that are to be taken, and identifies the individual(s) responsible for completing each action item.
6. A participant attempting to speak out of turn should identify themselves by name to the moderator and request recognition to speak.
7. Written minutes of the conference should be provided to each participant within a reasonable time following the meeting.

Table 12. Umbrella Standards for Digital Videoconferencing

Rec.	Related Issues
T.120	Real Time Data Conferencing
H.320	Audiovisual communication (i.e., videoconferencing) via circuit-switched networks
H.323	Audiovisual communication (i.e., videoconferencing) via packet-switched networks that do not provide guaranteed Quality of Service
H.324	Audiovisual communication (i.e., videoconferencing) via "plain old telephone service" (POTS) links plus other more sophisticated channels

to carry low volumes of data between users of wireless telephones. In many wireless networks, however, the SMS service has become so popular that messaging traffic threatens to choke the operator's control network. The exponentially increasing popularity of SMS illustrates a parallel of "convergence" between the paradigms of packet-based, Internet-style messaging and conventional (wireless) telephony. The issue that drives these disparate technologies to a form of "convergence" is the fundamental requirement for efficient communication between the users.

Courtesies and Other Etiquette

The etiquette of communicating electronically is often given the name "netiquette." Since electronic communications involve the sending and receiving of information without the opportunity to experience the verbal and visual cues available in face-to-face interactions, the recipient is unable to establish the tone of voice, facial expression, body language, or gestures of the sender. Therefore, care must be taken to ensure that the printed text conveys the exact emotion desired.

Since only ASCII-strings are often transmitted, features such as font changes, italics, boldface type, and underlining are unavailable. Several conventions have evolved to counter this problem, and some typically accepted examples are shown in Table 2.

Some email software allows composition of emails formatted with "rich text." In these cases, the sender has the privilege of using different font styles, font sizes, and colors as well as text enhancements such as bold face type, underlining, italics, and complex spacings. In this environment changes in font size can be used to indicate level of importance, and color changes or indention can be used to emphasize various points in the text. However, the recipient's experience with the transmitted correspondence may differ significantly from the sender's intentions.

Table 13. Component Standards for Digital Videoconferencing

Rec.	Description	Member of
	Session Management	
H.221	Frame structure for a 64 to 1920 kbps channel in audiovisual teleservices.	H.320
H.223	Multiplexing protocol for low bitrate multimedia communication	H.324
H.225	Messages for call control including signaling, registration and admissions, and packetization/synchronization of media streams	H.323
H.230	Frame-synchronous control and indication signals for audiovisual systems	H.320
H.242	System for establishing communication between audiovisual terminals using digital channels up to 2 Mbit/s	H.320
H.245	Control protocol for multimedia communication	H.323, H.324
	Video Compression	
H.261	Video coding for audiovisual services at p × 64 kbps	H.320, H.324
H.263	Video coding for low bitrate communication	H.323, H.324
	Multipoint Control	
H.231	Multipoint control unit for audiovisual systems using digital channels up to 2 Mbit/s	H.320
H.243	System for establishing communication between three or more audiovisual terminals using digital channels up to 2 Mbit/s	H.320
	Voice Compression	
G.711	Pulse Code Modulation (PCM) of voice frequencies	H.320, H.323
G.722	7 kHz audio-coding within 64 kbit/s	H.320, H.323
G.723	Defines speech coding for multimedia telecommunications transmitting at 5.3/6.3 Kbps	H.323, H.324
G.728	Coding of speech at 16 kbit/s using Low-Delay Code Excited Linear Prediction (LD-CELP)	H.320, H.323
	Data Conferencing	
T.122	Multipoint Communication Service (MCS) Service Description: Describes the multiport services available to developers	T.120
T.123	Protocol stacks for audiographic and audiovisual teleconference applications: Specifies transport protocols for a range of networks	T.120
T.124	Generic Conference Control (GCC): Defines the application protocol supporting reservations and basic conference control services for multipoint teleconferences	T.120
T.125	Multipoint Communication Service (MCS) Protocol specification: Specifies the data transmission protocol for multipoint services	T.120
T.126	Multipoint Still Image and Annotation Protocol: Defines collaborative data sharing, including "white board" image sharing, graphic display information, and image exchange in a multipoint conference	T.120
T.127	Multipoint Binary File Transfer Protocol: Defines a method for applications to transmit files in a multipoint conference	T.120

Table 14. Additional Guidelines for Managing Video Conferences

Always include . . .
1. A "site moderator" should be identified for each conference site. The site moderator is responsible for managing discussion from each site, introducing and recognizing each speaker from his/her site, and ensuring that each participant at their site has appropriate materials in hand.
2. The conference should begin with the conference moderator identifying all participants at their site and then calling on each siter moderator, in turn, to identify the participants at their site.
3. Questions and discussion should rotate among the sites, with each site moderator recognizing the speakers from their site. A participant attempting to speak out of turn should identify themselves by name to the site moderator and allow the site moderator to request recognition for the speaker.
4. When ballots are required, balloting should be accomplished at each site by the site moderator with the site moderator announcing the vote. The conference moderator can then total votes and announce the outcome.

Table 15. Four Guidelines for Managing Electronic Conferences

Always include ...
1. Prior to the conference, a convener should be identified who will be responsible for scheduling the meeting; selecting the electronic conferencing technology to be used; distributing information on how the required software can be acquired and initiating a host site; identifying all individuals that will participate in the conference; and publishing an agenda for the conference that contains all "handouts" for the meeting, a list of all anticipated participants, the time period, and meeting log-in and password information. For synchronous meetings, a moderator should be identified.
2. Synchronous conferences should begin with a roll call to identify the presence of each participant after everyone has logged-in to the meeting.
3. For synchronous meetings, the moderator should begin by stating the ground rules for discussion. Two example rules are as follows: (1) Each participant should request recognition by typing Q (for question) or C (for comment) and then wait to be recognized by the moderator before typing the question or comment. (2) When a participant has a lengthy response and wants to transmit a portion of the response while typing additional information, the transmission should end with an ellipsis ("...") indicating that additional information is coming and then conclude the last transmission with `<end>` to designate that comments have concluded.
4. A written log of the conference should be provided to each participant within a reasonable time following the meeting — preferably on a secured Web site.

Recall that the entire email message must comply with RFC 822. This imposes a requirement for a plaintext message body. So, email messages composed with "rich text" formatting extensions must be MIME-encoded and transmitted as an attachment to the plain-text message. Unfortunately, the process of extracting a plain-text message body from the original "rich text" message is not prescribed by any standards, and may not have a particularly appealing outcome. Additionally, the recipient's email software may not be configured to handle such messages properly, or interpret the "rich text" attachment correctly. As a result, "what you see" may not be "what they get.".

Care should be taken when authoring email. Email is often forwarded to others; and, once text has been transmitted, there is a possibility that the text will continue to circulate for a long time. So, effort should be expended to ensure that the desired message has been conveyed. Additionally, since the reader will form an impression of the sender based upon the structure and content of the message, care should be taken by the sender to present himself "in the best light". The simple rules listed in Table 3 will aid in accomplishing this goal.

