To many hams, TCP/IP (particularly in the forms of NET & NOS) is just a fancy mailbox. TCP/IP is, or can be, much more than that. This chapter will try to give a wider view of TCP/IP. It is not intended to provide information for setting up a TCP/IP station. See Chapter 19 (Volume 2) for availability of TCP/IP software.

Interest in TCP/IP has been growing steadily among hams. Its popularity is largely due to the develpment of NET and NOS by Phil Karn, KA9Q. Versions are available for many computers including PCs, Amigas, & Macintoshes

15.A WHAT IS TCP/IP?

TCP/IP stands for Terminal Control Protocol/Internet Protocol. While the native environment for AX.25 might be considered radio, the native environment for TCP/IP is Ethernet. This is a cabled network widely used to link computers. In spite of these differences, these two protocols essentially share common lower levels of the layer model (see section 11.B). In radio enviroments, the two differ most obviously in how packets are moved.

TCP/IP is strongly associated with The Internet. The Internet is a system of linked computer networks. Its development was promoted by the U.S. government's National Science Foundation. Initially, it was intended as a network to link research activies at universites and government laboratories. It has since grown to include many companies and is now international in extent. Linking takes place in many ways including microwave, optical fiber, and satellite. The standard data rate is about 10 MB (10 MegaBaud). It is now being pushed to speeds approaching 100 MB. See the Bibliography in Chapter 25 of Volume 2 for printed information about TCP/IP and Internet.

What is normally thought of as TCP/IP is actually a collection of protocols. In addition to the formal IP (Internet Protocol) and TCP (Terminal Control Protocol), there are ARP (Address Resolution

Protocol), FTP (File Transfer Protocol), SMTP (Simple Mail Transfer Protocol), and TELNET (an internet interface allowing non-TCP/IP connections). Many of these will be discussed briefly in this chapter. There are also a number of other protocols which are considered part of TCP/IP but with which hams are less involved.

15.B ADDRESSING

TCP/IP addressing differs quite significantly from that of AX.25. All TCP/IP stations should have a numerical address assigned by an area address coordinator. The address is of the form aa.xx.yy.zz. This address is composed of 4 numbers, each in the range from 0 to 255. When expressed in binary, each number occupies 8 bits; thus, the entire address can be expressed as a 32 bit quantity.

The first number specifies which network the installation is associated with. Hams are assigned to an amateur network designation even though their connection with each other might be through a university or some other network. Our designator is 44 so that all ham IP addresses are of the type 44.xx.yy.zz. The middle two parts of the address are generally associated with a specific physical location. The last part is associated with a specific machine. Actually, if a machine joins several networks, there is a separate address for each connection to that machine.

One of the ways hams express the numerical address is to convert the last three sections to hex. The hex (hexidecimal) number system is base-16 and counts 0,1,2,...,9,A,B,C,D,E,F. The hex number 10 is decimal 16 (1*16+ 0) and the hex number 5A is decimal 90 (5*16 + 10). The first section is ignored because all hams have the same 44. As an example, the author's IP address is 44.26.1.2. The number 26 has the hex value of 1A (1*16 + 10). The number 1 has the hex value of 01. The number 02 has the value 02 (11*16 + 0). In this form, it is expressed as 1A0201 and can be used as a node alias in the AX.25 network.

There is also a name associated with each machine. In the case of hams, all are of the form callsign.AMPR.ORG. Again, in the author's case, it is KA7EHK.AMPR.ORG. This address is called a domain name.

As you come across systems tied into The Internet, you will also see addresses like guille.ece.orst.edu. This computer is part of the edu

(education) network. It is at the location orst (Oregon State University). At that location, it is in (sublocation, department, division, etc) Electrical & Computer Engineering (that is, ece). Finally, the machine is named guille. We will see in discussions about ARP how this domain name is related to numerical addresses.

As an aside, there are only a few highest level domain names. Two have been used above. EDU is used for educational institutions and ORG is used for an organization not otherwise on the list (ie, hams). Other such domain names include COM for commercial organizations, GOV for U.S. government agencies, MIL for U.S. military organizations, and NET for centers involved with internet organization and management. Sites in foreign countries uses a country code in the last position of the domain name.

