An Introduction to APRS

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1 What is APRS

The Automatic Packet/Position Reporting System (APRS)[1] developed by Bob Bruninga, WB4APR, is a lightweight system that allows users to tranmit location and other data in single data packets. Normally stations being tracked use GPS receivers to provide real time tracking data.

APRS uses existing packet TNCs (terminal node controllers), Soundmodems and small, low cost micro-controller driven units to transmit standard AX.25 packets on a frequency of 144.800 (144.850 secondary) at 1200 baud. APRS can also be used over HF and satellite links.

APRS is intended as a short-range tactical system; however, APRS systems can be viewed over broad areas using internet gateways. The gateways can be run on low-cost computers, and can mediate the transmission of packets to and from the international APRS-IS system.

APRS is supposed to augment your voice system and should help reduce voice traffic - but is not a replacement for it!

Some applications of APRS have been the following:

- Post Disaster Management
  - Damage assessment
  - Liason tracking
  - Logistics management
  - Site talk in
- Search and Rescue
- Public Service Events
  - Bike Rallies
  - Parades

    - Hillwalking

- Repeater Advertising

2 How does APRS work?

An APRS station broadcasts (beacons) a single packet of information to all stations in range. This packet usually contains GPS co-ordinates and other information. The packet may be received and decoded by any station that can hear it and has suitable software or hardware. Digipeater (Digital Repeater) stations can also hear the packet and rebroadcast it based on rules in the digipeater software and commands that are integral to the packet. Packets that need to travel long distances can also be routed across the public internet.

The fundamental principles of APRS as described by Bob Bruninga are:

- The system should provide reliable real time, tactical digital communications.
- Use a 1200 baud network system operating as an Aloha random access channel.
- You should hear everything nearby or within 1 digipeater within 10 minutes.
- You should hear everything within your Aloha circle within 30 minutes.

3 Whats this Aloha Circle?

In an Aloha network, stations contend for access by waiting to transmit for a random period of time and have not heard any other stations in that period. At 1200 baud, the 144.800 frequency can support 50 or so user stations at reasonable packet sizes and beacon rates. An Aloha Circle is the radius around you that contains enough stations to fully fill up the channel. This will be unique at any location (Look up http://web.usna.navy.mil/ bruninga/aprs/ALOHAcir.txt).

There are some problems with this however. The Aloha circle definition is based on the premise that APRS packets take a finite amount of time to transmit and so only a limited number of users may operate in a given area. Poor station configuration can cause packets to travel too far over RF, causing traffic congestion in distant APRS networks, and thus making the channel unusable for those users. Also, mis-configured stations can cause digipeaters to bounce a packet back and forth, effectively blocking out all other users in the area. In addition, stations that beacon too fast take transmit time away from other users without getting any benefit because the change in location is too small to be seen on a map (or non-existent if the station is fixed).

This means that the rate at which an APRS station transmits beacons is an important consideration. The more often a station beacons, the fewer users can use the system. Your beacon rate should take into consideration what you are intending to accomplish and how fast you expect to be

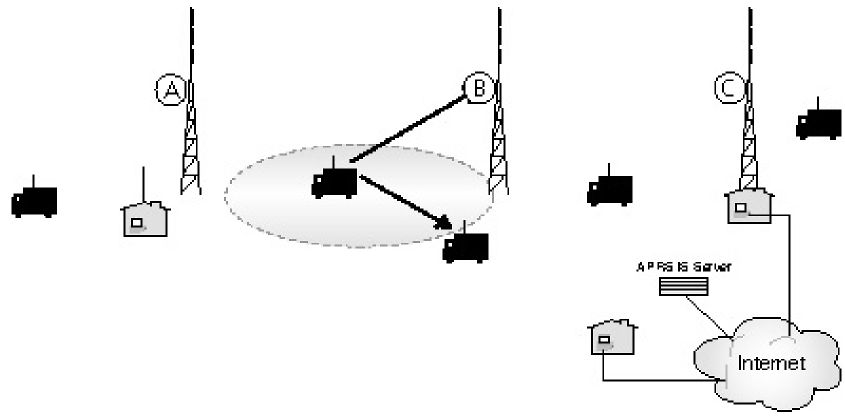

Figure 1: An APRS station beacons and is heard by every other APRS Station in direct range.

