What's All This Racket About Packet?

Packet radio is growing *fast.* What's it like? Read on.

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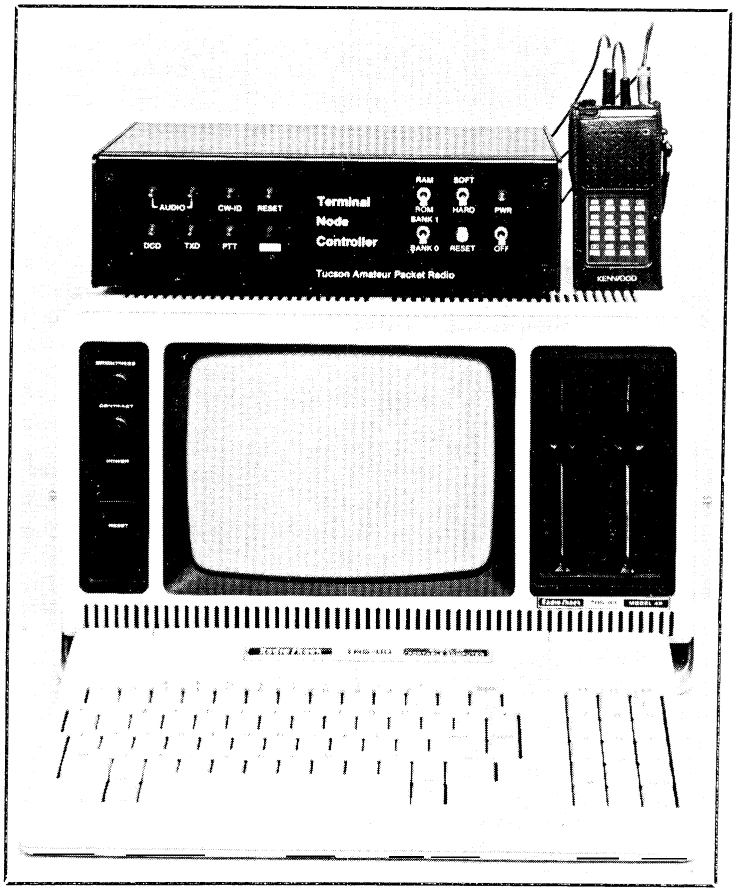
This is an article about packet radio. If you don't know what packet radio is, that pronouncement won't mean much to you. "High Speed CD/CSMA Digital Communications in the Amateur Radio Service, Theory and Applications" isn't a real grabber either, so "this is an article about packet radio" will have to do. This article will have a slant different from most previous articles about packet radio. It will not discuss what you will be able to do with packet in the future, but what you can do with packet now: how to use the existing networks, which of several frequencies in your area are being used for packet, what packet controllers are available and what you can expect when you get on packet radio.

After we discuss what packet does, there will be some theory-an explanation of how packet does what it does (there's no such thing as a free lunch). Those of you who want to dig deep into technical topics should consult the bibliography at the end of this article.

A final word of warning: This is a sales pitch! The goal is to get you interested enough in packet radio that you will get involved. Whether you visit a friend's packet-equipped shack, see packet in action. at a radio store or Field Day site, go to local packet-radio meetings, or jump in and buy or build a packet controller, you'll learn far more by doing than by reading.



Executive Summary

Packet radio, or simply "packet," is the common name for a digital communications mode in Amateur Radio that provides error-free communications. It is designed to allow automatic linking of systems for cross-country networks. Packet uses high speeds; 120 characters per second is standard on the 2-meter band, and a recent development permits 960 characters per second on the 220-MHz band. Below 30 MHz, 30 characters per second is used. Assuming that you already have a radio and a computer or terminal, it will cost you between $180 and $500 (higher cost for more "bells and whistles") to get on packet radio. This is the cost of a *terminal node controller* (TNC), a box that connects the data-generating device to the radio. In other words, packet allows hams to exchange information much faster than before with no errors at a reasonable cost.

What Is Packet?