The next higher levels of the domain name are called subdomains. In the case of amateur domain names, the AMPR denotes something like AMateur Packet Radio.

15.C TCP/IP MESSAGE TRANSPORT

Message transport for TCP/IP uses datagram or connectionless methods previously disussed in Chapter 11.E. Recall that in earlier discussions of AX.25, a link is established between two locations by making a connection. This connection is made when one requests the other to establish a link. When the second acccepts the request and replies to the first, the link is established.

The datagram style is quite different. The sending location simply transmits an Un-numbered Information (UI) packet. It is addressed to the neighbor which the transmitting station believes is capable of delivering the packet. It is then up to the neighbor to do the same until it arrives at the destination.

For this datagram system to be effective, several practical matters must be considered. The primary is that within a particular LAN (in this case, stations on a single frequency), all must be able to hear each other. It is possible to specify digis in routing tables but that, as usual, defeats a lot of the other features.

15.D HOSTS, CLIENTS, SERVERS AND SESSIONS

The concept of a host generally does not mean much to hams unless they have had contact with Internet or similar computer networks. It is a machine which provides servers for users (that is, clients} .

The idea of servers was introduced in Chapter 5. If you read that chapter and some of the following ones, the idea should not be too foreign. If you did not, now is a good time to go back and at least skim that part. TCP/IP uses the idea of servers quite heavily. Some of them are hidden from the user while others (such as telnet) are up front.

A session is the time during which a user interacts with a server. When you ask a callbook server (section 5.D) about a callsign, you initiate a session. In that case, the session continues until the server hands you back to the host. In the case of callbook servers, that happens when the information about the call is delivered to you.

In our AX.25 world, a G8BPQ node can be thought of as a host. It has a variety of servers attached to it. These might include a BBS, a converse server, and a callbook server. There are also the hidden servers which manage connect requests (both local and network). When you activate one of these servers, a session begins and the host is transparent to you. This state of affairs continues until the session ends and you are returned to the host.

In the TCP/IP world, a host is perhaps most easily thought of as a TCP/IP installation. The client might be a user typing at that station's keyboard or it might be another ham who has connected to the station.

While these might just be thought of as fancy names for the things which go on in our network (AX.25 or TCP/IP), the underlying concepts are quite useful. It is also very useful to have well recognized names for these ideas.

15.E TELNET

Telnet is a simple interface between AX.25 packet users and TCP/IP systems. All of the KA9Q programs & derivatives have this package. When you connect to a station using one of these programs and get a prompt line, it usually looks something like this:

```
Area: ka7ehk Current msg# 0.
?,A,B,C,D,E,F,H,I,IH,IP,J,K,L,M,O,P,R,S,T,U,V,W,X,Z >
?
?)help A)rea   B)ye     C)onnect D)wnload E)scape F)inger    H)elp
I)nfo  IH)eard IP)route J)heard  K)ill    L)ist   M)boxusers O)perator P)orts
R)ead  S)end   T)elnet  U)pload  V)erbose W)hat   X)pert     Z)ap
Area: ka7ehk Current msg# 0.
?,A,B,C,D,E,F,H,I,IH,IP,J,K,L,M,O,P,R,S,T,U,V,W,X,Z >
```

As with many mailboxes and BBSs, you get a prompt line on connect. Sending a ? produces the expanded list of commands. From this, it can be seen that the T command initiates a telnet session. When we ask for more information about telnet, the result is generally something like this:

```
?,A,B,C,D,E,F,H,I,IH,IP,J,K,L,M,O,P,R,S,T,U,V,W,X,Z >
H T
     T[elnet] <hostname> [<port_number>]

     The telnet command allows you to initiate a TCP  connection from the
     NOS mailbox out across  the network to another host.  This allows an
     AX.25  user with nothing more than a terminal and TNC to gain access
     to the TCP/IP network.

     By  including  the optional port_number,  you can connect to any TCP
     server at the given  host.  The  default is to  be connected  to the
     "telnet"  server, which  in the case  of NOS  software, is the MBOX.

     To quit the session at any time, enter the escape character (<CTRL>X
     by default, can be changed with the E[scape] command).

Area: ka7ehk Current msg# 0.
```

