

APRS: How It Works



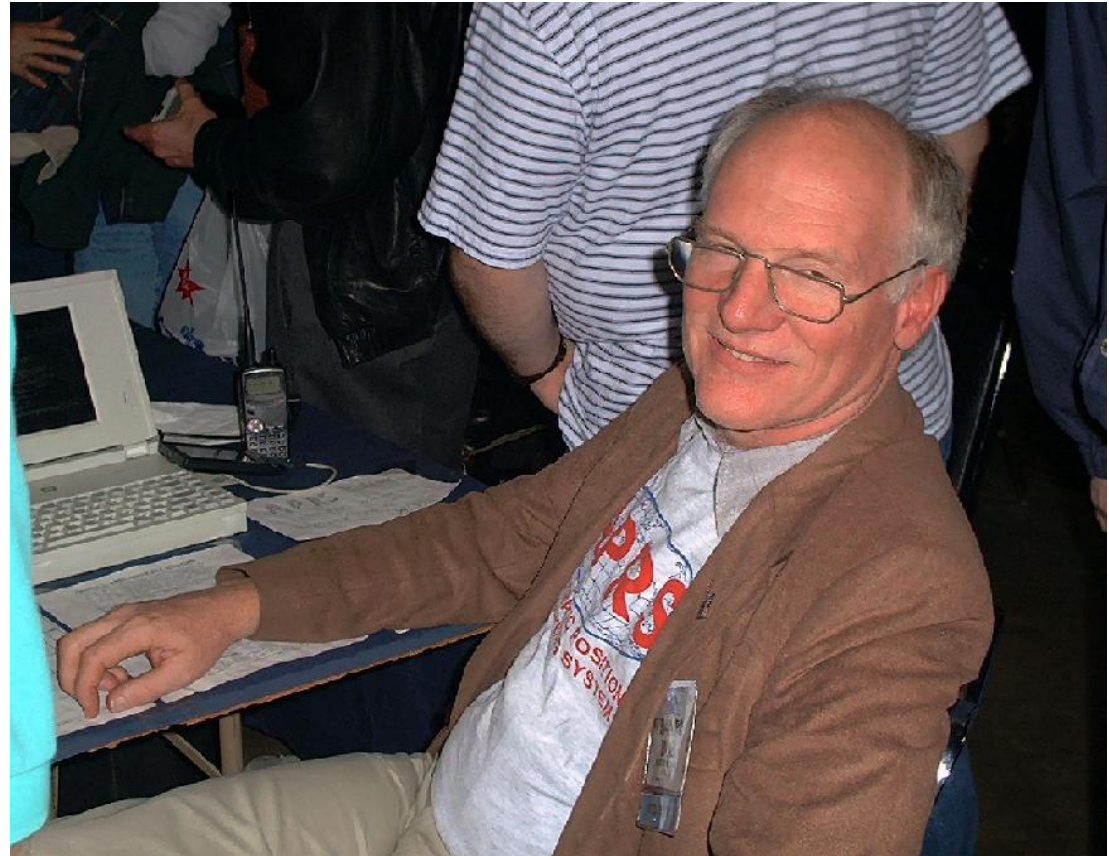
Concept of APRS

- Multicast digital packet radio
- One-to-many transmissions
- Lossy but redundant
- Simple ASCII text packet format
- Short packets for local tactical info updates
- Not just for vehicle tracking!
- Information exchange for everyone!

“**Automated Packet Reporting System”**

Where did APRS come from?

- Originally invented in 1984 by Bob Bruninga WB4APR at USNA
- Current version established in late 1990's



How does APRS work?