Packet is usually character communication. Letters and numbers entered on a keyboard or from a computer are sent from one amateur station to another. On the surface, this sounds no different from RTTY, which has been around in Amateur Radio for many years. Packet radio has three major characteristics and several beneficial side effects that make it stand out from other amateur digital communications modes.

Packet radio guarantees perfect reception.

Information sent via packet is checked to see that it was received exactly as it was transmitted. Data is automatically retransmitted until it is accurately received. There is only a very small chance (one in millions) that bad data will sneak through.

Packet permits a single frequency to be shared by several simultaneous conversations.

This also makes possible a bit of magic called a "simplex repeater"-a repeater with its input on the same frequency as its output.

Packet allows for "routing" information among stations, so that any packet station can be part of a linked set of "repeaters."

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For example, there is a set of packet stations in California that allows information to be sent from San Diego to Sacramento, a distance of 480 miles, on 145.01 MHz. Before users of mega-linked VHF/UHF FM repeater systems start chuckling at this "paltry" distance, consider that each station on the packet link uses a single frequency, a single antenna and a single transceiver. Stations do not require additional telemetry, diplexers, duplexers, circulators, link radios or large amounts of money. The packet-radio link can also support multiple simultaneous conversations between the ends of the path, as well as between points in the middle. Similar packet-radio "networks" exist in Florida, the Northeast and Mid Atlantic states, and in several Midwestern states.

Like the man says on TV, "And what would you expect to pay for all this? Don't answer yet, there's more . . ."

Packet allows computers to speak directly to each other in their "native tongue."

Most personal computers use the ASCII code, which has 256 separate characters. Baudot, the code most often associated with the term "RTTY," has 32 characters and a trick called "shifting," which allows an additional 26 characters to be recognized. Transmitting ASCII computer characters over Baudot RTTY causes serious problems for computer users. Packet radio can transmit ASCII characters with no restrictions or shifting.

Packet is fast.

Packet is faster than Baudot RTTY because of technical standards, equipment availability, convention and regulatory issues. For whatever reason, you won't see much Baudot above 100 words per minute (WPM). On the other hand, you won't see much packet below 360 WPM on HF or below 1440 WPM on VHF. We are starting to see packet at 11,500 WPM on 220 MHz and above, and packet has been sent experimentally at 300,000 WPM on the 70-cm band. I've taken a small liberty in expressing packet radio speeds in WPM; the actual speeds in bits per second (bit/s) are 300, 1200, 9600 and 250,000, respectively. You say that you can't type 300,000 words per minute, or even 360? Keep reading—packet isn't just for typists.

Packet provides "non-realtime" communications.

What this means is that you and the person you are talking to don't have to be home at the same time. Much of the present use of packet radio is leaving messages for others on a centrally located *bulletin board.* A bulletin board is a message-storage device, usually maintained at the home of a local ham. If the person you want to talk to isn't on the air when you are, you can leave a message for him or her on the bulletin board. The message can be about anything: plans for the breakfast meeting tomorrow, the fact that you worked the Clipper-ton DXpedition on 160 meters, your new antenna, etc. Although similar systems have been available on traditional RTTY systems, packet lends itself nicely to bulletin-board operation. Because packet is fast and many users can share the same channel, a properly designed mailbox can share the frequency with several non-mailbox conversations, or several mailboxes can be on the frequency at the same time without mutual interference.

Packet-Radio Frequencies

Packet is in use on many bands, with the most concentrated activity being on 2 meters. The national packet community is attempting to get the frequencies from 145.0 MHz to 145.1 MHz allocated to digital use, with at least the channel at 145.01 MHz available throughout North America. The following is a list of areas where official action by that area's frequency coordination body has set aside 145.01, 145.03, 145.05, 145.07 and 145.09 MHz for digital communication: Alaska, Northern California, Southern California, Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, Minnesota, New Hampshire, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia.

The Florida Repeater Council (FRC) has coordinated 145.01 MHz as the statewide 2-meter packet frequency. A request for 145.03, .05, .07 and .09 MHz is pending. Other states with action pending include Arizona, Illinois, Missouri, Nebraska and Oklahoma.