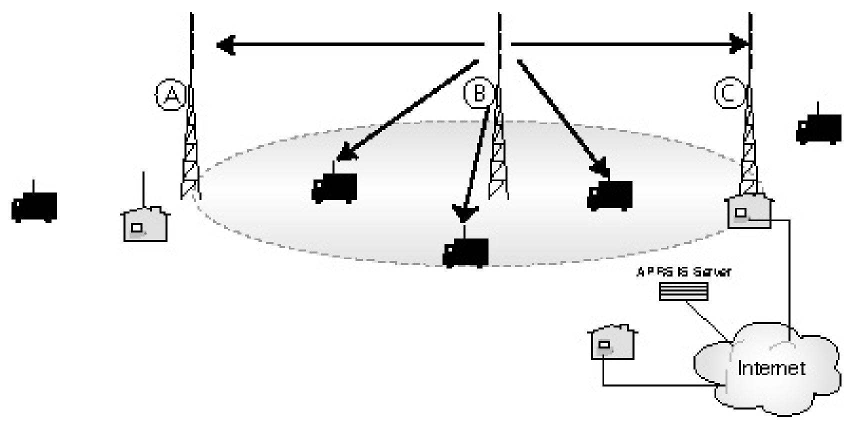

Figure 2: The packet is re-broadcast by every digi than can hear it. The packet is heard by every other APRS station in direct range, including other digi.

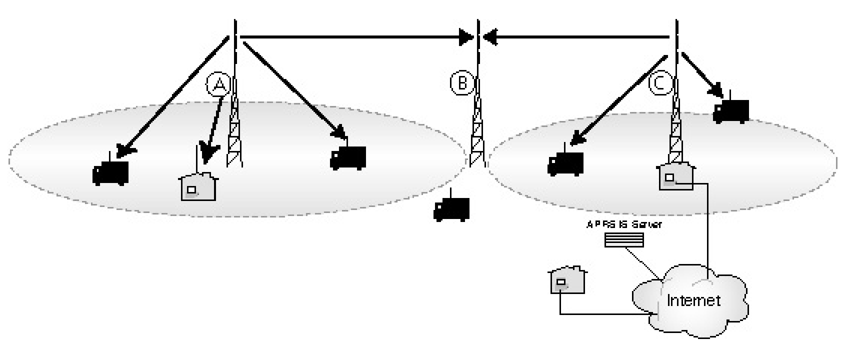

Figure 3: The packet is rebroadcast by every digi that heard the first digi. The packet is heard by every APRS station in direct range of this second set of digis, including the first one.

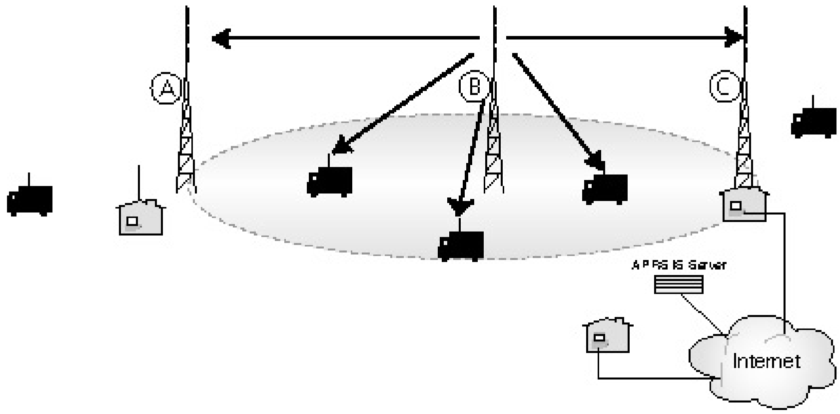

Figure 4: The packet is again rebroadcast by every digipeater in direct range of the second set of digis, including the original digipeater. The new WIDEn-n paradigm (i.e. the use of WIDE2-2 etc) is intended to control this process.

moving. Stations that expect to be moving very slowly over a large area should beacon occasionally (walking/offroading). Stations that are moving rapidly over a small area should beacon more often. If you expect be tracked on a high-resolution map and the person(s) tracking you needs to know exactly where you are, then it makes sense to beacon faster.