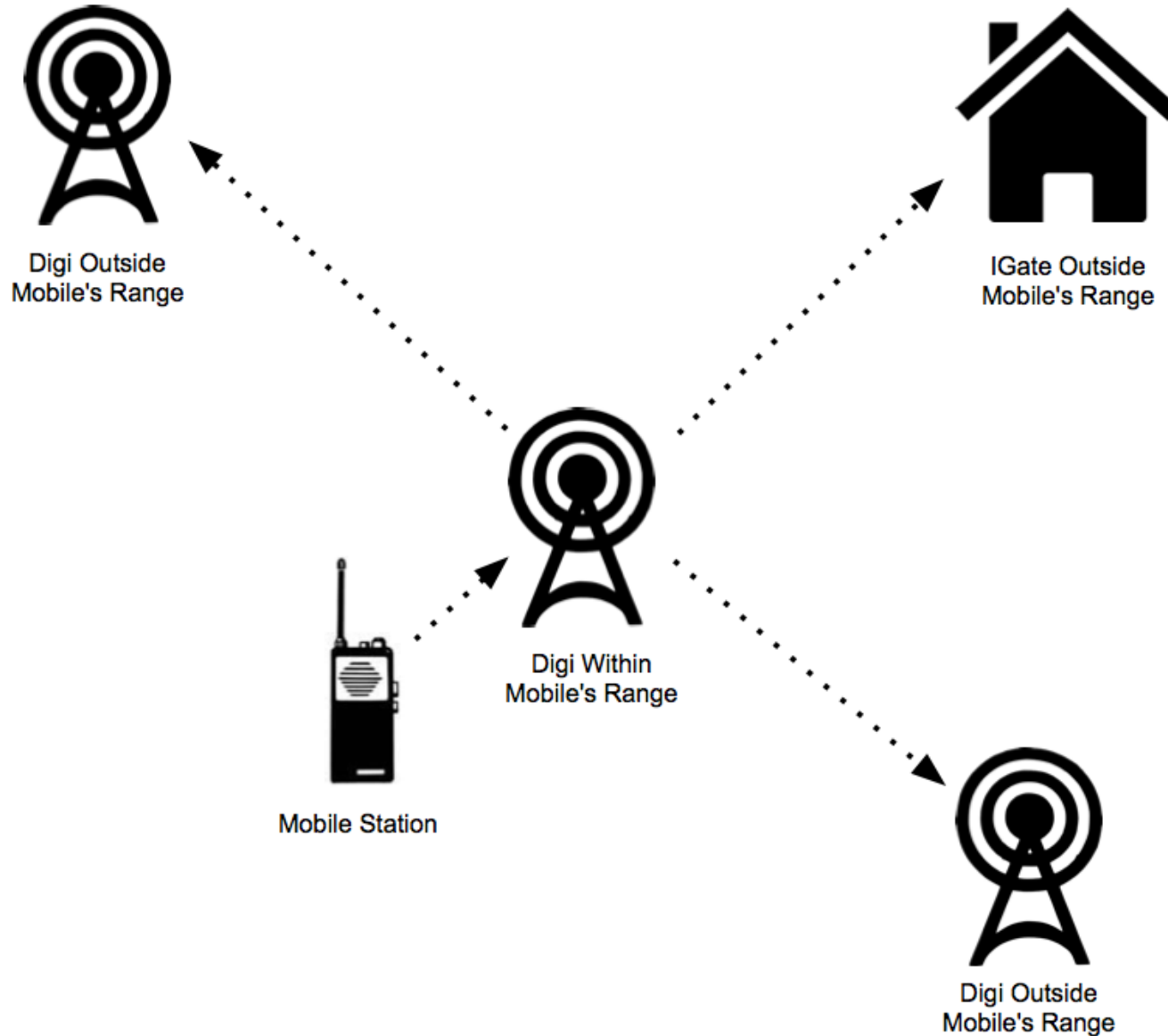
- AX.25 packets using CSMA for collision avoidance, Bell 202 modem tones for 1200 baud (AFSK 1200 and 2200Hz), HDLC synchronous serial
- Transmit AX.25 UI (unnumbered information) packet

Flag	Address	Control	PID	Info	FCS	Flag
01111110	112/224 Bits	8/16 Bits	8 Bits	N*8 Bits	16 Bits	01111110

- Sender callsign is station's callsign
- Destination callsign is arbitrary (usually identifies sending station type); all stations in range process packets regardless of destination
- PID=0xF0: no level 3 AX.25
- Body is ASCII text, APRS Protocol Specification describes packet formats

<http://www.aprs.org/doc/APRS101.PDF>

More range → digipeating



Digipeat paths

- Old connected-mode packet required you to know callsign of each digipeater to be used
- Digipeater callsign marked as has-been-repeated on retransmit
- APRS invented generic aliases
 - If station is a digipeater, it accepts for alias as well as its own callsign

