VHF Packet Radio
With a Focus On EMCOMM

Presented to the
Stamford Amateur Radio Association

by

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In an EMCOMM situation, it is expected that the bulk of information that would be sent by ham radio is data and not voice

- **Data examples**
  - Shelter population lists
  - Logistics lists
  - Volumes of health and welfare messages
  - Stuff that can be stored on computers, sorted, processed, printed, etc.

- **Why not voice?** According to the senior ARES people:
  - We are not “first responders”, we are not field search and rescue
  - We can expect to be at shelters and other fixed sites communicating volumes of information
  - Voice is a much less efficient means of communicating volumes of information
  - Data can be stored on computer, can be further processed, can be sorted and summarized, etc.

Contrast with Public Service scenarios that are mostly short-message, real-time voice
VHF Packet uses radio and computer to send data reliably

- Uses a protocol (AX.25) similar to that of the internet to transfer data
  - Internal error checking
  - Automatic retransmission in case of errors or missing data

- For ham radio, generally 1200 or 9600 baud (bits per second), including the control, numbering, error correction, and routing information, but not including retransmissions
  - Figure 20-40 characters per second of actual data at 1200 baud
Data sent via Packet Radio can be stored on computer

- Once on the computer as a file (e.g., Word, Excel, email message), the data can be further processed, routed, sorted and summarized, etc.
  - EOCs in disaster prone areas have large, self-contained networks for handling data
Sample transmission times

- KB1QBZ in Stamford to N1EZT in Rowayton, using an older Dell laptop (Latitude D600) and a Yaesu FT-7800 at 25 watts FM

- Notes:
  - 3600 seconds in an hour
  - Includes time to connect/handshake and time to disconnect
  - Random generated message contents

<table>
<thead>
<tr>
<th>Chars</th>
<th>Seconds</th>
<th>Equiv Minutes</th>
<th>Characters/Second</th>
<th>Equiv lines of text (100 chars/line)</th>
<th>Equiv H&amp;W emails (200 chars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>52</td>
<td>&lt;1 min</td>
<td>&lt;1</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>100</td>
<td>49</td>
<td>&lt;1 min</td>
<td>2</td>
<td>1</td>
<td>n/a</td>
</tr>
<tr>
<td>1,000</td>
<td>73</td>
<td>1:13</td>
<td>13</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>10,000</td>
<td>403</td>
<td>6:43</td>
<td>25</td>
<td>100</td>
<td>50</td>
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<tr>
<td>100,000</td>
<td>3295</td>
<td>54:55</td>
<td>30</td>
<td>1000</td>
<td>500</td>
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</table>
Packet Radio is also the most commonly used form in ham radio for sending telemetry data such as APRS.
Packet Radio is a form of digital communications

- What is “digital communications”?  
  - Sending information as digital “bits” (0s and 1s)  
  - Can be:
    - Voice that has been digitized (e.g., Voice over IP)  
    - Data (letters, numbers, punctuation)  
    - Digital representations of amorphous objects like pictures (e.g., JPGs, MPEGs, WAVs)

- In ham radio, “digital communications” mostly refers to sending data, if for no other reason than bandwidth issues
  - Not much digitized voice  
  - Pictures, voice, etc. generally too big for efficient communications at HF and even VHF

- At a bigger picture level, digital is generally a more efficient communications method than voice or even CW
  - Much lower power required  
  - Much reduced bandwidth needs  
  - Some modes provide error checking (see later)  
  - e.g., Worldwide DX on 40 meters at 25 watts using PSK31
A brief refresher - how data is represented digitally

- **ASCII code** – used in Packet Radio -- uses 8 bits (combinations of eight 0s and 1s) to represent the alphabet, numbers, punctuation, and control codes.
  - For example:
    - 01000001 represents ‘A’ (capital A)
    - 01100001 represents ‘a’ (small A)
  - With 8 bits, ASCII can represent 256 letters, numbers, punctuation, other characters and control symbols
  - ASCII is the standard for most computers

- **Various other codes have been developed over the years**
  - Baudot: used for RTTY, invented in 1870, uses 5 bits
    - Inefficient with modern computers due to limit to number of different possible combinations
  - Huffman: used for PSK31 and others, invented in 1950s, uses variable number of bits
    - 010 represents ‘a’ (small A)
    - 1101 represents ‘f’ (small F)
    - 10011 represents ‘p’ (small P)
Packet is a specific protocol that defines how to send the bits in a way that limits transmission errors

01011101110010111010000100101010101011100110101110011010111100001101010101010111001101010011100011

