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By Richard Parry, W9IF

Position Reporting with APRS

Put yourself on the map—literally!

A few years ago, someone handed me a small Global Positioning System (GPS) receiver and said that this little device would tell me where I was located anywhere on Earth. I could not believe my eyes or ears, and was not prepared to be sucked into this canard. How could this device, barely the size of a cellular phone, tell me where I was located within a hundred feet? It just couldn't be; this had to be a hoax. Upon further discussion and a demonstration, I was hooked. I knew I had to have one, but wasn't sure why. It took a while to come up with an excuse, but I finally did, thanks to the pioneering work of Bob Bruninga, WB4APR, and his *Automatic Packet Reporting System* (*APRS*).

Before my final purchase, I spent two years playing armchair APRS quarterback. I stared at maps on my computer screen, watching the symbols that represented the locations of my fellow hams. Some of these symbols even *moved* while I watched! They represented hams who had GPS receivers in their automobiles, boats or whatever. The GPS receivers sent position information to packet radio TNCs (terminal node controllers), which then process the data for transmission to the APRS network.

With nothing more than a simple packet setup and *APRS* software, I could see my fellow Amateur Radio operators going to and from work, and see their weekend trips to the local ham store. Watching members converge on the Palomar Amateur Radio Club (PARC) meeting once a month was particularly interesting. Watching real-time special events—balloon expeditions, parades, satellites, boat races, and marathons—was fascinating.

APRS has many serious applications besides entertainment. In this article I'll concentrate on what I learned while installing my own APRS station. Although APRS is conceptually easy to grasp, the network protocol can be a little enigmatic, even for the advanced user. Setting TNC parameters can also be a little tricky.

There are several ways that you can start with APRS, ranging from literally no Amateur Radio equipment whatsoever (see the sidebar, "APRS on the Web") to a mobile system replete with TNC, GPS receiver, and transceiver.

Getting Started

If you have a packet station (TNC, transceiver, and computer or terminal), you have all the hardware you need to start monitoring APRS activity in your area. All that remains is to obtain an appropriate version of the *APRS* software. There are currently three versions, for Apple Macintosh, DOS, and *Windows*. By the time you read this, there might even be an *X Windows* version to run on Sun and Linux workstations.

Any of the Web pages listed in this article will direct you to the latest version of the software. The software is offered as *shareware*, which means you may freely download the software and try it. The Macintosh and *Windows* programs are full working versions, only the ability to save settings has been removed. If you decide to continue to use it, you should send the authors the requested registration fee. This entitles you to future updates and support. The software comes with installation instructions, but if you need help, there is the **aprssig@tapr.org** mailing list, where you will typically get an answer within hours, if not from the authors, by thousands of "Elmers" ready, willing, and able to help you.

Where to listen is the next piece of information you need. There are presently two main frequencies dedicated to APRS work: 10.151 MHz LSB on HF (the mark/space frequencies fall within the 30-meter ham band) and 145.79 MHz (in most areas) on VHF. For northern California, it is 145.01 MHz and in Canada it's 144.39 MHz. Monitoring the HF band will show activity across the US, because of the propagation characteristics of 30 meters. The VHF band provides a picture of activity predominately on your home turf. However, as we shall see, there are exceptions to this rule!

Although I've indicated that there are only a few APRS frequencies, the situation is rather "fluid" and varies around the country. If you have Internet access, you'll find Web pages for the major metropolitan areas that provide excellent frequency coordination tools. There is APRS activity on HF bands from 40 to 10 meters, and also on 6 meters.

With standard packet station equipment and software, tune to one of the frequencies indicated and watch the activity. It won't be too long before you'll want to put yourself on the map, so to speak! So let's see what it takes to transmit APRS packets.