Many areas have activity on frequencies other than 145.01 MHz. These include Southern California, 145.36 MHz and 146.745/.145 MHz; Salt Lake City, 146.10/.70 MHz; southern and central Illinois, Iowa, east Missouri and Michigan, 147.555 MHz; southern Wisconsin and northern Illinois, 144.95 MHz.

If you are in doubt about what frequency to use, listen on 145.01 MHz.

On HF, 14.103 MHz and 10.147 MHz are the popular packet frequencies. HF packet stations transmit at 300 bauds, using a 200-Hz shift (Bell 103 standard).

Packet is information transfer.

Because of these characteristics, packet lends itself well to connecting a central store of information, usually called a *host system,* to a local network of users. For example, in Southern California we have a host run by WB6YMH that is kept stocked with the latest Amateur Radio information available. Electronic versions of the *ARRL Letter, Gateway* (the ARRL packet-radio newsletter), the *W5YI Report, AMSAT Satellite Report* and newsletters from several other organizations are made available via packet radio and the host system to any suitably equipped amateur in the area.* A typical issue of the *ARRL Letter,* around 20,000 characters, would take about an hour to send at the standard RTTY speed of 60 WPM. At the standard VHF packet rate of 1200 bit/s, it takes about 3 minutes.

Now, what would you pay for all of this? Wait, there's more . . .

Packet is 97.1(b).

Part 97 of the FCC rules under which we live states the purpose of the Amateur Radio Service. One of the subparagraphs contains these words: "Continuation and extension of the amateur's proven ability to contribute to the advancement of the radio art." One of the better recent examples of amateurs advancing the radio art is the current activity in packet radio. Packet didn't originate in the Amateur Radio Service, but we have taken the basic idea and have shaped it into things that didn't exist before, or which have a slant different from what has been tried before. We have also added the traditional amateur touch-extremely low cost. Amateur-designed and -built packet-radio controllers flew in official weather planes through the eye of a hurricane. Army and Navy MARS stations are integrating amateur packet-radio technology into their activities. Several commercial manufacturers have taken the amateur-designed controllers and have begun to sell them both in and out of the amateur market.

Packet is satellites.

AMSAT-OSCAR 10 is an excellent medium to use for packet radio. Large amounts of data have been sent across the continent via OSCAR 10. Using a special packet device called a *teleport,* a packet station in northern Canada was connected through the satellite to a station in Los Angeles; data was then relayed through another packet controller to a station in San Diego. The UoSAT-OSCAR 11 satellite carries a packet-radio controller that can store 120,000 characters and retransmit them later to any other point on the globe. PACSAT, an amateur satellite currently under development, will use packet radio to store up to 4 million characters for relay between stations.

Packet is international.

The packet-radio protocol, AX.25, is now accepted as an international standard.

*Gateway, the ARRL packet-radio newsletter, is available from the ARRL. U.S. subscriptions are $6 for ARRL members and $9 for non-members.

Packet Operating Tips

Because it breaks' up a data stream into short sections called frames, packet looks, to the operator, like full-duplex communications+ Full duplex means both parties can speak at the same time (similar to a telephone call). This is analogous to "full-break-in." or OSK CW. Most amateurs wha have had previous exposure to . . keyboard-based communications are used to RTTY, which is half-duplex—only one side talks at a time. Most packet controllers can be adjusted to display characters from the other station only when you aren't typing yourself; this prevents your characters from being mixed on the screen with incoming characters. Sometimes, a full-duplex packet conversation can be very natural, with rapid exchanges of ideas. At other times, it can be very confusing, with the answer to one question coming in while another question is going out. Different areas of the country have came up with various ways to make a packet conversation appear more RTTY-like.

Once a "connection" is established (refer to the article text) you may begin typing. Some areas use K, BK, O or > at the end of a thought to say, "Okay, I'm done. It's your turn to transmit." Other areas simply put a blank line between thoughts to invite the other station to respond.