Fixed or stationary stations (digipeaters, home stations etc.) should only beacon once every 10-30 minutes

Mobile stations should generally beacon no faster than once every 3 minutes. With a three minute beacon rate, a station will move the following distances at a given speed:

Speed	Distance
100kph	5000m
80Kph	4000m
50kph	2500m
25kph	1250m
5kph	250m

Table 1: Speed vs Distance Travelled in 180 seconds

4 Station Types

Digipeaters A digipeater is a station that retransmits the packets that it hears. There should only be a few digipeaters in a given area i.e. they should have relatively little overlapping coverage. SEARG has the EI2WRC-1 Digipeater up on Mt. Leinster on the primary APRS frequency of 144.800Mhz. It is running APRS specific firmware.

Internet Gateways An internet gateway relays packets from radio to the internet and vice versa. It can be combined with a digipeater and / or a fixed station and would require a computer and

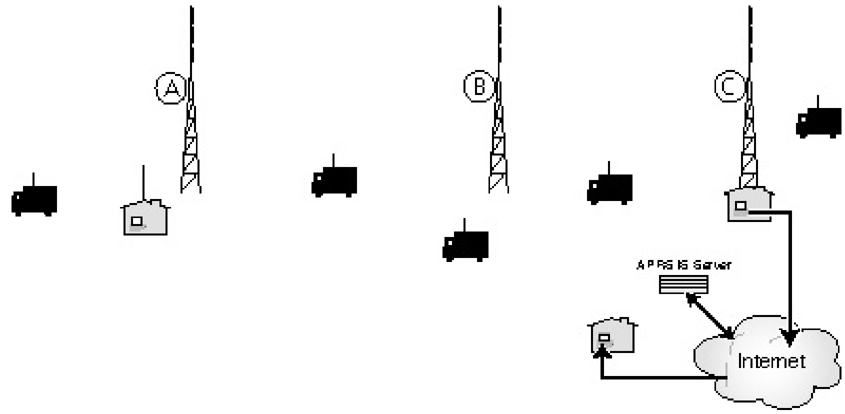

Figure 5: Any packet heard by an internet gateway is transmitted over the internet to an APRS-IS server. This data is relayed out to any APRS software that is connected to an APRS-IS server.

internet connection. Currently there are two in the South East, EI2WRC-3 on 144.800Mhz, and EI3RCW-2 on 144.850.

Fixed Station A fixed station transmits APRS packets, but remains in one place. It can be used to monitor an area or to transmit local information objects.

Trackers A tracker is an APRS station that is capable of transmitting a packet containing location information. They are usually small and portable for moving between vehicles. Examples I have used are the Byonics TinyTrack/PocketTracker[2], the opentracker[3], the Kenwood TH-D7.

Mobile Station Usually a tracker semi-permanently fixed in a vehicle. This can include a computer or a suitable GPS for display purposes (e.g. Kenwood TH-D700)

Passive Stations A passive station only listens to APRS packets, but doesnt transmit anything. Generally used with a computer just to see other stations (this is what we used at *Base* for the galtee walk).

EI3RCW-2 is currently acting as a digipeater and igate (on 144.850) and also as a link for EI3DIB's BBS to receive Packet bulletins. It has links to the dxcluster network and out to the packet radio internet backbone.

Until EI8JA and I have a better way of linking EI3DIB into the packet to internet backbone, this shall remain to be the case. Though 144.850Mhz can be used for APRS around Waterford City, we would encourage everyone to use 144.800Mhz. If and when we solve this problem, we may either put EI3RCW's 2m port onto 144.800Mhz or, more likely, put it on the 145.825Mhz frequency to act as a PCSAT satellite ground station.