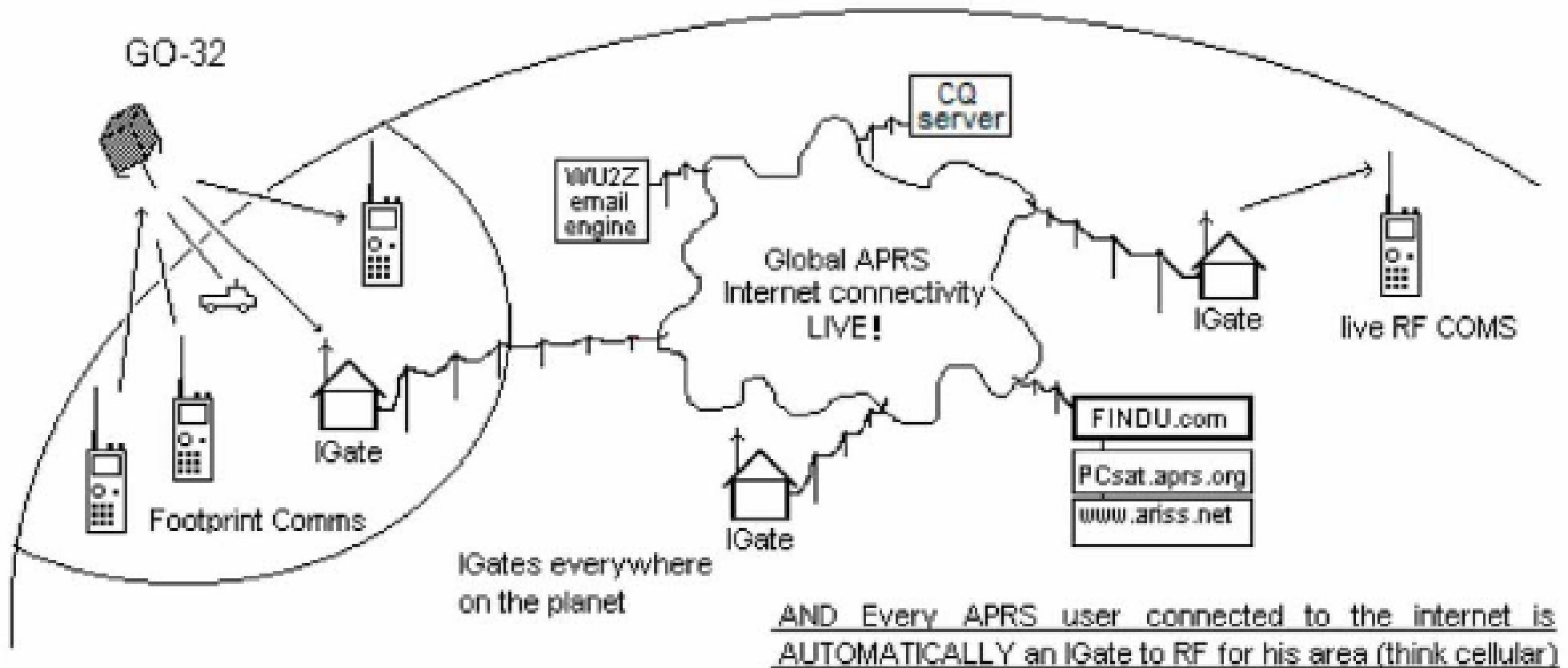
1st generation APRS digipeaters

- WIDE for wide-coverage digipeaters (high)
- RELAY for short-coverage “fill-in” digipeaters
- TRACE to make digi insert its callsign into path as used
 - Before: TRACE,TRACE
 - After: D1GI-2*,TRACE*,TRACE
- Problem for long paths:
 WIDE,WIDE,WIDE
 would ping back and forth between pair of digis, clogging local channel with duplicate traffic
- TRACE limited to 4 digis because of path expansion

2nd generation digipeaters

- “New-N” paradigm
 - Alias WIDEn-N, where n and N are numbers
 - Example: WIDE2-2 gets two hops
 - SSID number decremented at each use: WIDE2-2, WIDE2-1, WIDE2-0
 - When SSID reaches zero, alias marked as has-been-repeated
 - Trace callsign(s) inserted before alias
 - Before: WIDE2-2
 - After: D1GI-2*,WIDE2-1
 - After: D1GI-2*,D2GI-3*,WIDE2*
 - Digipeaters remember hash of digipeated packet
 - Sender callsign and body only, so path trace changes don't change hash
 - If hash seen in last 30 seconds, don't digipeat → loops prevented
 - Some local aliases SSn-N
 - example: MDn-N for only digis within the state of Maryland