- The data is broken into “packets” of some number of bits, with each packet containing error checking and routing information.
  - Number of bits depends on various factors such as transmission speed and conditions
  - Essentially the same protocol as is used for sending transmissions across the Internet
- The receiver uses the information to determine if it received everything and received it correctly
  - Internal consistency checking on receipt
  - Confirmation on receipt
  - Retransmission if errors detected
  - Not perfect, but pretty good
Digital is sent over radio by modulating SSB or FM with different tones

- Two primary schemes used in amateur radio:
  - Frequency Shift Keying (FSK)
  - Phase Shift Keying (PSK)

- Many other variations, but not normally found in amateur radio
  - GMSK (a/k/a GSM)
  - CMSK
  - MSK
  - ASK (Amplitude Shift Keying)
  - OOK (On-Off Keying)

- Some variations such as GMSK are highly sophisticated; others such as ASK and OOK are very primitive
  - GMSK is the scheme used in most cell phones (2G, 3G, 4G)
  - OOK, at its heart, is CW
Frequency shift keying simply changes tones – one tone represents 0s and the other represents 1s

- Variations such as AFSK, BFSK based on where the tone is inserted
- AFSK most common in amateur radio – tone is inserted at the microphone (or in place of the microphone)
  - Not as efficient as others, but much less expensive

Source: Wikipedia Commons
Phase Shift Keying uses the phase relation between two tones to represent 0s and 1s.

- Variations include BPSK, QPSK based on how the tones are phased and how the tones are combined.
- In general, PSK is more reliable than FSK (i.e., can be detected and decoded at lower levels of receive strength and higher levels of interference).

Source: Wikipedia Commons
Note that most digital communications is continuous duty cycle

- Duty cycle: percent of time the transmitter is outputting at full set power
- In SSB, the transmitter is rarely outputting at full power because it is amplitude (i.e., power) modulation
  - Similarly, CW is not continuous duty because of pauses between dots and dashes
- For most digital, and especially for packet, the transmitter is outputting continuously during a transmission – AND IS OUTPUTTING AT THE FULL SET POWER
- Most ham equipment CANNOT handle continuous duty cycle at full power
  - e.g., a 100 watt multimode rig that will run 100 watts on CW/SSB, but is limited to 50 watts on AM/FM
- It’s not just the transceiver – antennas, transmission lines, tuners, baluns, etc. may not be able to take continuous duty cycle

Equipment is usually rated for continuous duty cycle in FM (and AM), but can the antennas, etc. take it?
To get the data to/from the radio, we need two things:

1. **MOdulator/DEModulator**
   - Converts bits to sounds and converts sounds to bits
   - a/k/a MODEM
   - Used for years to let computers communicate over land lines

2. **Packet Assembler/Disassembler (PAD)**
   - Create packets for outbound data
   - Decode packets on inbound data (include the error checking)
   - Communicate with the other station and arrange for re-transmissions when there are errors

3. For extra credit, we can add “HOST” services such as a bulletin board system
Early interfaces were Terminal Node Controllers (TNCs), which provide a MODEM, PAD, and HOST services

- **Two modes of operation**
  - KISS: Basic MODEM plus PAD
  - HOST: Advanced services such as Bulletin Board systems

- **Needed TNCs in the “early days”** when our computers could not handle both the text processing and the packet processing at the same time (not to mention the HOST services)

- **Best known name: Kantronics**
  - TNCs ranging from about $200 to over $500 (new)
  - More advanced models can control multiple rigs and multiple computers
  - Relatively bulky and need their own power supplies
But more current computers have plenty of computer power and have sound cards

- Basic computer sound card does everything a modem does
- Plenty of software that can process packets; plenty of processing power
- Enter sound card interfaces such as RIGblaster
  - Need a good sound card in good working order and a reasonably fast computer (say circa 2002 or beyond)
  - Does not provide HOST services
  - Some older software does not work with sound card interfaces, but other newer software only works with sound card interfaces
  - Less than half the price of a full Kantronics TNC
  - Also: Small and lightweight, no power supply needed if connected to computer via USB
Newer radios have data jacks for a single connection for sound in, sound out, and rig control

• Eliminates connectors to mic and headphone jacks
• Advanced rig control functionality (tuning, squelch, mode/band)
• Example: Yaesu FT-897 6 pin mini-DIN

**Pin Description**

1. Data IN
2. GND
3. PTT
4. Data Out (9600 bps)
5. Data Out (1200 bps)
6. SQL
Some of the newest TNCs/interfaces are light, small, and relatively inexpensive

- Generally under $100, e.g.
  - TNCs: Coastal Chipworks TNC-X, Byonics TinyTrak4
  - Sound card interfaces: RIGblaster (various models), Buxcomm Rascal
  - External sound card: Tigertronics SignaLink USB

- No HOST mode

- With USB interface, powered by rig

- Provide packet processing for equipment that doesn’t have packet processing capabilities such as GPS receivers

- Suitable for very portable operations (e.g., field APRS transmitter, digipeater)

Byonics MicroTrak AIO (GPS field tracker) uses a MicroTrak4 connected to a 2m HT
So what do I buy?