That's about all there is to a packet conversation. Most TNCs send a packet after you press the ENTER or CR key. It is considered polite to use this key when you reach the end of a 40- or 80-character line, rather than continuously typing and letting lines wrap around the edge of the screen.

To end a conversation, some areas use SK at the end of a line; others may add U DISC. This is short for "I'm done talking. If you're done talking, go ahead and disconnect." You can then tell your TNC to break the connection, freeing your and the other station's TNC for a new conversation.

If your TNC is so equipped, you will occasionally see a message like

CONNECT REQUEST: NK6K.

This means NK6K has attempted to connect to you. This is like the "call waiting" feature on some telephones; you may disconnect from your current conversation and connect to the new station, or you may simply ignore the attempt. In any case, the other party will have received a "station busy" message, so the operator will know that you are on the air, but not available.

The best way to get started, as always, is to listen for a while, and then jump right in. It is simple to monitor the channel, or "read the mail." On the TAPR/Heath/AEA/Kantronics TNCs, simply type MON ON at the CMD: prompt. You'll see all the traffic on' the channel, with the call signs of both stations added to the beginning Of each message.

When you are ready to make a packet-radio contact, keep these suggestions in mind:

1) Transmit only short, infrequent CQ or QST packets, and don't route them through several repeaters.:

2) Remember fhat you are sharing a channel; don't start long program or message transfers if there is already a lot of activity an the frequency,

3) Move to 8 frequency with no digipeaters an it whenever you can connect directly to the station that you want to work.

4) Have fun!

Amateurs worldwide are working together on future standards and applications. Papers from Japan and Germany appeared in the *Proceedings of the Fourth ARRL Amateur Radio Computer Networking Conference*, and North American papers were presented at last year's packet-radio meeting in Sweden. Three amateur satellites, JAS-1, Phase III-C and PACSAT will all use the same basic access methods. These satellites involve many parts of the world, including Canada, Germany, Japan, the U.K. and the U.S.

Packet is digital.

Experimentation with non-character communications has just started. That makes this a discussion of the future, which I said I wouldn't do till the end, but . . .

Packet is not limited to character communications. Take two SSTV units with digital outputs, plug them into packet controllers, and send absolutely error-free pictures. Better yet, store the pictures on the local host system for retrieval anytime. Digitized voice can be sent over packet radio. Several voice repeaters could share the same high-speed digital network for cross-country linking. Using packet techniques and digit al compression technology, medium-scan TV that approaches fast-scan quality can be sent at 56,000 bit/s and can be routed over high-speed packet nets with other traffic. You're putting us on, right? Nope. Check the cover; this isn't the April issue.

The Hard Part

Here's the technical part, snuck in at the middle. Don't worry, it will be over quickly. The secret of why packet can do all these amazing things is buried down in the bowels of the *protocol*. The protocol is a language spoken by the computer in your packet controller. The protocol is complex; the description of it takes many pages of nearly incomprehensible computerese, and several books have been written about it. Fortunately, you need never know how it actually works, just as you don't have to know how to alloy copper and zinc to pound brass. After all, you've just paid for a computer to understand the protocol for you. The protocol used by most amateurs is called AX.25, and probably represents the largest number of specific rules ever voluntarily agreed to by a large number of hams.

What the packet technique does is break the data sent to it into small pieces called *packets*. Several *addresses* are added to the front of the packet. An address is usually an amateur call sign. There are always at least two addresses: that of the sending station and that of the intended recipient. There may also be some addresses of stations that are supposed to repeat the packet. A Frame Check Sequence (FCS) is added to the end of the packet. The FCS is the answer to a calculation that is performed on the rest of the information in the packet. That's a packet.

The breaking up of the data into small parts allows several users to share the channel; packets from one user are interleaved with packets from another user. The address section allows each user to separate things intended for him from things intended for other users. The addresses also allow each packet to be relayed through many stations between its source and its eventual destination. The FCS allows the receiving station to make sure the data has been received correctly. The same calculation is performed on the data by the receiving station as was performed by the sending station that placed the FCS in the packet in the first place. If the FCS calculated by the receiving station matches the one sent by the transmitting station, the data is correct.

