Packet Radio: *Introduction to Packet Radio*

by: Greg Jones, WD5IVD

Originally published in Packet Radio: What? Why? How? / Articles and Information on General Packet Radio Topics, TAPR, Publication #95-1. 1995. 130 pages.

Listen to Packet Radio for the Beginner a '94 Dayton talk.

Listen to The History of Packet Radio and TAPR.

Contents

Don't forget to take a look at: What is packet radio? A primer.

Packet radio is a particular digital mode of Amateur Radio ("Ham" Radio) communications which corresponds to computer telecommunications. The telephone modem is replaced by a "magic" box called a terminal node controller

(TNC); the telephone is replaced by an amateur radio transceiver, and the phone system is replaced by the "free" amateur radio waves. Packet radio takes any data stream sent from a computer and sends that via radio to another amateur radio station similarly equipped. Packet radio is so named because it sends the data in small bursts, or packets.

What is the history of packet radio ?
Data packet technology was developed in the mid-1960's and was put into practical application in the ARPANET which was established in 1969. Initiated in 1970, the ALOHANET, based at the University of Hawaii, was the first large-scale packet radio project. Amateur packet radio began in Montreal, Canada in 1978, the first transmission occurring on May 31st. This was followed by the Vancouver Amateur Digital Communication Group (VADCG) development of a Terminal Node Controller (TNC) in 1980.

The current TNC standard grew from a discussion in October of 1981 at a meeting of the Tucson Chapter of the IEEE Computer Society. A week later, six of the attendees gathered and discussed the feasibility of developing a TNC that would be available to amateurs at a modest cost. The Tucson Amateur Packet Radio Corporation (TAPR) formed from this project. On June 26th 1982, Lyle Johnson, WA7GXD, and Den Connors, KD2S, initiated a packet contact with the first TAPR unit. The project progressed from these first prototype units to the TNC-1 and then finally to the TNC-2 which is now the basis for most packet operations worldwide.

Why packet over other modes?
Packet has three great advantages over other digital modes: transparency, error correction, and automatic control.

The operation of a packet station is transparent to the end user; connect to the other station, type in your message, and it is sent automatically. The terminal Node Controller (TNC) automatically divides the message into packets, keys the transmitter, and then sends the packets. While receiving packets, the TNC automatically decodes, checks for errors, and displays the received messages. Packet radio provides error free communications because of built-in error detection schemes. If a packet is received, it is checked for errors and will be displayed only if it is correct. In addition, any packet TNC can be used as a packet relay station, sometimes called a digipeater. This allows for greater range by stringing several packet stations together.

Users can connect to their friends' TNCs at any time they wish, to see if they are at home. Some TNCs even have Personal BBSs (sometimes called mailboxes) so other amateurs can leave messages for them when they are not at home. Another advantage of packet over other modes is the ability for many users to be able to use the same frequency channel simultaneously.

What elements make up a packet station?
Figure 1 shows an illustration of a typical station setup with a schematic diagram of a station wiring.

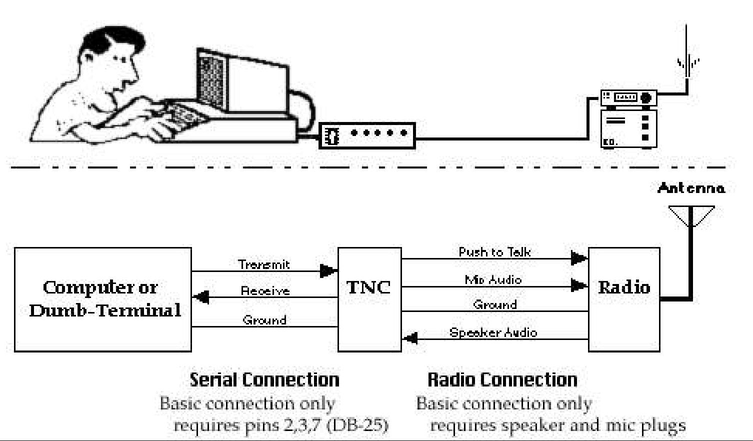

Figure 1 –Packet Radio Station

TNC (terminal Node Controller)

A TNC contains a modem, a computer processor (CPU), and the associated circuitry required to convert communications between your computer (RS-232) and the packet radio protocol in use. A TNC assembles a packet from data received from the computer, computes an error check (CRC) for the packet, modulates it into audio frequencies, and puts out appropriate signals to transmit the packet over the connected radio. It also reverses the process, translating the audio that the connected radio receives into a byte stream that is then sent to the computer.

Most amateurs currently use 1200 bps (bits per second) for local VHF and UHF packet, and 300 bps for longer distance, lower bandwidth HF communication. Higher speeds are available for use in the VHF, UHF, and especially microwave region, but they often require special (not plug-and-play) hardware and drivers.