Configuring Your TNC and Software

The APRS protocol relies on Unnumbered Information (UI) packet frames to transmit location information. If you have previously used packet radio, you have used UI frames when you called CQ or activated your beacon function. For APRS work, all that is required is changing your *beacon text*, *beacon rate*, and *path*. On

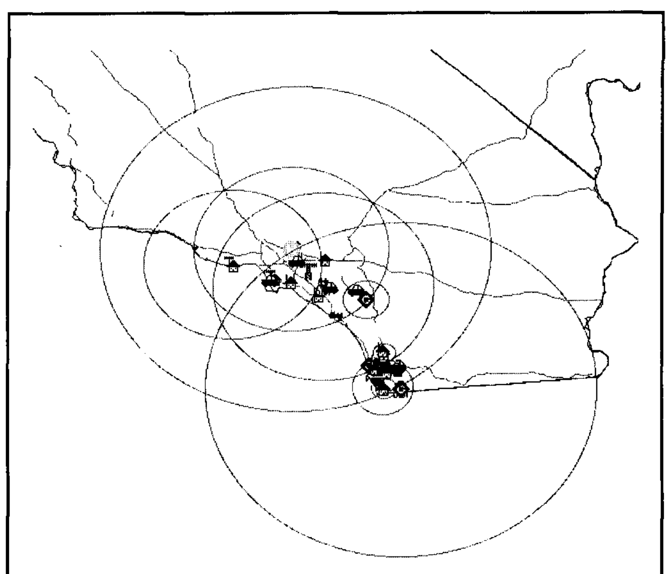

Figure 1—Coverage circles for APRS stations in southern California; the upper cluster is Los Angeles and the lower cluster, San Diego. The circles are based on PHG (Power, Height, and Gain) information broadcast by the stations. Although it makes an interesting display, it provides valuable information for the user to select an efficient digipeating path.

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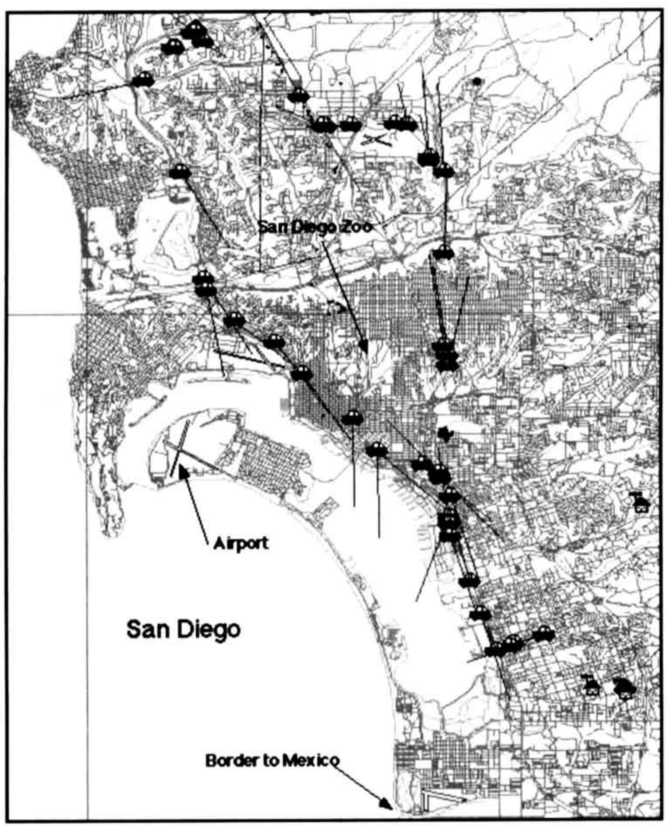
most TNCs these parameters are BTEXT, BEACON, and UNPROTO, respectively. In practice, there may be a few other parameters needing initialization, but these three are particularly important.

APRS is becoming so popular, virtually all TNC manufacturers advertise APRS-compatible TNCs that provide additional functionality specifically designed for APRS work. These features include the ability to easily interface with an external GPS unit. These TNCs also have parameters and buffers dedicated to APRS use. In those cases, the standard parameters (BTEXT, BEACON, UNPROTO) remain the same and you specify APRS specific parameters.

For example, one manufacturer of an APRS-friendly TNC has a Location Text (LTEXT) parameter where you specify your position and therefore leave BTEXT unchanged. This assumes that the TNC is being used in a stand-alone configuration (no computer control). When a computer with *APRS* software is used to control the TNC, you specify the parameters with simple "fill in the blank" boxes and the computer system controls initialization. However, for simplicity and clarity, let's assume that you have a standard TNC and that it will be transmitting position reports independent of a computer.