I regularly do this while in work. I connect to one of the internet servers that I maintain (http://ireland.aprs2.net:14
This allows me, for example to exchange messages with any APRS station worldwide or track an APRS equipped station anywhere in the world.

5 Configuration Information

You will need to know the following information to configure your APRS station be it software or hardware:

- SSID (Secondary Station IDentification)
- Latitude and Longitude
- Unproto Address
- Beacon Comment
- Beacon Rate
- Status Text
- Status Rate (dealt with above)

Lets briefly examine each one in turn.

5.1 SSID

In Packet Radio you can have up to 15 Secondary Station IDentifiers (SSID's), an example is EI7IG-1 through EI7IG-15. EI7IG without an SSID extension, is considered the 0 (zero) SSID, thus it is possible to have sixteen different stations/calls on the air at the same time using our single call sign. That's where the numbers in the call sign come into play. The added dash numbers (-1 ... -15) are used to distinguish the various station(s) or node(s).

So, your SSID uniquely identifies your station. It consists of your callsign at a minimum and is transmitted every time you beacon. It is very useful when you have more than one station operating simultaneously (mobile/home/portable).

In the early days of APRS, the SSID was used to identify the 'type' of the station for display purposes (its symbol). Nowadays as almost all APRS devices are capable of having a symbol configured and included as part of the beacon this is no longer required, though this convention is still supported and mostly followed (i.e. -4 a bicycle, -9 signifies a car, -10 a motorcycle, -12 a jeep).

5.2 Latitude and Longitude

Latitude and longitude coordinates are angles that describe your location uniquely on the face of the earth. Latitude runs north and south, with values from 0 degrees at the equator to 90 degrees at the poles. Latitudes also need a N/S identifier. This may be done by setting the value negative for southern latitudes or including the letters N or S. Longitude runs from 0 to +180 degrees starting at a line running through Greenwich, England and going east. It runs from 0 to -180 going west towards US. This may be alternatively noted by including the letters E or W. APRS co-ordinates are expressed in degrees, decimal minutes format (+DD MM.mm). That is, the decimal places of the coordinate value are removed from the degrees and multiplied by 60 (i.e. the latitude +32.5000 would be expressed as +32 degrees 30.00 minutes). If you have a GPS connected to your equipment you will not have to enter this manually. The standard settings to use with a GPS are NMEA[4] Out or NMEA In/Out at 4800 baud.

5.3 Unproto Address

There has been huge debate on the 'aprssig' mailing list for the last few months as to what address should be used. Very recently a consensus was reached as to what the paths should be and how digipeaters should be configured[5]. For the South East EI8JA and I recommend that the following paths be used.

Fixed Station WIDE2-1, this should get a packet one hop through the nearest Digipeater and onto the nearest Internet Gateway.

Mobile Station WIDE2-2, as the network expands this should get a packet two hops from (for example) a fringe coverage area into an area with an Internet Gateway

Special Event Stations WIDE1-1, this should keep the traffic fairly local

Digipeaters None, keeps traffic local

Other (less frequently used) addresses that can be used are:

GATE means gate packet to HF

NOGATE, RFONLY means dont gate to Internet

TCPIP, TCPXX, qXX APRS-IS only, not used on RF

As per [5] there is no support for RELAY, WIDE or TRACE in any of the digipeaters or Internet Gateways that we have configured.

5.4 Beacon Comment

The beacon comment is a piece of text that goes out with each beacon Can be anything you want, as long as it is short Monitoring 145.525 Hi from Your email address (bad idea.. Spambots will get it eventually) Your web page

An interesting idea that could be used here comes from Bob Bruninga, which he calls APRS Voice Alert [6]. Basically this means that you do not turn the audio on the radio down, but leave it up and then set a 100Hz CTCSS (or whatever you fancy) tone to mute the speaker. This way you will not hear any packets, but anyone can call you with voice by setting a matching CTCSS Transmit Tone, then you can both QSY for your chat, and when finished you can return to your APRS configuration. This really only applies to mobile stations as a fixed station transmitting a 100Hz tone would cause serious annoyance to every mobile station within range. If you so desired, you could announce in your comment the CTCSS tone frequency you were using, thus anyone within range could call you, and then you could QSY. As it is, with the coverage of the repeater system, I think I'll probably put the IRLP node number in here instead, i.e. "monitoring IRLP Node 5883"

5.5 Status Message

The status message is a text message that is transmitted with your beacon, but not necessarily every time you beacon. Generally you can set your station to transmit your status once every n beacons (where $n > 1$).