- Older TNC, Sound Card Interface, or Newer TNC?

- Answer: Yes
So what do I buy?

- Older TNC, Sound Card Interface, or Newer TNC?

- Seriously, some of the issues:
  - At this point widest range of software works with older TNCs, but that is rapidly changing
  - The basic software we need works with sound card interfaces and with newer TNCs as well as older TNCs
  - Some sound card interfaces and newer TNCs come with cables pre-built for specific rigs
  - New TNCs better suited for use with APRS transmitters and with digipeaters
  - Conventional wisdom is that sound card interfaces and newer TNCs can be more difficult to get connected and working, but not clear that this is true -- or at least that connecting them is any worse than connecting TNCs
  - $s
  - No known compatibility issues re: signals sent through older TNC being read by newer TNC/soundcard or vice versa
Many ARES groups are focusing on VHF packet with Winlink

- Winlink is a worldwide emergency email system connected to the Internet
  - Five servers around the world (planned), three currently in operation
  - Radio access (RMS) from local stations and also direct internet connection (CMS)
  - Once a message makes it to a Winlink server, it enters the Internet as a standard email message, and regular internet email can flow from Winlink to the local packet stations via RMS or CMS (//WL2K preface)
  - RMS station is VHF packet radio interfacing to a computer running RMS software
  - http://www.winlink.org
Basic concept is packet radio within the disaster area to an RMS packet station outside the disaster area

- Local stations can send each other email (via Winlink) and also communicate with the outside world via the RMS Packet station outside the disaster area
With the addition of RMS Relay, a station in the disaster area can perform as a message server

- Local stations can send each other email via the RMS Relay station without a need to get a signal outside the disaster area
The RMS Relay station can communicate with the outside world through digipeaters

- Local stations can send each other email via the RMS Relay stations
What software/hardware for the local station accessing Winlink?

**Email Client**

Standard email client such as Outlook, Outlook Express, or Thunderbird

**Paclink**

Free software from Winlink – interfaces between the email client and the packet engine. Replaces Airmail, which was its own email client

**AGW PE**

Packet engine software (processes the packets) – AGW PE (free) or AGW PE Pro ($30) from SV2AGW

Technically don’t need AGW if using a TNC, but most people use the AGW software and leave the TNC in KISS mode

**Limit of 120,000 characters per message**
You can see a map of local Winlink stations

http://www.winlink.org/RMSPacketPositions
Repeaters, digipeaters, and Packet Radio

• Typical VHF Packet Radio does not work well with regular VHF ham repeaters
  – Typical repeater’s delay between unkeying and carrier drop will often cause time-outs
  – Courtesy tones do ugly things to packets

• Digipeaters (DIGItal rePEATERS) are repeaters specifically designed for extending digital communications (and especially Packet Radio communications).
  – Generally small, lightweight (size of a typical VHF mobile radio or smaller)
  – Generally can run for days on 4 AA batteries
  – Can be quickly deployed with a portable antenna
Other protocols may also be of interest

- **NBEMS (Narrow Band Emergency Messaging System)** – a newer method focused on HF for direct communications from disaster areas to EOCs (inside or outside of the disaster area)
  - Can also be used for VHF

- **HF Pactor** – Packet Radio over HF for longer-range communications, including EMCOMM from within a disaster area to outside the disaster area
  - Most users operating Linux with higher-end computers
  - Does not work with most sound cards interfaces
  - Typically 300 baud

- **WINMOR** – HF protocol for use with Winlink
  - New
  - Works with sound card
  - 300-1200 baud

- **PSKMail** – mail via PSK31 (or other PSK modes)
  - Works well with relatively short HF messages
  - Very limited error checking
Useful Web Sites

- Winlink: //http:www.winlink.org
- Yahoo Loading WL2K group: groups.yahoo.com/group/LOADING_WL2K_USER_PROGRAMS/
- Yahoo Winlink EMCOMM group: //http:groups.yahoo.com/group/wl2kemcomm/
- Yahoo Paclink group: //groups.yahoo.com/group/PaclinkMP/
- Narrow Band Emergency Messaging System: //w1hkj.com/NBEMS/
- Yahoo DigitalRadio group: //groups.yahoo.com/group/digitalradio/