Setting the beacon rate requires a little understanding of the APRS network. Technically, there is no reason you can't transmit a location as often as you like. In practice, however, fixed stations (eg, home stations), should not transmit more frequently than every 30 minutes. There is a good reason for this: APRS is an *unconnected broadcast protocol*. This means there is no acknowledgment between stations when a packet has been received. Therefore, if packets collide, there is no retransmission and the information is lost. This is significantly different than the normal AX.25 *connected protocol* that assures error-free transmission. So, to reduce collisions, the rate between transmissions should be extended to assure a high probability that the channel is available.



Here is a street map of San Diego showing the daily commute of the local APRS group. The area displayed is approximately 18×15 miles. The vector lines show vehicle direction. Call signs of stations are not shown for clarity—and to protect the innocent.

Since a fixed APRS station, by definition, is not moving, updating its position more often than every 30 minutes is superfluous and counterproductive, so every 30 to 60 minutes is a reasonable interval. Some versions of the *APRS* software set rates to 20 minutes and others to 30, but you can set the rate as desired. For our current fixed location application, set your beacon rate to 30 minutes or BEACON 180 on most TNCs (180 = 1800 seconds = 30 minutes).

The beacon text is the second important parameter that needs to be initialized. Because we're only talking about a fixed APRS station, there is no need for a GPS device. All you need to know is your location. Borrow a GPS receiver just long enough to determine the latitude and longitude of your station. With that information, you can set up your BTEXT. For example, BTEXT for my fixed station is:

/120800z3300.28N/11702.39W-PHG2230/Rick in Poway, CA

If you don't know your latitude and longitude, or if you don't want to tell the world your exact location, the standard procedure is to use your six-character grid-square designator, which provides accuracy to within a few miles. For example, here is an alternate beacon text for my location:

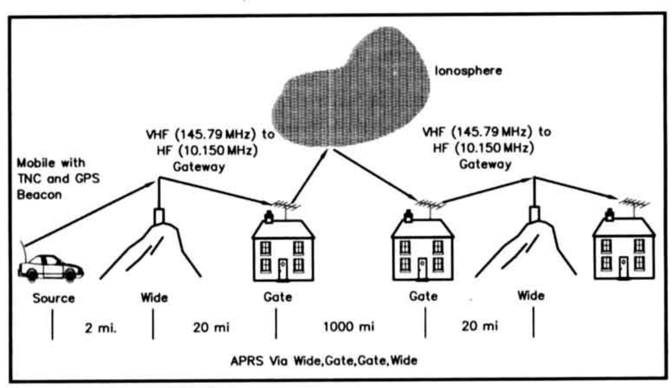
/120800z[DM13la]-PHG2230/Rick in Poway, CA

All of these strings may seem like gibberish, so let's examine them in a little more detail. The first field consisting of the single slash character (/) indicates you are a fixed station with no APRS messaging capability. The second field uses the format, DDHHMM to indicate the date and time. Normally this field contains the current time and date based on real-time GPS information, but since we don't have a connected GPS for this system (or a real-time clock embedded in the TNC), the accepted practice is to specify the date that you started your *APRS*. In our example, 120800z indicates that the system was started on the 12th day of the month at 0800 Zulu Time. The next two fields contain the latitude (3300.28N) and longitude (11702.39W), or a single field for the six-character grid square (DM13la). The next character is a hyphen (-), which indicates that you are a fixed station at your home. There are nearly 200 symbols (characters) available that will designate your station as being in anything from an ambulance to an airplane!

The Power Height Gain (PHG) field contains four digits that represent the power of the transmitter, the height, gain and radiating pattern of the antenna. For our example, 2230 represents a transmitting power of 4 W, and the antenna is 40 feet high with 3 dB gain, with an omnidirectional radiating pattern. If this has you scratching your head in bewilderment, don't worry! The *APRS* documentation (see PROTOCOL.TXT in the *APRS* software bundle) explains it in detail. We'll come back to this in a moment.