Since the Internet is international, the meaning of geographic/regional and national references can be lost on the reader. Consider the following examples.

- A person living in the western part of the United States should not use the phrase "`we in the west`" because "`west`" is a relative term and can convey a different image to a person in Europe. The phrase "`we in the western portion of the United States`" would be more appropriate.
- Terms or phrases that possess a national context, e.g. "`first amendment`," "`un-American`," and "`American values`" should be avoided since they have no

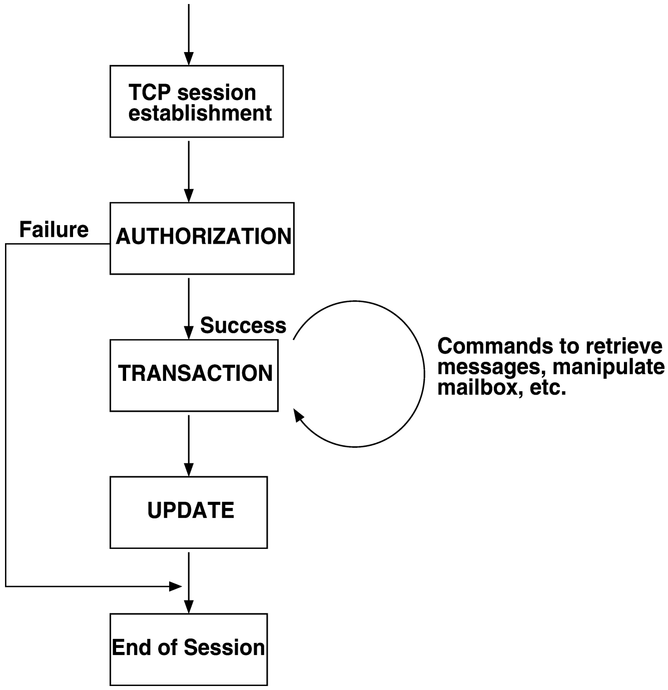

Figure 1. State diagram of POP3 session.

meaning to most residents of other countries.

Finally, netiquette does allow the use of popular abbreviations including FYI (for your information), BTW (by the way), and ASAP (as soon as possible).

Facsimile Transmission

Facsimile transmissions, or "faxes," have developed into a commonplace means of communication between humans for purposes ranging from transmitting technical specifications to ordering pizza. Fax machines with telephone handsets and sophisticated user interfaces can be purchased as stand-alone devices, and "multifunction" office machines with fax, phone, printer, scanner, and photocopying capability are also commonplace. Additionally, many modems for personal computers have support to transmit/receive faxes in addition to data capabilities. All of these devices are based on international telephony standards (specifications) set forth by the International Telecommunications Union, Telecommunications Standardization Sector (ITU-T, formerly the CCITT). Ther are standards for control of modem functions, interfaces between applications and modem hardware, the modulation techniques used for certain data rates, the procedure used by modems which are communicating fax data, and the types of "massaging" that can be performed on the data to reduce transmission time. As with most telecommunications functions, the domain of faxes is awash in a sea of acronyms and cryptic mnemonics. The purpose of this section is to give a general overview of the relationship between the most significant acronyms, the functions, and the application-level capabilities of modems, faxes, and computer interfaces.

General Background

In its grossest form, the communication of a fax entails scanning a document in raster fashion with a bright spot of light and classifying the reflected light as either white or black. Since most documents have a large amount of white space, the data which results from scanning can be compressed in a simple, lossless fashion and is usually transmitted using sophisticated, efficient modulation schemes.

Standards for facsimile transmission were initially proposed by the American National Standards Institute (ANSI), the Electronics Industry Association (EIA) and the Telecommunications Industry Association (TIA). The standard, called EIA/TIA-614 (now obsolete) and later subsumed in ITU-T Recommendation T.2, is also called "Group I" fax and describes the transmission of a page of information using very simplistic modulation schemes and poor resolution. The "Group II" fax standard (ITU-T Recommendation T.3, almost obsolete) describes an implementation of a more sophisticated modulation technique to allow faster transmission of a page (about three minutes at a resolution similar to Group I). One of the current standards for fax transmission is described in ITU-T Recommendation T.30 as "Group III" fax. Group III fax machines are currently the most commonly used fax technology and can transmit a page in about one minute.

Group III Fax

The ITU-T standard for Group III fax (T.30) specifically covers the procedure for initiating and managing a fax transfer. Supporting ITU-T Recommendations (i.e. T.4) cover the page size, resolution, transmission time, image format, and supported compression schemes. According to T.30, a Group III fax call proceeds through five states: *Call Set-Up, Pre-*

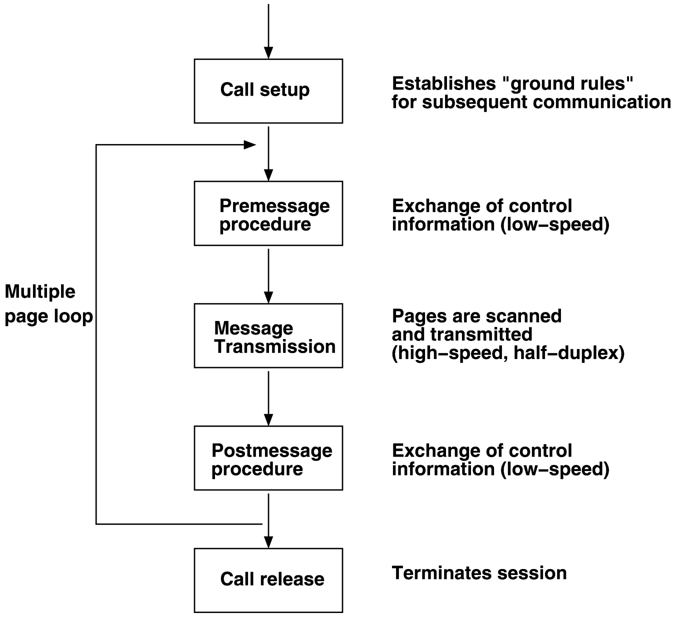

Figure 2. Group III fax state diagram.

Message Procedure, Message Transmission, Post-Message Procedure, and *Call Release*. The *Set-Up* and *Release* states are typical of protocols which place data calls into the public telephone network. The *Set-Up* state specifies tones to be emitted by the calling and answering machines as part of the analog "handshake" procedure prior to transferring data, and the *Release* state essentially hangs up the phone. This procedure is illustrated in Fig. 2.

Based on the "ground rules" established during *Set-Up*, the two fax machines enter the *Pre-Message Proce-dure* state and begin exchanging control information to determine compatible capabilities, maximum reliable signalling rate for the channel, and so on. During the *Pre-Message Procedure*, the destination machine explains to the sender what capabilities it has (i.e. resolution, page size, receiving speed, etc.); and, based on this information, the sending machine sets the capabilities which will be in effect for the ensuing page of scanned data. The control information is exchanged via "usual" data-modem modulation technologies and, consequently, operates at fairly low data rates (like 2400 bits/s).