Can be used to transmit the status of your station (i.e.):

- On duty
- On station
- En Route
- Committed
- Emergency

If you are using a Tracker of some sort, or a Kenwood APRS capable radio, please, please, be careful about the "Emergency" setting. Every time an "Emergency" status message gets to the APRS Internet System (APRS-IS), all connected terminals worldwide will be alerted to your 'emergency' and may start calling police stations. This could be your local station or their own in order to get assistance to you. I can't imagine how a member of the Gardai would react if an American (most likely source) was on the phone telling them that:

> A Mr O'Donnell, EI2**/MM living on a boat near Cork City at the co-ordinates
> 51 51.00N 008 50.00W needs your assistance immediately!

Worse still, if they did respond, and they found you sitting down in front of the TV watching re-runs of "The Simpsons". This has happened in other countries. You have been warned!

6 APRS Hardware

6.1 TNC

A TNC (Terminal Node Controller) is a basically a packet modem. One port interfaces to a radio, the other to a computer (or GPS receiver).

A Windows software package called AGWPE[7] can replicate the functions of a TNC, thus reducing the cost of a system. On Linux, the soundmodem[8] package acts in a similiar role, replicating the functions of a TNC.

There are some dedicated low cost devices that take the place of TNCs. These include the TinyTrak/PocketTrack and the OpenTracker, in the 50-100 range. These devices are attached to a GPS receiver and are only for transmitting location data they cannot receive (though the TinyTrak & OpenTracker can detect an open squelch).

6.2 GPS Receiver

There are many GPS receivers to choose from, in many shapes and sizes. Some are more practical than others for specific applications. Garmin and Magellan are common handheld brands. Prices range from 100 and up. Bargains can be had(search on Ebay). Any GPS receiver used for APRS must have a data connection and must output NMEA format data (most do). Pfranc [9] are a cheap source of cables which will allow the powering of a GPS from external 13.8 Volts, instead of internal batteries.

6.3 Radios

Whether you use a Mobile or Handheld (lower power) depends mostly on personal preference. Also, as the there is relatively little traffic in Ireland, handhelds should be ok for the foreseeable future, however as the amount of traffic increases (bold assumption!), experience has shown that attempts to use Handhelds have generally been unsatisfactory since the handhelds are having to fight mobile stations putting out 20 to 50 watts. Also worth bearing in mind is that cabling standards can be quite different for each radio / TNC combination. That said, some radios have 'data' DIN plugs that allow for simple, common connections (e.g. FT817/FT7100/FT1500/FT857/FT847 are all identical). There are some radios such as the Kenwood TM-D700 and the TH-D7 that have TNCs and APRS firmware built in, just add a GPS.

6.4 Computers

You only need a computer if you want to see other stations or you want to run an internet gateway or smart digipeater. The one thing to make sure about whether the computer is a laptop or desktop is that it has a serial port to allow you to interface with a TNC/soundmodem. If your laptop/desktop only has a USB port, you can get a USB to Serial adapter for 20 which should do the trick. If you want to run really portable, consider using a palm device or a pocketPC (such as a Compaq iPaq). These are really good if you want to be pedestrian-portable but still need to see other stations. The TH-D7 & Garmin Foretrex can also accomplish this but instead of viewing the stations on a computer, you are looking at them on the screen of the GPS.