After the PHG field you append a comment. This is typically your city and state, name and perhaps a short salutation ("Howdy!").

The only other major TNC parameter that must be set is



Ever wonder how a 2-W, 2-meter mobile station can broadcast its location to the world? With the digipeater path shown, the mobile extension can hop from one station to the next to reach almost anywhere. However, this is not an efficient path and is displayed here to show a concept rather than to propose a realistic use of the APRS network.

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APRS on the Web

You say you can't get on packet? You can still marvel at the APRS information that is available through the Internet. If you have a Web browser and Internet access, you can see live data from Amateur Radio operators around the country and from satellites circling the globe. You can also play back recorded journeys of balloons, cars, and sailboats from history files.

The Kansas City APRS Working Group offers an excellent page at **http://www.kcaprs.org/**. Of particular importance is the link to *Recommended Operating Practices* for APRS users on the Kansas City LAN (Local Area Network). This is a great idea—it aids users in developing efficient networks, which is particularly important for APRS. Also provided is a section on the Kansas City digipeaters, with vital statistics. This page can serve as a model for APRS networking because it not only provides information, it is an excellent coordination tool for the hams in the area using APRS.

Java, the computer language developed by Sun Microsystems, has been available for many years. However, it was not until the advent and widespread use of the Internet that Java has become popular. Amateur operators, and Steve Dimse, K4HG, in particular, were quick to see the potential of using Java to enhance APRS and disseminate information. Steve authored *JavAPRS*, which allows Java-savvy Web browsers to display live APRS traffic. For the Miami, Florida area, point your Web browser to **http://www.bridge.net/~sdimse/javAPRS.html**. There you will find links to many APRS Web sites and the ability to playback previous APRS expeditions such as Steve's 8730-mile journey from Miami to Seattle and back. With *JavAPRS* you can even control the display. You can zoom in and out, up or down, change the center of your viewing area, scroll the map, change colors and more. If this doesn't get you excited, check your pulse.

No amount of APRS Web surfing would be complete without a visit to the Home Page of Bob Bruninga, WB4APR, the father of APRS. At **http://web.usna.navy.mil/~bruninga/aprs.html** you will not only find the position of live VHF and HF APRS channels but also the location of GPS satellites. Terrestrial links are provided to boats, aircraft, and more. This page is an impressive resource and an excellent source for a quick overview of just how pervasive and powerful APRS has become. Of particular importance is a link to **http://web.usna.navy.mil/~bruninga/digis.html**, which shows all known APRS digipeaters nationwide, a *must-see* for all newcomers. It is a live display that will let you see the activity in your area.

The Atlanta Area APRS Home Page at **http://www.mindspring.com/~rwf/aprs1.html** provides an excellent description of APRS, the activities of the Atlanta APRS group, and links to other APRS Web sites. Again a good example of how the Internet can help coordinate and disseminate information.

The authors of the Apple Macintosh and *Windows* version of APRS software, Keith Sproul, WU2Z, and Mark Sproul, KB2ICI, provide excellent Web pages at **http://aprs.rutgers.edu/index.html** and **http://msproul.rutgers.edu/APRS/MacAPRS.htm**. There you can download all three versions of *APRS* software (Mac, *Windows*, and DOS). Also provided are a large number of detailed maps and documentation on virtually any APRS subject.

For information on northern Illinois APRS activity, visit **http://tbcnet.com/~jleonard/n9vjq.htm**. There you will find links to other sites along with a *JavaAPRS* real-time display. Of particular interest are two links that show the path taken by a balloon flight. The 3-D view is particularly interesting.

For northern California, Bob Wilkins, N6FRI, provides an excellent APRS page at **http://www.ccnet.com/~rwilkins/aprs.html**. There you will find links to numerous other APRS Web pages around the country. You will also have a good starting point for finding information on the Global Positioning System (GPS). To aid APRS frequency coordination, a list of the digipeaters in the area is also provided.

Our neighbors to the north in Ontario, Canada, are no strangers to APRS. Take a trip to **http://www.peel.com/javAPRS.html**, where you will find real-time APRS traffic (updated every 15 minutes) as well as the ability to view traffic in previous periods (ie, 15 minutes to 24 hours).