On the surface, this may seem like so much gibberish, so lets look at what happens in actual use. In the author's area, there are a number of TCP/IP installations. One is an internet gateway and one is a development site for JNOS40 software (see Chapter 25, Volume 2, for more details). The following is an example which begins as a normal AX.25 connection to JNOS40. Then, a telnet session to wg7j.ece.orst.edu. In this case, the result is not particularly interesting because the result is the same as if one did a direct AX.25 connection to IPOSU (the AX.25 node name for wg7j.ece.orst.edu). But what is different is the login/password requirement.

```
cmd: c jnos40
cmd:*** CONNECTED to JNOS40
NOS for the DataEngine.

Type ? for help
t wg7j.ece.orst.edu
JNOS40:WG7J-1}  Trying...  the escape character is: CTRL-T
JNOS40:WG7J-1}  Connected to wg7j.ece.orst.edu:telnet (escape enabled)

KA9Q NOS (wg7j.ECE.ORST.EDU)

Use your callsign as login.
```

```
login: ka7ehk
Password: {
```

Where telnet is the most interesting is internet access. For those who are familiar with the workings of internet, this does not represent any problems. But if you have never used internet, it can be mysterious, indeed. If you need help, section 15.I.

15.F SIMPLE MAIL TRANSFER PROTOCOL (SMTP)

The Simple Mail Transfer Protocol is a procedure for sending mail between TCP/IP stations. SMTP causes mail to be moved in much as it is between AX.25 store-and-forward BBSs. But SMTP generally involves movement between TCP/IP stations (including MSYS BBSs which have TCP/IP capability).

SMTP is a protocol which is used with NOS/NET software. Regular AX.25 users see its effect only when such a message is moved from the TCP/IP world to the AX.25 world. The most obvious difference to users is the message header; it is quite a bit larger than AX.25 BBS messages. This factor has often lead to criticism of TCP/IP as producing BBS mail which is too large.

15.G FILE TRANSFER PROTOCOL (FTP)

The File Transfer Protocol is a method for moving files through a TCP/IP system (including Internet). One may initiate an FTP session and request that a host send a file to you. The host need not be a local one (so long as there is TCP/IP routing to the host). In fact, through Internet, one can have access to files in other computers world-wide. If you are not familiar with the idea of file transfers, see Chapter 14.

It is often through FTP that new versions of NOS are made available.

15.H ADDRESS RESOLUTION PROTOCOL (ARP)

Back in section 15.B, the subject of IP addresses was opened. One of the questions left unanswered in that section was: how do messages get routed to other hosts (that is TCP/IP stations). A second unanswered

question is how addresses get translated between names and numbers. The Address Resolution Protocol is (at least partially) a solution to both questions.

15.H.1 ARP On the Air: Suppose that one TCP/IP station, say 44.26.1.2 (the author, ka7ehk.ampr.org) wants to send a message to 44.26.1.8 (kb7irs.ampr.org). 44.26.1.2 sends a special ARP packet. This packet basically says: what ham station out there has the IP address 44.26.1.8? In this case, it is answered by KB7IRS which says I DO. After this exchange, KA7EHK constructs packets with KB7IRS as the to-call and KA7EHK as the from-call, then sends them as a broadcast or UI packets.

If there was no response, then it is assumed that the specified TCP/IP station is not part of the LAN. LAN, by the way, is an acronym for Local Area Network. Messages to destinations which are not LAN members are directed to a gateway which may be a BBS or a formal gateway into internet.

15.H.2 DOMAIN NAME SERVERS: A key part of address resolution is the domain name server. The domain name server is a device which keeps a list of domain names and associated numerical addresses. It is generally easier for most of us to remember names than numbers. But the TCP/IP system needs the numerical addresses. The domain name server provides translation from domain names to numbers.