Even more range → I-gates



I-Gate architecture

- APRS stations with both radio and Internet
- APRS-IS backbone network
 - Worldwide network of Internet-linked servers
 - Tier 1 (core) servers: aprs.net
 - Tier 2 (regional) servers: aprs2.net
 - noam.aprs2.net, euro.aprs2.net, asia.aprs2.net, soam.aprs2.net, aunz.aprs2.net
 - I-gates authenticated by callsign and passcode
 - Port 14501: status
 - Port 14580: filtered data feed

I-Gate operation

- Receiving
 - Every RF packet heard sent to backbone
 - Backbone forwards only first occurrence of same packet if received by multiple I-gates
- Transmitting
 - I-gate only forwards Internet packet to RF if:
 - 1)Text message specifically addressed to an RF station forwarded by that I-gate
 - 2)Next position report from Internet station sending use case 1 packet
 - 3)Specifically configured for forwarding by this specific I-gate
 - Transmitting may put I-gate operator at risk for “inappropriate content”
 - This is why anything connected to APRS-IS needs a callsign and passcode

What can APRS do?

- Trackers for public service events
- Weather stations
- Text messaging
- Bulletins
- Local Info Initiative
- Voice Alert
- QRU
- Internet services
- Telemetry
- Satellite communications
- Cross-connect with D-star (DPRS)

APRS Weather Data

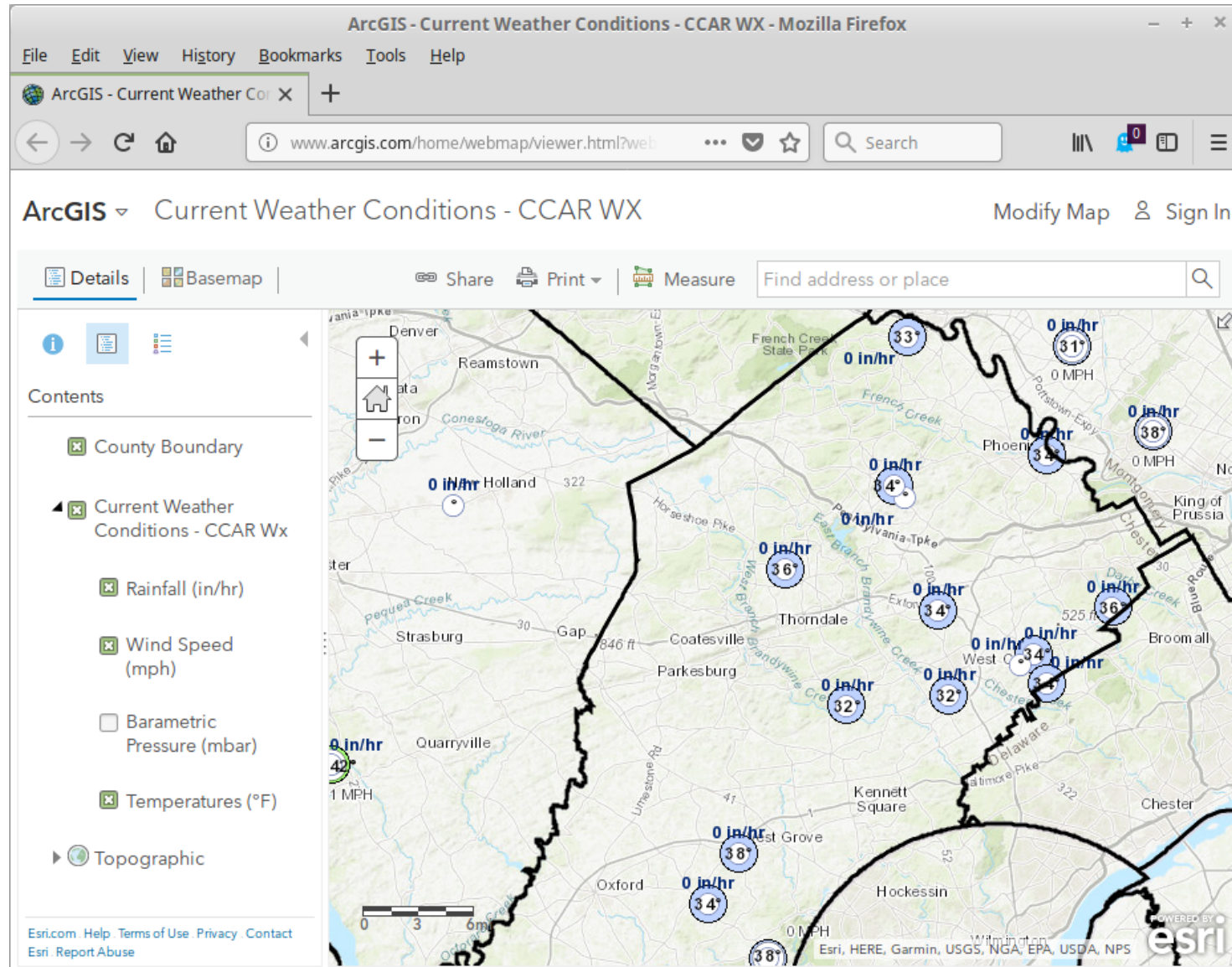
```
_11101627c000s127g127t056r7477p000P2304h87b05130wDVP  
!4009.00N/07524.00W_268/000g015t040r000P000p078h58b10167.VWS-DavisVP2
```