The future of APRS is constantly expanding. For example, take a trip to **http://web.usna.navy.mil/~bruninga/aprs.html** to find how you can have GPS on any radio using the MIM or MIC-EAPR. Pictures and further information on this unique technology can be found there.

The Tucson Amateur Packet Radio (TAPR) is the central point for virtually all Amateur Radio digital communication. Go to the APRS special interest group page at **http://www.tapr.org/tapr/html/sigs.html**. From there you will find a wealth of APRS information and resources.

For those with lots of questions, point your browser to **http://home.sprynet.com/sprynet/ku0g/APRSFAQ.HTM** to examine the APRS FAQ (Frequently Asked Questions). Gary Wells, N3HCP, has developed a page specifically for the newcomer at **http://users.nb.net/~gwells**. If you need more help, join the APRS mailing list by sending e-mail to **listserv@tapr.org** with **subscribe aprssig [FirstName LastName]** in the body of the message. When you ask a question, your message is sent to thousands worldwide and an answer often arrives within minutes.

UNPROTO (unprotocol). Like the PHG parameter, we will cover this in more detail when we discuss networks but, for the present, a good starting path for a fixed station is:

APRS VIA WIDE, WIDE

That's all there is to it. Slight variations may be required depending on your TNC. In most cases, however, it is as easy as setting BTEXT, BEACON, UNPROTO and tuning to 145.79 MHz. At this point you are able to see APRS activity and transmit your location to others. Now let's hit the road.

Taking It on the Road

If you intend to go mobile with APRS, you must have a GPS receiver because your position is constantly changing. The good news is that GPS receiver prices have dropped drastically. With a little careful shopping you'll find a useable GPS unit for under $200. Just make sure it has a NEMA-compatible data port.

Connecting the GPS to the TNC can be a bit tricky, but your TNC manual should offer a step-by-step description. Most GPS devices provide 4800-baud RS-232-compatible signals in a standard format that GPS-friendly TNCs can easily digest.

For mobile use, we are still typically concerned with three parameters: BTEXT, BEACON, and UNPROTO. If the TNC is configured properly, it will take the information provided by the GPS (latitude, longitude, time) and automatically use that as the beacon text. The beacon rate should be set to one-minute intervals, since we are now moving and need to update our position more frequently. Lastly, the UNPROTO path must be set. In our fixed station example, the UNPROTO path was set to APRS VIA WIDE, WIDE. For mobile applications it is common practice to add the digipeater RELAY so that our final path is:

APRS VIA RELAY, WIDE, WIDE

The APRS Network

After spending a lot of time looking at moving dots, I started to examine the packet frames to see exactly what was being transmitted. I had been in packet radio a few years, but seeing frames with a digipeater path of RELAY, WIDE, WIDE, or WIDE, WIDE, GATE, and virtually every other combination imaginable, I was lost! In this section I'll give you some examples of digipeating paths and explain why they are used. Let's pause for a quick

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AX.25 packet refresher course first.

APRS uses the AX.25 protocol, a wireless point-to-point protocol based on the international standard X.25 protocol. Enhancements to the X.25 protocol were necessary to accommodate the unique requirements of wireless communication and the Amateur Radio environment in particular. X.25 is a connection-oriented protocol. This means that it assumes that two stations will connect to each other and handshake before any information is passed between them. However, this would mean that Amateur Radio operators could never call CQ. Remember: By definition a CQ is a one-way broadcast to an unknown destination. For this reason, UI (unnumbered information) frames are provided in AX.25. This is important because all APRS information uses UI frames, so that a single packet can be heard by everyone. When an APRS station broadcasts its location, it has no idea if it is being heard, nor does it expect a response (acknowledgment) that the packet has been received. This means that the packet is operating on an unreliable channel. Because it is only a matter of a few minutes before the information is repeated again, a lost packet for APRS is not as critical as a lost packet in normal packet communication.