Computer or Terminal

This is the user interface. A computer running a terminal emulator program, a packet-specific program, or just a dumb terminal can be used. For computers, almost any phone modem communications program (i.e. Procomm+, Bitcom, X-Talk) can be adapted for packet use, but there are also customized packet radio programs available. A dumb terminal, while possibly the cheapest option, does have several limitations. Most dumb terminals do not allow you to scroll backwards, store information, upload, or download files.

A radio

For 1200/2400 bps UHF/VHF packet, commonly available narrow band FM voice radios are used. For HF packet, 300 BPS data is used over single side band (SSB) modulation. For high speed packet (starting at 9600 bps), special radios or modified FM radios must be used. 1200 bps AFSK TNCs used on 2-meters (144-148Mhz) is the most commonly found packet radio.

What is the distance limitation for packet radio?

Since packet radio is most commonly used at the higher radio frequencies (VHF), the range of the transmission is somewhat limited. Generally, transmission range is limited to "unobstructed line-of-sight" plus approximately 10-15%. The transmission range is influenced by the transmitter power and the type and location of the antenna, as well as the actual frequency used and the length of the antenna feed line (the cable connecting the radio to the antenna). Another factor influencing the transmission range is the existence of obstructions (hills, groups of buildings ,etc). Thus, for two-meter packet (144 - 148Mhz), the range could be 10 to 100 miles, depending on the specific combination of the variables mentioned above.

What do you mean we can all use the same channel?
Packet radio, unlike voice communications, can support multiple conversations on the same frequency at the same time. This does not mean that interference does not occur when two stations transmit at the same time, known as a collision. What 'same time' means in this sense is that multiple conversations are possible in a managed, time shared fashion. Conversations occur during the times when the other conversations are not using the channel. Packet radio uses a protocol called AX.25 to accomplish this shared channel.

AX.25 specifies channel access (ability to transmit on the channel) to be handled by CSMA (Carrier Sense Multiple Access). If you need to transmit, your TNC monitors the channel to see if someone else is transmitting. If no one else is transmitting, then the TNC keys up the radio, and sends its packet. All the other stations hear the packet and do not transmit until you are done. Unfortunately, two stations could accidentally transmit at the same time. This is called a collision. If a collision occurs, neither TNC will receive a reply back from the last packet it sent. Each TNC will wait a random amount of time and then retransmit the packet. In actuality, a more complex scheme is used to determine when the TNC transmits. See the "AX.25 Protocol Specification" for more information (ARRL, 1988).

What is AX.25?
AX.25 (Amateur X.25) is the communications protocol used for packet radio. A protocol is a standard for two computer systems to communicate with each other, somewhat analogous to using a business format when writing a business letter. AX.25 was developed in the 1970's and based on the wired network protocol X.25. Because of the difference in the transport medium (radios vs wires) and because of different addressing schemes, X.25 was modified to suit amateur radio's needs. AX.25 includes a digipeater field to allow other stations to automatically repeat packets to extend the range of transmitters. One advantage of AX.25 is that every packet sent contains the sender's and recipient's amateur radio callsign, thus providing station identification with every transmission.

Networking and special packet protocols
This is a sample of some of the more popular networking schemes available today. By far, there are more customized networking schemes used than listed. Consult your local packet network guru for specific network information.

Are there any other protocols in use other than AX.25?
AX.25 is considered the defacto standard protocol for amateur radio use and is even recognized by many countries as a legal operation mode. However, there are other standards. TCP/IP is used in some areas for amateur radio. Also, some networking protocols use packet formats other than AX.25. Often, special packet radio protocols are encapsulated within AX.25 packet frames. This is done to insure compliance with regulations requiring packet radio transmissions to be in the form of AX.25. However, details of AX.25 encapsulation rules vary from country to country.

Networking Schemes
What are some of those other networking schemes?

During the early days of amateur packet radio, it became apparent that a packet network was needed. To this end, the following packet network schemes were created.

Digipeaters

The first networking scheme with packet radio was Digipeaters. Digipeaters would simply look at a packet, and if its call was in the digipeater field, would resend the packet. Digipeaters allow the extension of range of a transmitter by retransmitting any packets addressed to the digipeater. This scheme worked well when only a few people were on the radio channel. However, as packet became more popular, digipeaters soon were clogging up the airwaves with traffic being repeated over long distances. Also, if a packet got lost by one of the digipeaters, the originator station would have to retransmit the entire packet again, forcing even more congestion.

KA-Nodes

Kantronics improved on the digipeater slightly and created KA-Nodes. As with digipeaters, KA-Nodes simply repeat AX.25 frames. However, a KA-Node acknowledges every transmission at each link (node) instead of over the entire route. Therefore, instead of an end-to-end acknowledgment, KA-Nodes allow for more reliable connections with fewer timeouts, because acknowledgments are only carried on one link. KA-Nodes therefore are more reliable than digipeaters, but are not a true network. It is similar to having to wire your own telephone network to make a phone call.