It is not necessary that all of the elements of a domain name server be in one location (especially with Internet access). In fact, there is an AMPR.ORG name server at University of California, San Diego (UCSD). If a local name server is queried about an amateur domain name, it is not a local name, and there is Internet access, the UCSD server is queried for the information. You, as a user, will never know as it all happens behind the scenes.

KA9Q software includes a simple name server. In general, this is a simple list which the operator must construct. Sometimes, it is done manually and sometime using lists which are circulated among users. In such lists, the user may attach any name (not just the formal Internet domain name) with a numerical address. For example, I could put in my list the name CALVIN for 44.26.1.8. Whether or not that is that stations correct domain name is irrelevant. It only matters if a network domain name sever must be used.

15.I A LITTLE BIT (MORE) ABOUT INTERNET

Internet provides a dizzying array of services and it seems that the list grows daily. But two of the early services are of particular interest to hams. These are E-mail and News Groups.

E-mail gives one the capability to send messages (that is, mail) to anyone with Internet access. While many hams have heard that this is possible, one of the most frequent questions is HOW? To send or receive E-mail, one needs access to a host which has both Internet access and a mail server. In the author's case, the local BBS is a JNOS installation with Internet access. It accepts both ham store-and-forward hierarchically addressed messages and messages addressed with Internet addresses. As an AX.25 user, one would connect to the BBS and *S name@host* instead of *S callsign@bbs*. The name and host for the destination must be known before the message is deposited on the BBS. The same AX.25 user could tell other Internet users to address mail to the user @ host. In the author's case, the host BBS is WG7J.AMPR.ORG and the complete address would be KA7EHK @ WG7J.AMPR.ORG.

News Groups also include Mail Groups. These are organized around a variety of technical topics including networking, TCP/IP, NOS, etc. The list is very large (about 5000 News Groups & 5000 Mail Groups). News Groups are distributed as bulletins to the whole Internet and are available for reading at many locations. An example of this is rec.ham-radio. Mail is forwarded as a single (sometimes large) message to each participant. One may simply read the messages or may participate in the discussion by sending an e-mail message to the group facilitator. If the message is in comment about someone else's message, that person is often forwarded a copy so that a reply can accompany your message. Your message then becomes part of the next distribution. The easiest way to find out about such News Groups & Mail Groups is to ask at the computer department of your local university.

15.J A WORD ABOUT SOFTWARE

Almost all ham operation with TCP/IP makes use of software originally written by KA9Q. The first try was called NET. It used the computers native operating system. The second version was called NOS and uses a special operating system for PCs which handles the multi-tasking needed for operation of many servers with multiple clients.

Phil Karn, KA9Q, unlike most program writers, has made the original source code of the programs available. He wanted others to be able to build on the core of his work and add the features needed to make it better for users.

NET, because of its use of native operating systems (that is, DOS for PCs) could (with some difficulty and limitation) be translated for other computers. Thus, there are versions for Macintosh and others. But, because of its special operating system, it is likely that NOS will never be available for anything other than a PC.

Because of the availablility of the source code, there have been quite a few versions of NET and NOS. NET-MAC (in several versions) is for Macintoshs. Because of the superiority of NOS, NET is hardly used on PCs any more. The original version of NOS is also rarely used because of the improvments in subsequent versions. The PA0GRI version of NOS is fairly popular and is quite close to the original. JNOS (WG7J) version adds both a good BBS interface for users and much superior node operation. JNOS40 is a version of JNOS for the V40 microprocessor (a super-8086) which is used in the Data Engine. WNOS is a version being developed in Germany. And there are likely at least several more.

15.K MIXING TCP/IP AND AX.25

Until a few years ago, it was widely assumed that AX.25 and TCP/IP would be relatively separate networks. In many areas, this is true. But things have changed significantly with JNOS, TheNet-X, and G8BPQ with IP routing (see Chapter 25, Volume 2).

But mixing of AX.25 and TCP/IP extends beyond this. There is now tunnelling of AX.25 over TCP/IP in which TCP/IP is used as the physical layer (see section 11.C) for AX.25. This system is now in use for BBS forwarding between a number of north American sites using Internet.

It also possible to tunnel TCP/IP over AX.25 to link regions of ham TCP/IP activity when there is no IP routing between the regions.