Since most APRS activity is on 2 meters, transmission is limited to the line of sight. Add the limitation of mobile communication where the power transmitted is low (typically a few watts) and the antenna system is limited (a whip), it would appear that a mobile APRS station has little or no chance of being heard outside a radius of a few miles. This obstacle is overcome with a little help from your friends. Other local, fixed APRS stations with more power and better antenna systems serve as strategically placed digipeaters. It is through the use of these digipeaters that a mobile can broadcast its location to a large metropolitan area—and beyond.

Let's look at a standard packet station example:

C KK5SU VIA WA3ZFE, KC5PVL

In this example, we are sending a packet to KK5SU through stations WA3ZFE and KC5PVL. This is known as *digipeating* and many packet users do it when the desired station cannot be contacted directly. WA3ZFE receives the packet first and rebroadcasts it to KC5PVL, who repeats it again, sending it to its final destination, KK5SU. This is old hat to the veteran packet user, but its importance cannot be overemphasized in APRS work. Digipeating is a powerful tool and forms the building blocks for APRS networks. It allows the APRS users to extend their range far beyond line of sight.

For standard packet station communication, we know the call signs of the digipeating stations (WA3ZFE and KC5PVL, in the previous example). The same cannot be said for APRS. So how do you digipeat through a station when you don't know its call sign? No problem. All you need to know are the standard *alias* names. Any station that is set up to respond to an alias is capable of handling your packets automatically, even if you don't know its call sign!

Commonly used aliases are: RELAY, WIDE, and GATE. Each alias denotes a very different type of station. A RELAY station is one with a limited range (a few miles). Clearly mobile stations and some fixed stations fall into this category. A WIDE station is usually a dedicated station with wide local or regional coverage. A GATE station has a very wide coverage area (500 miles or more). Most, if not all, GATE stations are really gateways from 2 meters to 30 meters. If you're monitoring your local 2-meter APRS network and suddenly see a symbol showing a station 500 miles away, chances are it is a packet relayed through a GATE. (Depending on your station setup, it might also be a packet that reached you directly via meteor-scatter. Yes, they're doing APRS meteor scatter, too!)

We are now prepared to return to the topic of the PHG (power, height, gain) parameter. As every Amateur Radio operator knows, the line-of-sight range of a station is primarily a function of PHG. Therefore, if we look at the coverage circles of local APRS stations, we are in a good position to develop digipeating paths that are customized to our particular location. Figure 1 shows coverage circles for southern California. If we examine these displays and we determine that we cannot hit a WIDE digipeater, then we would be justified in adding RELAY as the first hop of our digipeating path. In a similar way, if we know that we can hit two WIDE digipeaters, we may wish to use a digipeater path that specifies the call sign of the digipeater rather than using the generic WIDE alias. In this way, we bring up only one WIDE station and reduce channel congestion in the process.

There is a great deal more that can be said regarding the APRS network protocol. However, that is often best learned through on the air trial-and-error and a little experimenting with your particular system. Consider investing in a book that will become your APRS reference: *Getting on Track with APRS* by Stan Horzepa, WA1LOU. It's available from your favorite dealer or directly from ARRL Headquarters.

Conclusion

A lot has happened to APRS since its humble beginnings. I think even Bob Bruninga is surprised at what has become of his idea. New applications and uses are being developed constantly. Imagine enjoying your next fox hunt from the comfort of your car with a laptop computer and a graphical display. Imagine the ability of the Amateur Radio community to provide the National Weather Service with 100,000 weather data points throughout the country. Imagine the ease and accuracy of tracking people and vehicles during expeditions or emergencies. Imagine no more. It is here now; come and join the fun!

[Check out this month's "Up Front in *QST*" for a photograph of Bob Bruninga, WB4APR, the author of *APRS* for DOS, and Keith Sproul, WU2Z, the author of *MacAprs* and *WinAprs*, which perform the same APRS functionality for Macintosh and *Windows 95* platforms, respectively.—*Ed.*]

13842 Deergrass Ct
Poway, CA 92064-2276
e-mail rparry@qualcomm.com
WWW http://www.qualcomm.com/~rparry
packet W9IF @ K6JCC.#SOCAL.CA.USA.NA

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