During the *Message Transmission* state, the scanned image of a page of the document is actually transmitted. Transmission entails signaling over the channel at the baud rate determined during "training" and using transmission parameters which are compatible with the capabilities of both sending and receiving fax machines. The "standard" scanning resolution for faxes is 1728 pixels per horizontal 215 millimeter (mm) scan line with 3.85 scan lines per vertical millimeter. This format translates to approximately 98 dots per vertical inch by 204 dots per horizontal inch (dpi). An optional "fine" resolution doubles the number of scan lines to achieve a resolution of 196 $\times$ 204 (horizontal $\times$ vertical) dpi. To achieve efficient transmission of this volume of data, synchronous, half-duplex modulation techniques (such as ITU-T V.29 at 9.6 kbps) are used which are not compatible with the asynchronous, full-duplex modulation techniques of "usual" data-modems (such as ITU-T V.32 at 9.6 kbps). Consequently, a personal computer data-modem without specific additional support for fax will not be useable for fax transmission. After *Message Transmission* is complete, the *Post-Message Procedure* re-establishes low-speed communication between the devices for control purposes. This approach using high-speed, synchronous, half-duplex transmission of scanned pages sandwiched between low-speed control states allows for sending multiple-page documents, independent page verification, re-transmission, etc., as well as "re-training" if necessary before further communication. When the document is completely transferred, the session terminates with the *Call Release* state (3).

Courtesies and Other Etiquette

Fax transmission normally involves copies of already-typed information, e.g. a letter, a memorandum, an article, a chart, a table, or a combination of these documents. Fax etiquette ("fetiquette") requires that the first page being transmitted contain the items listed in Table 4. Clearly, it is preferable to number pages (including the cover page) in consecutive order to assist the recipient in identifying exact pages that are missing; however, certain communications do not lend to this feature.

THE INTERNET AND THE WORLD-WIDE WEB

The World-Wide Web, or simply, "the web" is essentially a point-and-click, graphical user interface (GUI) for the Internet. This GUI is built on a client/server paradigm like the majority of application-level Internet protocols. However, because of its inherent accessibility, web technology evolves at an extremely rapid pace which includes multiple, competing standards for interactivity between user and client/server software, incremental distribution of executable (interpreted or pre-compiled) code, transaction security, and vendor-specific enhancements. The purpose of this section is to highlight briefly the basic structure of web interactions, including some of the standard enhancements which provide useful, extra functionality. The web began at the European Center for Nuclear Research (CERN) where a large collection of researchers needed to easily share a collection of largely graphical documents. Instead of replicating these documents for all researchers, the CERN solution was to use "hyperlinks" to point to the distributed documents [1]. In this proposal for a network-based, hyperlinked "web" of documents, and supported by the maturity of the Internet protocol suite, the CERN physicists created the electronic equivalent of an atomic chain-reaction. The basic result of this technological explosion is that when a person using a freely-available "web browser" (or client software) follows a hyperlink from one document to the next, the browser uses a standardized protocol to (1) retrieve the document from the remote web-server which is indicated by the hyperlink, and (2) format and display the document, which may have additional hyperlinks, using the browser's built-in graphical interpreter.

Web Technologies

Interactions between browser/client software and web-server software which enable the retrieval of hyperlinked documents are carried out according to the rules of the Hypertext Transport Protocol (HTTP). In HTTP, browsers "request" objects such as documents (or files), and servers "respond" with the requested object or with some error condition. All HTTP requests are transferred between computers in clear-text format and followed by one RFC 822 MIME-like response. The most important HTTP requests are listed in Table 5. Of these, the GET request is likely the most common since it is the mechanism by which "web pages" are retrieved for display on the browser's screen. In the table, an "object" can be a properly-formatted web page, a file, or some other information to be used in processing web pages or web-based data entry. When a browser "follows" a hyperlink to connect to a web server, it actually issues a GET request for the item indicated by the hyperlink. A "full request" is composed of possibly several lines including a GET command (or another command), the hyperlink reference to the object, and the HTTP version number which is supported by the browser. The request terminates with a blank line, as follows.

`GET` www.someplace.com/documents/file.xxx `HTTP/1.0`
`(blank line)`

If the request is successful, the server responds with an HTTP status line followed by an RFC 822-format message with MIME-compliant extensions, some of which are specific to hypertext documents. The message is separated into header and body sections which are divided by a single blank line. The header section is a series of MIME `field: data` pairs which describe the body, and the body is typically a complex document created using some version of the HyperText Markup Language (HTML) and having multiple MIME-encoded embedded parts (1, 4). A typical response to a successful GET request might be as follows, where the payload has the "header" plus "body" plus "attachment" format as in SMTP's email payloads:

HTTP/1.0 200 Document follows
MIME-Version: 1.0
Server: CERN/3.0
Content-Type: text/html
Content-Length: 8247
(blank line)
(document body)
(document body)
(document body)

The Future of HTTP

Interestingly, the HTTP version 1.0 specification is available as an information-only document (RFC 1945). HTTP/1.0 is deployed by most existing Web applications even though RFC 1945 does not specify an Internet standard of any kind (1). HTTP/1.0 also has serious problems regarding performance and scalability which are well-documented. As a result, the HTTP/1.1 specification was developed and released to the Internet community as a draft standard under RFCs 2616 & 2817. HTTP/1.1 features capabilities for cache control, including an Age header for expiration of cached pages and a `Cache-Control` directive for restrictions on what can be cached by intermediate servers and the "staleness" of information the browser will accept. Additionally, HTTP/1.1 promotes efficient data access by allowing for transmission of portions of MIME objects (including "chunked encoding" for large/unknown datastreams). Associated Internet standardization which has influenced the "next generation" HTTP includes Digest Authentication (RFC 2617) where cryptographic hashes replace the existing Basic Authentication and clear-text passwords of HTTP for secured sites, and State Management (RFC 2965), a standardized approach which allows a server to maintain the relationship between subsequent browser requests. A non-standardized approach to state maintenance called "Cookies" was developed by Netscape Communications Corp., one of the leaders in the deployment of web software. The standard approach of RFC 2965 is compatible with (and bears a great resemblance to) Netscape's Cookies.

Security Issues

As mentioned previously, the security of IP-based protocols is often very lax because of a tendency to transmit everything in ASCI-encoded text strings ("clear text"). The dependence of modern commerce and other transactions on web-based interfaces and Internet transport isn't well-supported by such unprotected data structures. As a result, the IETF community has devised implicit "socket-layer" encryption mechanisms for such transactions.

The "secure socket layer" (SSL) protocol was the original approach to implicit (passive) security mechanisms for Internet-based transactions. SSL was developed by Netscape Communications to to provide privacy and data integrity between two communicating applications. SSL runs between TCP/IP and higher-layer protocols such as HTTP or IMAP, and uses TCP/IP on behalf of the higher-layer protocols. The Transport Layer Security Protocol

(TLS), defined in RFC 2246, is the IETF-standardized version of SSL, and is based on SSL version 3. The complete TLS protocol has two layers: the TLS Record Protocol encapsulates higher layer protocols, including the TLS Handshake Protocol. By using the TLS Handshake, communicating processes can authenticate each other, negotiate an encryption algorithm, and exchange cryptographic keys before the application protocol begins transmission.