Weather data includes:

- wind course, speed, gust
- temperature
- rainfall
- humidity
- barometric pressure
- other info (light intensity, station battery voltage, etc.)

WX example: CCDES Weather site

<http://arcg.is/1AhzTEt>



Example trackers

- Byonics MT-AIO
 - Tx-only
 - Based on TinyTrak3
 - Built-in GPS
 - Time-slotted

Other trackers include:

OpenTracker,
Sainsonic AVRT5



APRS Text Messaging

:recipient:"text message"}acksq

- *recipient* can be a station callsign-SSID or a generic service name
- *"text message"* is free text up to 68 characters (some named services require a specific format)
- *acksq* is optional sequence number for 1-to-1 addressed message, so receiver can acknowledge receipt; unacknowledged message retransmitted until retry exceeded or acknowledged or rejected

Date/Time	Sender	Addressee	Text	Seq#
19/Oct/2018 16:21:06	NE1CU-9	AB1JC-9	Wow!	32

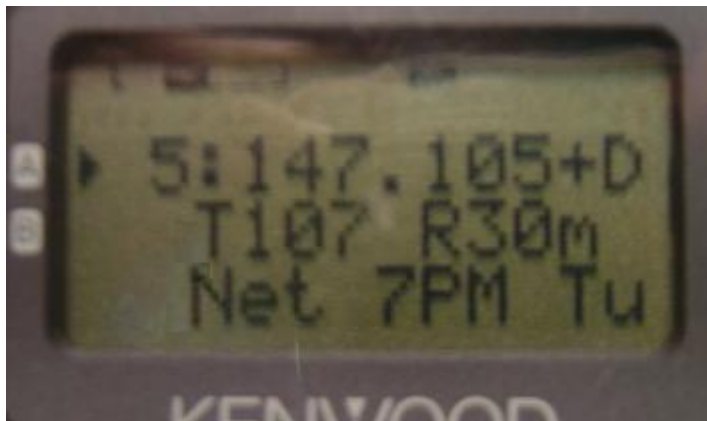
APRS Bulletins

- Special case of text message, meant for multiple recipients
- Recipient is *BLN n grp*
 - n is line number of multi-line bulletin
 - *grp* is optional identifier for different bulletin page from the same sending station
- Bulletin line can be updated at any time by retransmitting line packet with change

Date / Time	Sender	Addressee	Group	Message
27/Oct/2018 17:44:03	WXBOT	BLN0		WxBot 1.25 US weather forecast via APRS message.
27/Oct/2018 17:44:03	WXBOT	BLN1		Send a message to WXBOT for a weather forecast at your location.
27/Oct/2018 17:44:03	WXBOT	BLN2		see https://sites.google.com/site/ki6wjp/wxbot