NET/ROM

NET/ROM was one of the first networking schemes to try to address the problems with digipeaters. A user connects to a NET/ROM station as if connecting to any other packet station. From there, he can issue commands to instruct the station to connect to another user locally or connect to another NET/ROM station. This connect, then connect again, means that to a user's TNC, you are connected to a local station only and its transmissions do not have to be digipeated over the entire network and risk losing packets. This local connection proved to be more reliable.

NET/ROM doesn't use all of the AX.25 protocol. Instead, it uses special AX.25 packets called Unnumbered Information (UI) packets and then puts its own special protocol on top of AX.25. This is again used to increase efficiency of its transmissions. NET/ROM nodes, at regular intervals, transmit to other nodes their current list of known nodes. This is good because as new nodes come on-line, they are automatically integrated in the network. However, if band conditions such as ducting occur, ordinarily unreachable nodes can be entered into node lists. This causes the NET/ROM routing software to choose routes to distant nodes that are impossible. This problem requires users to develop a route to a distant node manually defining each hop instead of using the automatic routing feature.

NET/ROM is a commercial firmware (software put on a chip) program that is used as a replacement ROM in TAPR type TNCs. Other programs are available to emulate NET/ROM. Among them are TheNet, G8BPQ node switch, MSYS, and some versions of NET.

G8BPQ

In the early 1980s John Wiseman, G8BPQ, wrote a Personal Computer (PC) to NET/ROM multi-TNC gateway to support W0RLI, F6FBB, PRMPS and other BBS. The self-named G8BPQ code could interact with a network of TNCs and act as a driver for the BBS application program.

As of 2015 John still adds to and supports that program and it is now available for most MSWindows, MacOSX, and Linux (including one for the Raspberry Pi) distributions in pre-compiled and source file downloads.

It became sufficient and even advanced in that it now serves as a TCP/IP gateway, stand-alone packet radio network node, HF multi-protocol system, and a framework to support many different kinds of fully emulated TNCs.

The TARPN organization, dedicated to Amateur Radio VHF/UHF packet, uses, and documents the use of G8BPQ on the Raspberry PI embedded platform for a purely ham-radio slow-speed network.

ROSE

ROSE is another networking protocol derived from X.25. Each ROSE node has a static list of the nodes it can reach. For a user to use a ROSE switch, he issues a connect with the destination station and in the digipeater field places the call of the local ROSE switch and the distant ROSE switch the destination station can hear. Other than that, the network is completely transparent to the user.

ROSE's use of static routing tables ensures that ROSE nodes don't attempt to route packets through links that aren't reliably reachable, as NET/ROM nodes often do. However, ROSE suffers from the inability to automatically update its routing tables as new nodes come on-line. The operators must manually update the routing tables, which is why ROSE networks require more maintenance.

TCP/IP

TCP/IP stands for Transmission Control Protocol/Internet Protocol. TCP/IP is commonly used over the Internet wired computer network. The TCP/IP suite contains different transmission facilities such as FTP (File Transfer Protocol), SMTP (Simple Mail Transport Protocol), Telnet (Remote terminal protocol), and NNTP (Net News Transfer Protocol) The KA9Q NOS program (also called NET) is the most commonly used version of TCP/IP in packet radio. NOS originally was written for the PC compatible. However, NOS has been ported to many different computers such as the Amiga, Macintosh, Unix, and others. Smaller computers like the Commodore 64 and the Timex-Sinclar do not currently have versions of NOS available. TCP/IP based amateur networks are becoming more common each day.

TexNet

TexNet is a 3-port switch designed to create a 9600 baud backbone with 2 local access channels. The TexNet network provides transparent network access to the user. The user simply accesses his/her local TexNet node and then either connects to a user at another node or accesses various system services. TexNet provides the stability of fixed routing, while allowing new nodes to be automatically brought into the network.

BBS Message Transfer: Many of the BBS programs used in packet radio allow for mail and bulletins to be transferred over the packet radio networks. The BBSs use a special forwarding protocol developed originally by Hank Oredsen, W0RLI. Besides full service BBSs, many TNC makers have developed Personal BBS software to allow full service BBSs to forward mail directly to the amateur's TNC. This allows operators to receive packet mail at night and avoid tying up the network during busy hours.

References:

Finke, C. R. (Ed.) (1992, February 15). TPRS Quarterly Report. Texas Packet Radio Society, Inc.

Jones, G., G. Knezek, M. Hata. (1992). Packet Radio Prospects for Educational Data Communications. Proceedings of the Ninth International Conference on Technology in Education, 1, 218-219. Paris, France.

Lucas, Larry, Greg Jones, David Moore. (1992) An Educator's Alternative to Costly Telecommunications. Texas Center for Educational Technology, Univ. of North Texas.

Steve Watt, KD6GGD, steve@wattres.SJ.CA.US. (1993). Frequently Asked Questions from the listing in the rec.radio.amateur.packet newsgroup for the USENET network. Version 1.11.

Tucson Amateur Packet Radio Corporation. terminal Node Controller Manual, Firmware Release 1.1.8, Tucson, AZ: Author.