Computerized Radiograms

Traffic handlers will have recognized by now that this is the computerized equivalent of what they have been doing since the beginnings of Amateur Radio. Station of Origin, To address, a Check Number and formal procedures for relaying a message are all part of packet radio. Packet is putting the "RR" back in "ARRL."

The last piece of the pie is the acknowledgment procedure. When a packet is sent out, the sender expects an acknowledgment (ACK) that the packet was received correctly. If the ACK is not received, the packet is retransmitted. The receiver only ACKs the packet if it was received with a correct FCS. This protects a packet conversation from fades, static, collisions (when two packet stations transmit at the same time), adjacentchannel interference and other problems common in amateur communications.

What Does It Look Like?

So far we've talked about what packet can do for you and about how it does it. But what does a packet contact look like? In the following examples, we'll look at the procedures used by the TAPR, AEA, Heath and Kantronics TNCs. Other TNCs follow similar, but not identical, procedures.

First, you must tell the TNC your call sign. For example:

MYCALL NK6K

is the command to enter a call sign. Most TNCs allow you to change your call sign at any time and have a way to remember it while the power is off.

'As in all other modes of Amateur Radio, packet allows you to "read the mail" or monitor channel activity. This is called the *monitor mode,* and looks like this:

WA6JPR> WB6YMH: HELLO SKIP, WHEN IS THE NEXT OSCAR 10 PASS?
WB6YMH >WA6JPR: HANG ON WALLY, I'LL TAKE A LOOK.

The call signs of the stations involved appear as "from> to,'' and the contents of the packet appear after the '':''. In this manner, you can monitor all traffic on the frequency. You can also watch for a station calling CQ, which might look like this:

WB6HHV >CQ: MIKE IN SAN DIEGO LOOKING FOR ANYONE IN SIMI VALLEY.

You can send a CQ by entering the *conversation mode* of the TNC. You go to the conversation mode by typing:

CONVERSE

You can then type your CQ:

MIKE IN SAN DIEGO LOOKING FOR ANYONE IN SIMI VALLEY.

Your TNC adds your call as the FROM address, and CQ as the TO address. The receiving station's TNC adds these addresses to the front of the displayed text.

You answer a CQ or establish a contact by using the CONNECT command. This "connects" your TNC to another station and begins the acknowledgment procedure discussed earlier. An example of a connect command is

CONNECT W6IXU VIA WA6OZJ, K6TZ, WB6DAO

This asks for a connection between you and W6IXU routing through (via) three other stations. When the connection has been established, the TNC notifies you by printing

***CONNECTED TO W6IXU

This means that the computer in your TNC has exchanged some preliminary information with the other TNC and is ready to proceed. If the other station had already been in a connection with a third TNC, you would get a busy signal:

***W6IXU BUSY

If W6IXU is not on the air, your TNC would make several attempts to establish the connection and then print a message telling you that it has not succeeded.

Assuming you get connected, everything you send to your TNC will now be sent to W6IXU with all the error checking and retransmission just described. Each time you hit the ENTER or RETURN key, a packet is formed and sent. Packets received from the other station are displayed between the lines you enter, much as if a full-duplex RTTY QSO were taking place.

When you are done with the conversation, you disconnect by entering CONTROL-C and typing DISC.

The commands and scenario above are all you need to know to carry on a packet-radio QSO. There are many other options (around 60) and several other combinations of connected and monitor modes, but they are like the 40 knobs, switches and meters on most modern HF rigs; there are operators who constantly twiddle, and those who only use the push-to-talk switch or the key.

So What Are You Waiting For?

We've only touched briefly on what can be done with packet and mentioned even less the technical details of how it works. For some, packet is an end to itself—experimenting with new ways to transfer data. For others it is just a tool-anew way to pass traffic, spot tornadoes, run a parade, score points on Field Day or meet new people. To find out more, look into any of the references listed at the end of this article. Or, wait for the second part of this article, which describes a TNC in detail. See you on packet!

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