APRS Local Info Initiative

- Provide local information to mobile stations as APRS Objects
 - Nets
 - Hamfests
 - Local repeaters (with autotune for Kenwood and Yaesu APRS rigs)



<http://aprs.org/localinfo.html>

APRS Voice Alert

- Kenwood APRS radios can do this
- Set CTCSS squelch to PL100.0 on APRS channel
- If your Kenwood shows another Kenwood's beacon, you can voice talk to them (QSY off APRS frequency)
- Yaesu FTM-350 can do this too

QRU

- Ask for specific types of local info
- Text message to QRU the info type request
- In-range QRU servers respond with answers
- Common requests:

CLUB – ham radio clubs

FIRE – fire stations

HOSP – hospitals

RP2M – 2m analog repeaters

RP70 – 70cm analog repeaters

RD70 – 70cm Dstar repeaters

INFO – what requests are locally understood?

APRS Services

- APRS-IS pseudo-stations responding to query text messages
 - WHO-IS – send back QRZ data for callsign
 - EMAIL-2 – send one-line email
 - SMSGTE – send SMS text message to commercial cell phone
 - ANSRVR – announce interest/membership in some group (JOTA, etc.)
 - CQSRVR – call CQ
 - WLNK-1 – access your Winlink account emails
 - WXBOT – get a weather forecast for your location
- Note that all these require a Tx I-gate near you to receive an answer on RF

APRS Telemetry

- Standard telemetry sends 5 analog (8-bit A/D) and 8 binary values
- Self-addressed text messages used to describe value meanings, scaling, bit polarity

Source	Desti...	type	Message Body
W4VA-10	APDW15	APRS	W4VA-10>APDW15, TCPIP*, qAC, T2VAN: :W4VA-10 :EQNS.0,1,0,0,1,0,0,1,0,0,-1,0,0,-1,0
W4VA-10	APDW15	APRS	W4VA-10>APDW15, KN4IJF*, qAR, WC4J-3: :W4VA-10 :UNIT.Volts,%,deg.F,dBm,dBm,unused,unused...
W4VA-10	APDW15	APRS	W4VA-10>APDW15, KN4IJF*, qAR, WC4J-3: :W4VA-10 :PARM.Supply,Humidity,Temp,5GHz_remote,5G...
W4VA-10	APDW15	APRS	W4VA-10>APDW15, TCPIP*, qAC, T2VAN:<IGATE,MSG_CNT=0,PKT_CNT=0,DIR_CNT=23,LOC_CNT=79,RF_C...
W4VA-10	APDW15	APRS	W4VA-10>APDW15, TCPIP*, qAC, T2VAN:T#359,12.04,51.0,69.8,67,66,00011101

Station	Proj/Seq#	A1	A2	A3	A4	A5	D1	D2	D3	D4	D5	D6	D7	D8
W4VA-10		Supply	Humidity	Temp	5GHz_remote	5GHz_base	unused	unused	unused	5G_link	AllStar	APRS	unused	DR1X
16:30:41	362	11.84	56.0	66.2	-66.0	-65.0				5G_Link	AllStar	APRS		DR1X

APRS via Satellites

- Several amateur radio satellites are digipeaters

K4IPH>CQ,RS0ISS*,qAR,W0ARP-

15:=4035.60N/07934.34W-Bob in Vandergrift, PA

- Use satellite's callsign as digipeater in path
- Use satellite APRS frequency for uplink

<http://aprs.org/astars.html>

DPRS: Dstar GPS to APRS

ICOM Dstar radios that accept GPS can send position data in leftover bits of digital data stream

Dstar gateways can decode this extra data from directly-received radios and pass to APRS-IS