7 Getting Set Up

GPS to TNC and TNC to Computer connections are generally RS-232 connections (more on this later) These tend to use either 9 pin or 25 pin DB connectors. RS-232 connections were intended to connect a computer (DTE) to a piece of communications gear (DCE). If you are not sure which pin is the transmit pin and which is the receive, check the voltages between pins 2 and ground and also pin 3 and ground. Generally the pin with a negative voltage is the transmit pin. This should be connected to the receive pin on the GPS and vice versa.

TNC to radio connections are custom depending on both the TNC and Radio. Most Computer to GPS, GPS to TNC and Computer to TNC connections use RS-232 connections.

The physical connector at the GPS receiver is often proprietary, forcing you to buy from them. Garmin has a range of 3rd party connectors available (eBay and pFranc). The physical connector at the computer (or TNC) end is usually a DB-9 9 pin connector. Other connectors are possible (a stereo miniplug, is used by the Kenwood TM-D700/PocketTracker).

You can test your GPS by plugging it into your computers RS-232 port and configure a terminal program (such as Hyperterminal/Minicom/Zterm) to look directly at the comm port rather than a modem. The most standard data configuration for GPS is 4800 baud, 8 bits, 1 stop bit, no parity. You may have to configure your GPS for is NMEA (maybe NMEA OUT / NMEA IN). NMEA stands for National Marine Electronics Association, and is a standard that defines all sorts of connection standards for shipboard navigation equipment.

7.1 GPS Accuracy

If accuracy is how correct a position is, with precision being how finely resolved a position is, then GPS positions are often very precise, but not that accurate (switch on your GPS with a clear sky, sit still and watch the numbers slowly change). Accuracy is influenced by environmental factors including ionospheric distortion and satellite geometry.

Consumer grade GPS receivers are accurate to 30 meters (90 feet), some are a bit better. Some receivers have WAAS (Wide Area Augmentation System), a separate correction signal that adds additional accuracy, down to about 5 meters (I've yet to see it work properly here, though I have seen some *extra* satellites appearing now and again).

8 Software

If you want to see APRS stations, youll need some software There are software packages for most operating systems:

- Dos: AprsDos
- Windows: WinAprs, UIView, APRS+SA, APRSPoint, Xastir
- Mac: MacAprs, Xastir
- Unix: Xastir
- PocketPC: APRS-CE
- Palm: PocketAPRS, PalmAPRS

And some internet based services such as findu (i.e. http://www.findu.com/cgi-bin/find.cgi?EI7IG-9) For comparisons, see WE7Us list at: $http : //www.eskimo.com/\ archer/aprs_capabilities.html$

If you wish to connect to an Internet Server I would suggest connecting to Ireland.aprs2.net port 14579. Look at http://ireland.aprs2.net:14501 for more information on the ports available.

8.1 Does this APRS stuff work?

In short Yes! To keep the channel active locally, I've currently configured the Node in Templetown EI2WRC-3 to automatically track and transmit satellite objects for the satellites vo52, ao51, iss, so50, and uo22. If you have a Kenwood APRS radio switched on and tuned to 144.800Mhz you should, after a few minutes, see a list of satellite objects along with other stations that are acive, this will include:

EI8JA his Weather Station is running 24x7.

EI2WRC-1 APRS Digi on Mt. Leinster.

EI2WRC-3 APRS Igate/Digipeater in Templetown.

EI7M-1 APRS Digi in Cork (should be operational by the time you read this).

Depending on the time of day you may also see:

EI7IG-9 mobile on my way into or from work (Status will be On-Duty)

EI7IG-5 walking (most likely in the hills somewhere)

EI8JA-9 mobile

EI8FRB-9 mobile

EI5HW mobile on his way into work or following a balloon somewhere

As well as many other stations (EI and others) that are able to hit either the Templetown or Mt. Leinster Digipeaters.

8.2 Discussion

In summary, APRS is a real-time tactical digital communications protocol for exchanging information between a large number of stations covering a large (local) area. As a multi-user data network, it is quite different from conventional packet radio.

APRS turns packet radio into a real-time tactical communications and display system for emergencies and public service applications (and global communications). Normal packet radio has only shown usefulness in passing bulk message traffic (Email) from point to point. It has been difficult to apply conventional packet to real time events where information has a very short life time and needs to get to everyone.