The independence between TLS and the application protocol is a significant strength of such implicit security techniques. Higher-layer protocols and applications layer transparently on top of TLS. For example, RFC 2487 & 2595 describe the use of SMTP, IMAP, and POP with TLS, and RFC 2817 & 2818 describe the use of HTTP over TLS.

The HyperText Markup Language (HTML)

In addition to the HTTP protocol which structures the interaction between computers on the WWW, there is a basic protocol or language by which information content is conveyed between the humans who are using the computers. This language is the HyperText Markup Language, or HTML, which is actually a specific application of the Standard Generalized Markup Language (SGML) of ISO standard 8879 (1). Statically authored web-documents are composed using HTML syntax and placed under the control of server software at a website. When a human's browser software follows a hyperlink to an existing object, the server sends an affirmative response to the browser (using HTTP as described earlier) and includes an RFC 822/MIME formatted document. The body of the server's response document is the "web page", which contains particular graphical and formatting commands to be interpreted and used by the browser in displaying the content of the page. The formatting commands are expressed in HTML syntax so that the browser software can adjust the onscreen appearance of the document for different browsing conditions (monitor resolutions, etc.). HTML formatting commands embedded in the document, also called tags, are enclosed in angle-brackets and usually come in pairs to indicate the beginning (i.e. `<tag>`) and end (i.e. `</tag>`) of a particular section of formatting (4, 5). Some tags act without a mate, and some tags take arguments (or, named parameters). Examples of tags that denote fundamental sections of HTML documents are `<HEAD>`, `<TITLE>`, and `<BODY>`. More details about the structure and function of HTML tags can be found in the references and at multiple websites devoted to the subject of web publishing.

Forms and Tables

As the popularity of the web increased, the limited capabilities of HTML version 1.0 were soon outgrown. As a result, standardization work on HTML versions 2.0 and 3.0 enabled many more capabilities for clever web-page content, including the ability for browsers to render tabular data, use subsections of images as hyperlinks, and accept user-entered data into a form for submission and processing by special software at the web server.

The `<table*>`... `</table*>` tags (introduced formally in HTML 3.0, see RFC 1942) and associated formatting rules allow a web page to contain cells of data organized in rows and columns. The cells can contain static text as well as any valid HTML tag including images, anchors, and so on. Several new formatting tags are defined to accommodate the special cases of tabular data, including a `<CAPTION>` tag, cell effects such as horizontal/vertical alignment, justification, borders, etc. and tags to distinguish headings and/or data for particular cell locations.

The `<FORM>`... `</FORM>` tags (introduced formally in HTML 2.0, see RFC 1866) and associated formatting rules allow a web page to contain special fields to capture data entered by the user of the browser and transport the data back to the web server for processing (1–5). In a general sense, the HTML form (in concert with the HTTP POST function) is a mechanism for declaring variables for a hyperlinked subroutine, interactively capturing data for the variables, pushing the data values on the "stack", and invoking the procedure on the computer which hosts the webserver. The arguments of the `<FORM>` tag are shown in Table 6 which draws a comparison with similar functions in "usual" computer languages. An HTML `<FORM>` is built by including `<INPUT>` tags, which have several arguments. These arguments are shown in Table 7, which again draws a comparison with similar functions in "usual" computer languages. In all computer languages, there are a limited number of data types available during variable declaration. HTML again follows suit with the "values" (or data types) which are allowable for the TYPE argument of the `<INPUT>` tag. These "data types" are shown in Table 8, with a short description of the effect which is rendered by the browser's HTML interpreter.

Some TYPE values for the `<INPUT>` tag have very specific formats and effects when rendered in the browser's interpreter and are not used for interactive data capture. These "special data types" such as `<HIDDEN>` are loosely equivalent to the "static" variables of other languages.

Content Modification on the Client/Browser Side

Since a web browser is essentially an interpreter for the HTML "language", it makes sense to generalize the concept of the interpreter to include some capabilities for other slightly different "languages." In this generalization, and with an interpreter which allows for more robust programming constructs, tremendous additional capabilities can be conferred on the web-client. The most interesting of these capabilities allows the browser to manipulate pages which contain executable content in addition to display content. Several technologies have been proposed for this purpose by various commercial entities, for various operating systems and browsers, and with various capabilities. Since the objective here is to focus on the technologies which enable the interchange of information, emphasis will be to give a high-level overview of the pertinent concepts focused on a particular, representative implementation of executable content delivery (JavaScript). This approach essentially utilizes "services" of the browser or its contents which have been exposed to the web-page author for the purpose of creating client-side executable content. This is often called the "Document Object Model".

In keeping with the model from the previous section, which regards web-based computing as a distributed, dy-