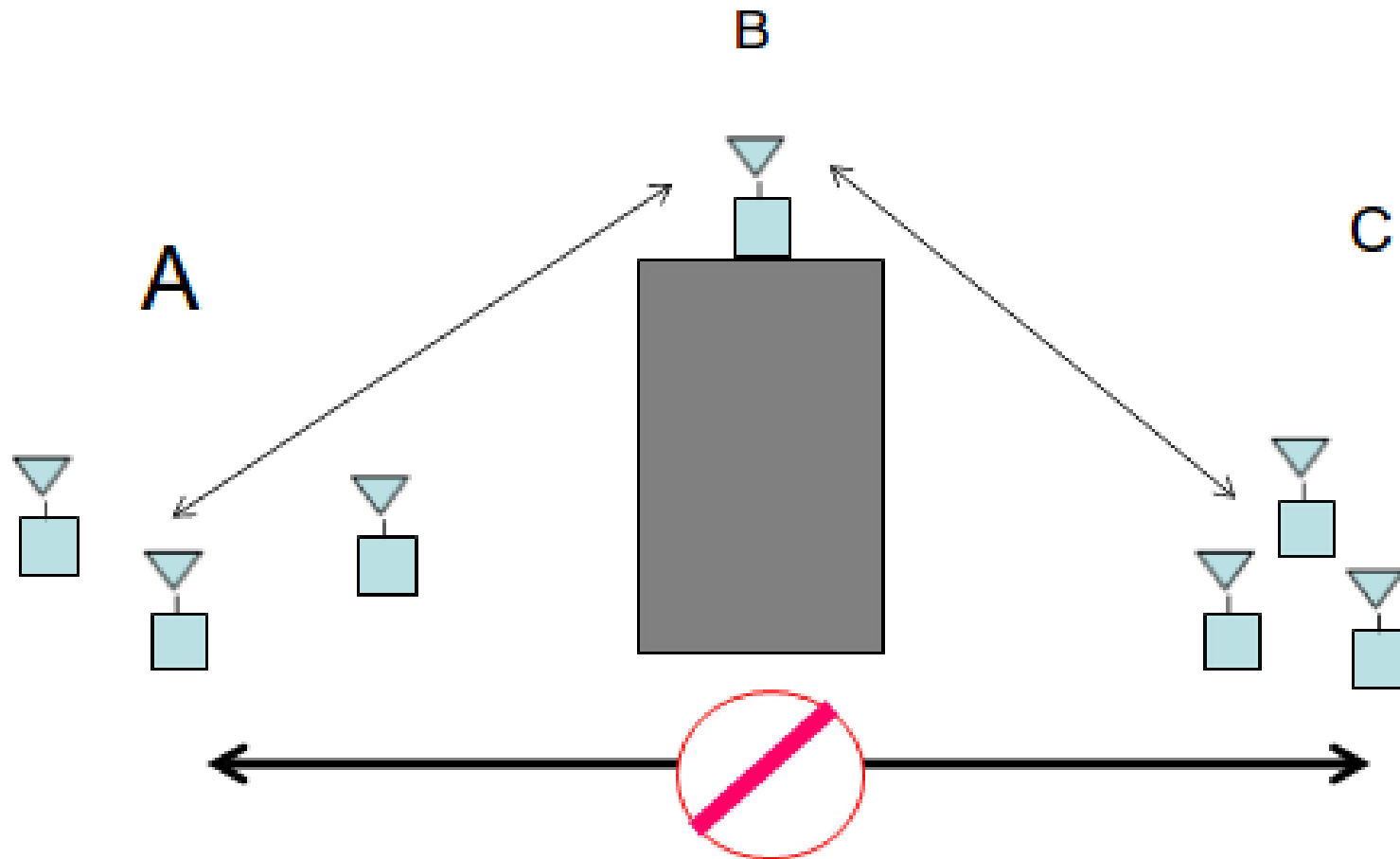
“Why doesn't APRS work?”

- Distorted signal (overmodulated, pre-emphasis)
- Weak signal (no error correction)
- Collisions (hidden transmitter, Tx-only trackers)
- Squelch set wrong
- Too much range (exceeding Aloha circle)
- Transmitting too often

Signal distortion

- 2 FSK tones, should be at same amplitude
- Pre-emphasis & de-emphasis in radio audio circuits will skew relative amplitudes
- Overmodulation causes audio harmonics
 - If radio has limiter, will also distort tones