Although the recent interfaces to the Internet make APRS a global communications system for live real-time traffic, this is not the primary objective. How we use APRS in an emergency or special event is what drives the design of the APRS protocol. Although APRS is used almost all of the time over great distances, and benign conditions, the protocol is designed to be optimised for short distance real-time crisis operations.

APRS provides universal connectivity to all stations by avoiding the complexity and limitations of a connected network. It permits any number of stations to exchange data just like voice users would on a voice net. Any station that has information to contribute simply sends it, and all stations receive it and log it. Secondly, APRS recognises that one of the greatest real-time needs at any special event or emergency is the tracking of key assets. Where is the Scene Co-ordinator? Where are the emergency vehicles? In order to provide for these scenarios, APRS is a full featured automatic vehicle location and status reporting system too.

Although most APRS software can automatically track mobile GPS equipped stations, it also tracks perfectly well with manual reports. Additionally, any station can place an object on his map including himself and within seconds that object appears on all other station displays. In the example of a parade, as each checkpoint with packet/APRS comes on line, its position is instantly displayed to all in the net. Whenever a station moves, (s)he just updates his position on his map and that movement is transmitted to all other stations. To track other event assets, only one packet operator needs to monitor voice traffic to hear where things are. As (s)he maintains the positions and movements of all assets on his screen, all other displays running APRS software display the same displays[11].

Some Radios such as the Kenwood TM-D700 have APRS built in, this allows it to be used completely independently of a computer. If it is used as a home station, and the position is programmed into the radio, a distance and bearing to all received stations is available on the display, and short messages can be exchanged with other stations on frequency. With the addition of GPS to this radio (and indeed its smaller brother the TH-D7), the mobile station can be tracked in real-time on the console of any other APRS capable radio or on the screen of any APRS equipped computer. Also, if the connected GPS is capable of storing waypoints, the TM-D700 can be configured to put waypoints into the GPS of received APRS equipped stations. These Waypoints can then be used as 'gotos' and, in some cases, one can navigate towards one of these points, even if it is moving (the radio keeps updating the GPS, which keeps recalculating the distance and bearing to the station).

Things change slightly with the addition of an Internet Gateway (or Igate). An Igate takes the packets heard on RF and pushes it into the APRS internet backbone. Briefly, there are several core[12] servers that exchange all packets between them, there are also second tier[13] servers which connect to these core servers. The purpose of these is to reduce the load on the core servers. I run a tier two server (http://ireland.aprs2.net:14501) on a server belonging to my (most benovelent) employer[14] hosted in HEAnet[15] in Dublin. The Igate which is running in Waterford IT (EI3RCW-2) is connected into this aprs-is server as well as is Igate in Templetown (EI2WRC-3). Both send all (received from RF) position reports and messages up to ireland.aprs2.net, and also receive (and transmit to RF) all messages destined for a local ARPS station. This allows someone removed from the situation i.e. in a different country, to see what is happening in an area around an Igate. This allows me, for example, to monitor APRS activity while I'm in work with no radio. I connect my APRS application, Xastir[16] to the ireland.aprs2.net, as the Igates receive packets on their RF ports they forward them to the tier 2 server, which sends them back down to me (and other clients) and also forwards those packets onto one of the core servers.

Users are encouraged to use the tier two servers, as it helps reduce the load on the core servers. If you are looking for an internet server to connect to I would recommend ireland.aprs2.net. Use port 10155 if you wish to see all the APRS data for europe, port 14578 for just the UK or port 14579 for Ireland. The primary frequency for APRS in Ireland is 144.800, have a listen out, you might just be surprised at how many stations are within radio range.

9 Acknowledgements

This article is largely based on a presentation given by John Beadles N5OOM[17]. Many thanks to John McCarthy, EI8JA for his work on the Packet Network in the South East and to Mr Kristian Walsh for asking difficult questions. APRS is a registered trademark of Bob Bruninga, WB4APR

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