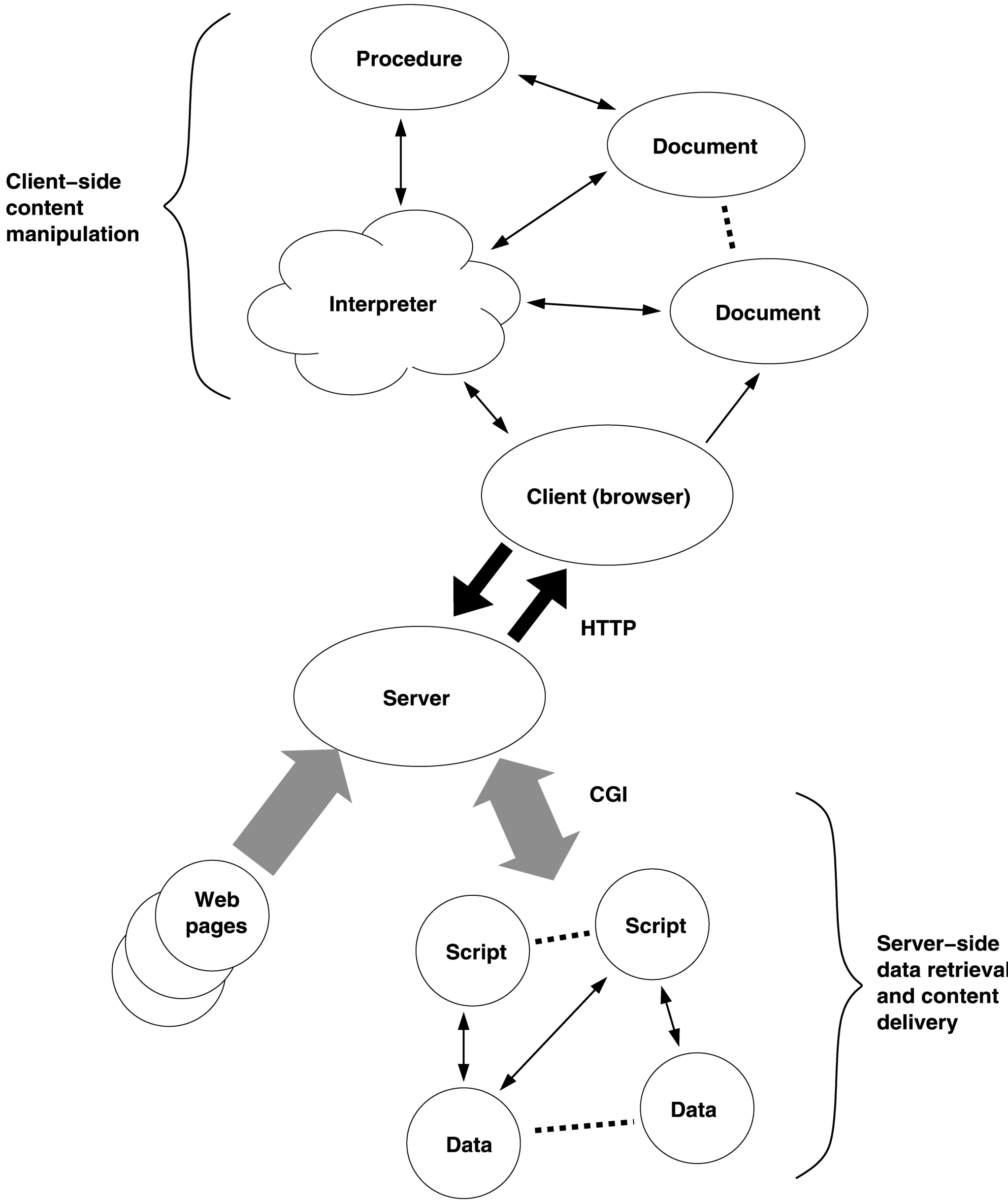

Figure 3. Server-side and client-side Web interactions.

namically (hyper-)linked software process, one can easily see how client-side subroutines can be invoked much like server-side subroutines. Just as the web-server performs dynamic binding and execution for CGI scripts requested by a web-client, the web-client can perform dynamic binding and execution of local (client-side) subroutines which are delivered in or referenced by an HTML document. Additionally, the web-browser can allow for manipulation of objects, data, and subroutines which are described (embedded) in the HTML document or created "on the fly." This general concept is illustrated briefly in Fig. 3. There are many alternatives by which executable web content can be delivered to the browser. In the case of subroutines or "applets" which are written in the Java language, the web-browser must have some capability to "render" (compile) the source code into a form which is executable by the browser's computer; or it must be available pre-compiled in a well-known place on the browser's computer. In a similar fashion, JavaScript and VBScript "scripts" must have access, through an interpreter, to well-known functions and data which are built-in to the browser software itself or exposed by its objects.

Distributed Objects

The JavaScript scripting language is an example of a means to manipulate objects, data, and methods (in an object-oriented programming sense) which are created inside a web-browser. These objects have either been made publically available and are well-known, or they can be created "on the fly" by some HTML or JavaScript algorithm. Once created, these objects can be manipulated by embedded algorithms which set data values, invoke methods associated with other objects, gather input from the user, perform computations, and so on.

JavaScript procedures are embedded in the header section of HTML pages via the `<SCRIPT>` tag, which also supports other platform-specific languages (4, 5). In addition to providing extensive formatting capabilities for web pages, JavaScript procedures can access and manipulate data from HTML forms, control the behavior of the browser (i.e. effect a state-machine), and interact with available Java objects and functions. In fact, much of the "control structure" of JavaScript derives directly from traditional C and C++ computer languages, with syntax such as `for`, `if...else`, `while`, and so on (5). JavaScript also has the usual operators and precedence.

A construction available in JavaScript which may be foreign to programmers not familiar with graphical environments is the ability to trap user-initiated events via "event handlers." For example, the `onclick ()` event handler is a method defined and created for each HTML button, checkbox, or other input object when that object is rendered by the browser. The `onclick ()` event handler can be "attached" to a user-written JavaScript function, so that the function will be activated by a mouse-click on the object. Since the web (some would argue "the Internet") is essentially a nascent distributed computing model, it makes sense to generalize the type of objects that can be referenced from either the client or server. Just as the DOM decomposes and structures client-side interaction into objects and their associated properties & methods, there are also several approaches to server-side decomposition. Earlier sections have loosely described web-based interaction in terms of "remote procedure" invocation. The Simple Object Access Protocol (SOAP) is an example of a formalized, platform-independent approach that applies this relationship to generalized objects.

Wireless Application Protocol (WAP)

Internet access from portable, wireless terminals is a key objective of most modern telecommunications deployments. The deployment of third generation wireless telecommunications networks will enable end devices to use TCP/IP protocols to connect to Internet-style networks via relatively high bandwidth channels. The Wireless Application Protocol (WAP) is an intermediate phase of technology between existing, voice-only wireless telephony and the Internet-capable wireless telephony of "3G" (and beyond). WAP-enabled wireless handsets use a "microbrowser" to request information from WAP sites in a client/server procedure similar to "normal" web surfing. The WAP standards include facilities designed specifically to compensate for the bandwidth and device constraints of contemporary wireless environments. As a result, WAP addresses several areas that are not part of HTTP, including options to push information to users and to integrate data and voice in one application. However, WAP doesn't support multimedia content and it doesn't have support for even simple graphics. Additionally, the components of the WAP standard, including transport protocols, presentation technologies, security, and client-side scripting languages, don't leverage existing IETF standards. As a result, the deployment of end-to-end IP-capable wireless networks is likely to quickly supercede WAP technology (6).

Controlling the Amount of Information (Search Engines)

There are two general classes of information repositories which attempt to categorize, organize, and simplify the massive amounts of information available via the web. These repositories are known as "search engines".; and although they conceptually perform very similar functions, a basic understanding of their very dissimilar architectures can be helpful in controlling the amount of (potentially incorrect) information which is literally "at your fingertips.".

The distinguishing factor between the two main classes of search engines is the manner in which information is entered into their databases. On one hand, "search trees" rely on manual categorization and data entry for web pages; while, on the other hand, "search indexes" rely on automated methods for categorizing other web pages (7).

Search Trees

Informal search trees are kept by practically every active "web surfer." In the loosest sense, a page of personal favorite sites (often called "bookmarks") is the ultimate manual search tree. When a user finds a site that is worthy of future reference, it is manually entered into a list of sites and possibly categorized with other sites that are similar. The next time the user wants to access the book-marked site, the list of available bookmarks is scanned until the site's hyperlink is located.

Formal web search trees, such as www.yahoo.com, function in much the same way, except that they have a much larger and more complex collection of hyperlinks. Their contents, which are often hierarchically-structured lists of web pages with minimal comments, are updated manually by the operator of the site which hosts the search engine. In addition, formal search trees often have a labor-saving entry point to the huge list of sites: an indexed database or other search engine. The function of the search engine is to accept some keywords, Boolean expressions, or phrases to use in narrowing the list of hyperlinks to a specific topic. Unfortunately, due to processing, transmission, storage, and time constraints, the search procedure must be carried out on the search tree's database which represents the hyperlinked pages instead of the actual content of the hyperlinked pages (7).

As with most computer-based information retrieval systems, the web search tree's database is only as good as the humans who configure, update, and access it. If the indexing system is not well-constructed, if the keywords are not "usual" or "expected", or if there is some other mismatch between the way that information is categorized and the way that information is requested, the search may produce ineffective, voluminous, or otherwise useless results.

Search Indexes

Search indexes such as www.lycos.com and www.google.com, which effectively replace the manual construction of the search tree's database with an automated procedure, suffer from the same "keyword mismatch" problems which plague the search tree. The automated database generation is carried out by specialized web browser software (often called robots, spiders, or crawlers) which accesses, analyzes, and categorizes the information and hyperlinks contained in a web page, then uses the links of that page to repeat the process. The list of categorized hyperlinks are then stored in a centralized database which can be searched using a search engine. The ease of use and efficiency of the automated data gathering processes comes with an unfortunate side-effect: since there is no human interaction to filter or consolidate the data which is automatically retrieved, searches into the database of a search index can produce lists of matching sites which are quite large. To control the relevance of the searches, indexes such as www.google.com use page-ranking algorithms based on usage and reference metrics.

Regardless of the problems inherent in web-based information classification and retrieval, the utility of a worldwide, searchable archive of information has had a tremendous effect on the dissemination of a wide variety of knowledge.

CONVENTIONAL TELEPHONY

The almost ubiquitous availability of telephones, both wired and wireless (cellular) is a testament to the human requirement for voice communication. The accurate and natural re-creation of the human voice has been an active area of research and development worldwide for several decades. Recent advances in digital signal processing and microelectronic technologies have enabled the development and standardization of several complex voice coding algorithms. In turn, the deployment of these sophisticated algorithms in mass produced (inexpensive) consumer electronics has fueled renewed efforts in digital speech compression which relate directly to the profitability and availability of advanced telecommunication technologies.

Digitization and Compression

In most cases, telecommunications channels which carry voice signals between distant locations utilize digital technology to represent speech waveforms. The most straightforward approach is to sample (discretize in time) the analog voltage waveform produced by a microphone and quantize (discretize in amplitude) the resulting samples. Typically, an analog speech signal intended for transport in the public telephone network is sampled at 8000Hz, resulting in an effective bandwidth of 4000Hz which is compatible with existing analog subscriber lines for voice communication. Logarithmic quantization according to ITU-T G.711 is commonly used to represent the speech samples with 256 discrete amplitude values. G.711 effectively reduces the "quantization noise" which can be audible and bothersome for low-amplitude portions of speech signals. The resulting stream of discrete speech data requires 64 kbps for lossless transmission and is generally referred to as "toll-quality speech." This level of audible quality and the associated transmission rate are used as benchmarks for more sophisticated "compression algorithms" which attempt to reduce the data rate while maintaining some reasonable semblance of "toll-quality.".

All compression algorithms which are used for reducing the data rate of digitized speech waveforms are "lossy" in that they irreversibly destroy some of the original speech. The effects of different lossy approaches tend to show up audibly in a variety of ways which are difficult to describe, but quite easy to discern. Two of the most common artifacts of speech compression algorithms are "quantization noise" which sounds like "hissing", and "spectral shaping noise" which can make the compressed speech sound "tubular." A few well-known, standard speech compression algorithms which are often encountered in commercial products are summarized in Table 9 along with their data rates after compression, their usual acronyms or "pseudonyms", and rough classifications of quality and complexity.

Multiplexing and Aggregation

In addition to speech compression, the advanced call processing, multiplexing, and signaling technologies which have been implemented and deployed in the public telephone network have fueled rapid economic growth in the telecommunications sector. Some capabilities such as call-waiting, call-forwarding, speed-calling, caller-number-ID, etc. are simply software features that can be optionally enabled by a telecommunications provider for an individual subscriber. These features are made possible by advances in Signaling System 7 (SS7), the processing and signaling "language" used in modern, electronic equipment deployed in the public telecommunications network. In the context of web-based interactions, these features might be described essentially as server-side applications.

Regardless of the equipment or software utilized, the purpose of telecommunications networks, public or private, is to cost-effectively aggregate and transport multiple voice or data channels. These methods of aggregation and transport can be quite cryptic, and they are extremely complex. This complexity is due, in part, to the extensions which allow for transport of "packet-switched" data generated by computer networks in addition to the usual "circuit-switched" data of voice traffic.

Voice traffic data streams have very specific requirements for end-to-end delivery. Voice traffic represents a type of "isochronous" data stream, and isochronous data does not tolerate delay variation (or "stretching") within the stream. Since voice traffic discretized via G.711 has consistent requirements for both delay and bandwidth (64 kbps), it requires a very specific "style" of channel for adequate transport. These channels are often called "circuit-switched." Further, since the channels for multiple voice calls have identical requirements, it is conceptually straightforward to "bundle" many of them together in an organized fashion. The Synchronous Optical Network (SONET) and Synchronous Digital Hierarchy (SDH) of telecommunications channels represent standard and well-known approaches to hierarchically multiplexing individual digital channels into larger and larger units. Table 10 lists several common telecommunications services and the bandwidth they provide (8).

MODERN CONFERENCING METHODS

As LAN/WAN boundaries continue to erode, multimedia-intensive applications tend to increasingly dominate network resources. Although human communication can be enhanced by effective use of multimedia technologies, the inefficient use of network resources can seriously inhibit multimedia communications. As a result, the users of resource-hungry applications must understand and carefully manage their technological tools. Telephone and video conferencing are two of the multimedia tools that have become commonplace in the modern network. Although the technologies used in “high tech” conferencing are complex, observing some simple guidelines can produce dividends in the effectiveness of these tools as well as the efficient use of network resources.

Telephone Conferencing

The advanced technological state of public and private networks has permitted meetings to be held via telephone involving participants throughout the world. Successful meetings are held even in the presence of the use of various (a) speech compression techniques at participant sites and (b) transport systems. These conferences not only accommodate voice but also accommodate the transmission of data and static (i.e. fax) images.

Courtesies and Other Etiquette

Telephone conferencing for groups of four or more participants require structure and management. A collection of “guidelines” are listed in Table 11 which have been used in a variety of situations to effectively manage teleconferences.

Videoconferencing

In addition to speech, another important type of isochronous data is real-time digital video which can be used in point-to-point videoconferencing, video distribution networks, and so on. The recent trends in application of videoconferencing technologies seem to be merging “traditional” point-to-point digital video systems, which are structured around circuit-switched transport channels with LAN-based computer workstations, which are structured around packet-switched transport channels.

Standards for Videoconferencing

The traditional point-to-point approach to videoconferencing or “multimedia teleconferencing” follows a full-duplex, peer-to-peer communications paradigm much like that used for voice traffic in the public telecommunications network. The ITU-T “umbrella” standards T. 120, H.320, H.323, and H.324 comprise the core technologies for multimedia teleconferencing in both wide-area and local-area scenarios, as shown in Table 12. Each of these “umbrella” standards encompasses several other components related specifically to video, audio, session control, and so on (8, 9). A brief overview of each “umbrella” standard and a few of the components is provided in the table.

The H.320 standard governs the basic concepts of audio, video, and graphical communications for full-duplex, isochronous, telephony-based videoconferencing. H.320 covers all aspects of video telephony by specifying requirements for processing and synchronizing audio and video information, providing common formats for compatible audio/video inputs and outputs, and dictating protocols whereby multimedia terminals can participate in or control videoconference sessions via traditional telecommunications links. A common misconception is that compliance with H.261 (the video compression standard) is enough to guarantee interoperability. This is not the case since multiple data streams and protocols are required for full compliance with the H.320 suite. The H.323 standard is a logical and necessary extension of H.320 to include packet-switched networks such as LANs. Because it is based on the IETF-standard Real-Time Protocol (RTP/RTCP), H.323 can also be applied to video over the Internet. As such, H.320 is sometimes referred to as a “packet to circuit gateway protocol” (8). The components of these standards are briefly described in Table 13.

Data and Document Sharing

The T.120 “umbrella” standard governs the audiographic (document conferencing and data sharing) portion of the H.320, H.323, and H.324 standards, and operates in conjunction with H.32x or by itself. The component recommendations of T. 120 specify how to distribute files and graphical information efficiently and reliably in real-time during a multipoint teleconference or “virtual meeting.” The objectives are to assure interoperability between terminals, permit seamless data sharing among participants including “white board” images, graphic display information, and image exchange, and to specify infrastructure protocols for audiovisual applications. The components of these standards are briefly described in Table 13.

Courtesies and Other Etiquette

Video conferencing provides a distinct advantage over telephone conferencing in that visual interaction is available. However, visual interaction can be bothersome with multiple sites. Normally, each site is equipped with two displays — one with the video being transmitted to other sites, and one displaying the present (or last) site producing an audio signal. If the second display is triggered by an audio signal such as inadvertent tapping on a table, the rustling of papers, or a whispered, side-conversation, this video display can rapidly switch from one site to another. Consequently, extreme care must be taken during a video conference where this type of technology is deployed to minimize sound at “listening sites.“.

Since video conferencing is an extension of telephone conferencing, the importance of structure and management cannot be minimized. Consequently, it is not surprising that the list of etiquette issues (10) is similar to those for telephone conferencing. In addition to the guidelines indicated in Table 11, videoconferencing etiquette includes the items shown in Table 14.

Electronic Conferencing

An emerging replacement for teleconferencing and videoconferencing is electronic conferencing. This platform makes use of the Internet and its associated technologies. While electronic conferencing is less costly than teleconferencing and far less costly than videoconferencing, it has the disadvantage of supporting only text communications.

Meeting Formats

Electronic conferencing is normally conducted in one of two formats: asynchronous meetings where participants communicate when available, over a discrete period of time, adding individual comments to previously submitted comments, and synchronous meetings where participants meet electronically at the same time in a structured environment.

Asynchronous meetings are most appropriate for brainstorming sessions where ideas on a topic are solicited, time is available for thinking and responding, the services of a moderator are not really required, and a free exchange of ideas is desirable prior to the development of a prioritized list that will serve as the basis for further activity. Synchronous meetings are appropriate for accomplishing project-oriented work and conducting the business of a group. These meetings are scheduled for a specific time, conducted in a formal manner, address specified topics with the intent of achieving a defined outcome, and provide a transcript of all discussions. (11)

Courtesies and Other Etiquette

Electronic conferencing for groups of four or more participants require structure and management. Guidelines for effective electronic conferencing are suggested in Table 15.

WIRELESS TELEPHONY — THE NEXT GENERATION

The role of wireless telephony is emerging as an integral part of everyday communications. Due to its intense popularity, wireless telephony has undergone rapid, dramatic evolution which parallels, and in many cases exceeds, the rapid growth of the Internet. Emerging wireless telephony networks are labeled "n-th generation" (nG) networks, and the architecture of each subsequent generation reflects the continuing shift of everyday communications from voice applications toward data and multimedia. The over-arching goal of each architecture is reflected in the "3G" mission statement: to enable the personalization and integration of data services across multiple networks — anytime, anywhere (12, 13).

Background

Most wireless telephony networks use *cellular* technology. A cellular network consists of groups of *base stations*-each providing radio coverage to an assigned region or *cell*. Each base station is responsible for allocating radio and network resources–for the purpose of providing telephony services–to *mobile stations* (or users' terminal equipment) within the base station's cell.

The first generation of wireless telephony networks implemented analog radio frequency technology known as "AMPS" (Advanced Mobile Phone System). For a given amount of radio frequency spectrum, AMPS networks assigned a small portion of the total spectrum to each base station. Such apportioning of the radio spectrum is known *as frequency reuse*. Frequency reuse is often denoted by a single integer number greater than or equal to one. The closer the frequency reuse is to unity, the more "spectrally efficient" the wireless network.

The most widely-deployed generation of wireless telephony networks is the *second generation*. The single most distinguishing factor between second generation (2G) networks and first generation networks is the radio frequency technology-or the *air interface*. 2G networks employ an all digital air interface and use one of two multiple user resource access methods: *time division multiple access* (TDMA) or *code division multiple access* (CDMA). The TIA-EIA IS-136 standard and the ETSI Global System Mobile (GSM) stan-dard employ TDMA, whereas the TIA-EIA IS-95 standard employs CDMA. Advanced radio technologies that are beyond the scope of this article-such as *intelligent antennas, fast power control*, and *fractional loading*-allow improved spectral efficiency for 2G networks. Similar to first generation wireless networks and conventional telephony, 2G networks are *connection-oriented-i.e.*, the networks are designed to support *circuit-switched* connections.

Voice telephony is the primary service for first and second generation wireless networks. However, increased demand in *wired* data services has also led to increased demand of *wireless* data services. Many radio and network resources are wasted on data services supported over 2G circuit-switched connections. Some packet-switched "2.5G" networks have been introduced as adjunct data solutions for 2G networks. These 2.5G data networks support "best-effort" data services at moderate data rates (e.g., $\approx$ 32 kbps on the air interface).

The design *of third generation* (3G) wireless networks, known formally as International Mobile Telecommunications 2000 (IMT-2000), focused on the integration of real-time packet-switched data services in addition to circuit-switched voice. In addition to broad use-case objectives, IMT-2000 specifies particular air interfaces and characteristics for a 3G system to be "IMT-2000 compliant." However, even in 3G wireless services, transport of voice traffic remains the primary architectural consideration, and data transport is secondary. (12–14)

All IP Core

Although the air interfaces defined for 3 G networks are significantly different from their predecessors, possibly the most interesting aspect of 3G wireless networks is the re-definition of their core network architecture (the non-wireless portion of the network). Most 3G core networks are evolving to an all-IP architecture -i.e., an architecture that employs internet protocol (IP) transport throughout the network. An all-IP network provides benefits to both the network operator and the network user.

An all-IP core network supports the use of commercial off-the-shelf IP components used in many other IP networks such as corporate intranets and the Internet itself. As the complexity of the network moves from the hardware to the software, the network operator benefits from increased economies of scale. Additionally, if the network's air interface efficiently supports IP packet data, then an all-IP network will facilitate IP all the way to the user terminal. Thus, an all-IP 3G network – possibly employing schemes such as header compression, various quality of service mechanisms, IP-based signaling – can support real-time IP data services such as voice over IP and streaming multimedia. Furthermore, an all-IP network will enable the personalization and integration of data services across multiple IP networks – e.g., an Internet service provider and a wireless network operator (15).

What's Next: WiMAX?

The true definition of "4G" is still unclear, and many 3G-capable network deployments are still underway. However, wireless telephony service providers and equipment vendors have strong opinions as to what will constitute 4G. Some perspectives include completely new air interfaces, new networks (and protocols), and new service models. Other perspectives view 4G as an evolution of 3G networks.

Certainly IEEE standards for wireless local-area (802.11, or "WiFi") and wide-area networking (802.16, or "WiMAX") are contenders for significance in this arena. The suite of standards in IEEE 802.11 specify the mechanisms by which end-stations (clients) attach-to and are managed-by local-area wireless infrastructure (access points). WiFi users can be mobile within the coverage area of individual access points (<100m), and some proprietary mechanisms exist for mobility between access points. However, WiFi is only suitable for pseudo-stationary use in unlicensed frequency bands, and doesn't provide for standardized "handoffs" between base stations.

IEEE 802.16 is amenable to a much broader type of usage than 802.11. With use-profiles and technologies for long-range, point-to-point and mesh wireless links, "fixed WiMAX" (16) is suitable for metropolitan or backhaul purposes. With use-profiles and technologies for portable operation, "mobile WiMAX" (17) is suitable for client radios in licensed and unlicensed frequency bands. The "one size fits all" nature of use-profiles combined with an aggregate data rate of more than 75 Mbps establishes WiMAX as a serious contender for true next generation wireless deployments. As a result, WiMAX equipment may leapfrog conventional wireless telephony in providing interoperable, broadband wireless connectivity. WiMAX technology has even gathered attention from the U.S. Military for its ease of use in early implementations, including in active combat zones (18).

The air interface used in 802.16 is an important item in the popularity, simplicity, and potential of the WiMAX solution. Based on Orthogonal Frequency Division Multiplexing (OFDM), WiMAX uses a large number of narrow, partially-overlapping sub-carriers ("frequency division") to transmit user data in parallel, non-interfering ("orthogonal") channels. OFDM's high spectral efficiency and resistance to multipath interference/fading provide increased robustness for the difficult metropolitan wireless environment. Additionally, groups of sub-carriers can be assigned to different users to effect a simple, efficient multiple-access scheme. OFDM technology is used in several other areas, such as Digital Subscriber Loop (DSL) and some types of WiFi, so re-use and commonality converge to create an economically viable, high-performance solution. A solution so attractive, in fact, that 3GPP/3GPP2 have focused on OFDM as a candidate for long-term evolution to the original 3G air interface, wideband CDMA (WCDMA). (19, 20). Although the path beyond 3G wireless is not readily evident, certainly, future wireless telephony will be driven by user services such as real-time data services, video and audio streaming, video conferencing, and virtual private network connections. Furthermore, 4G will likely be influenced by the need for higher data rates, increased user personalization, and seamless personal service delivery. Regardless of the physical, political, or technological constraints, the consistent goal of "next generation" personal communications systems will be to enable ubiquitous telecommunications, including one "phone" for any data service, any time, anywhere.

SUMMARY

Even as technology advances, becomes more complex, and re-invents itself at an ever-increasing pace, the requirement and desire for interpersonal communication remains constant. The machines which facilitate "human" communication must also "interface" with humans as well as each other in a reliable and widely understood fashion. Formal standardization and familiarity with pertinent standards for computer and communication interfaces is a crucial part of maintaining some semblance of "sanity" in an era where "information overload" is imminent. This chapter attempts to categorize, summarize, and briefly explain some of the technologies and related standards which have particular importance in modern human (computer!) communications, and re-iterate a few items of communications etiquette in a "technology-enabled" fashion.

BIBLIOGRAPHY

1. A. S. Tanenbaum, *Computer Networks*. Englewood Cliffs, NJ: Prentice-Hall, third ed., 1996.
2. T. Gray, "Message access paradigms and protocols." <ftp://ftp.cac.washington.edu-/mail/imap.vs.pop>, July 1997.
3. G. Pajari, "comp.dcom.com FAQ list." <http://www.faximum.com/faqs/fax>, June 1997.
4. S. Spainhour and V. Quercia, *WebMaster in a Nutshell*. Sebastopol, CA: O'Reilly and Associates, Inc., 1996.
5. E. VanderVeer, *JavaScript for Dummies*. Foster City, CA: IDG Books Worldwide, Inc., 1997.

6. T. Kunz, “Is the WAP a winner?, ” *IEEE Spectrum*, vol.**38**, pp. 78– 80, Feb. 2001.
7. L. Perrochon, “A quick tutorial on searching and evaluating internet resources, ” *IEEE Communications Magazine*, vol.**35**, pp. 142–145, June 1997.
8. B. Halhed, “The HEI glossary of audioconferencing, videoconferencing, telecommunications, video compression, ITU-T standards, including acronyms and related terms, ”July 1997.<http://www.hei.ca/glossary.html>.
9. C. E. Hendricks and J. P. Steer, “Desktop videoteleconferencing (DTVC) FAQ.” <http://www.bitscout.com/faqtoc.htm>, July 1997.
10. D. G. Green and D. A. Conner, “IEEE business meeting experiment with video teleconferencing, ” in *Proc. IEEE Int. Professional Comm. Conf.*, pp. 412–416, 1993.
11. D. G. Green, “Synchronous Meetings – version 1.1c.” <http://www.ewh.ieee.org/reg/3/e-conf/guidelines/master.html>, Jan. 2001.
12. “Third-Generation Partnership Program.” <http://3gpp.org>, Mar. 2001.
13. “Third-Generation Partnership Program –2.” <http://3gpp2.org>, Mar. 2001.
14. M. Zeng, A. Annamalai, and V. K. Bhargava, “Harmonization of global third-generation mobile systems, ” *IEEE Communications Magazine*, vol.**38**, pp. 94–104, Dec. 2000.
15. S. Dixit, Y. Guo, and Z. Antoniou, “Resource management and quality of service in third-generation wireless networks, ” *IEEE Communications Magazine*, vol.**39**, pp. 125–133, Feb. 2001.
16. “Air Interface for Fixed Broadband Wireless Access Systems, ” IEEE STD 802.16–2004, Oct. 2004.
17. “Air Interface for Fixed and Mobile Broadband Wireless Access Systems, ” IEEE P802.16e/D12, Feb. 2005.
18. B. Sullivan and E. Bohman, “Ruggedized MicroTCA: A cost-effective solution for defense/aerospace applications, ” *COTS Journal*, Sep. 2006.
19. K. Fitchard, “OFDMA prepares to move on, ”*The Complete Guide to WiMAX*, in *Telephony*, Apr. 2006.
20. “Mobile WiMAX – Part II: A comparative analysis, ”WiMAX Forum, Apr. 2006.

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