Collisions: hidden transmitter

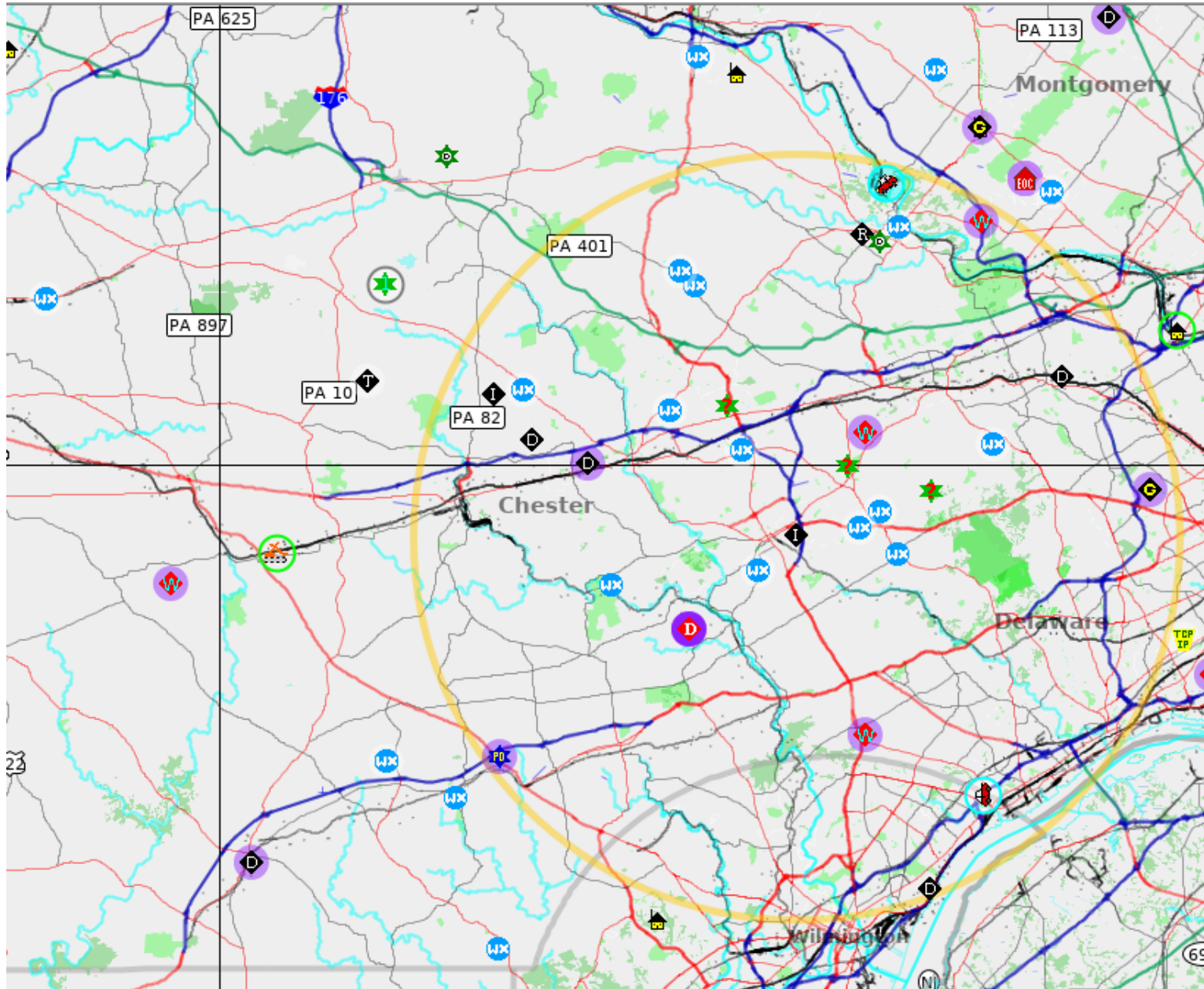


A and C cannot hear each other but B hears both

The Aloha circle

- APRS RF channel is a limited resource
 - Average 1200 baud APRS packet takes 1 second to transmit
 - Channel can only be loaded to less than 50%
 - => only ~900 packets per half hour (slowest APRS repeat cycle)
 - Only capacity for approx. 60 to 100 nearest local stations and objects using reasonable transmit rates
 - Aloha circle is radius out to the station/object that reaches channel capacity
 - Adding more traffic actually **reduces** capacity (part of available time used up by collisions instead of intelligible packets)
 - digipeaters add duplicate packet copies, so too many digipeaters hurts by dividing the channel capacity
 - Cell phone networks increase capacity by shrinking and splitting cells into smaller areas
 - Adjust your antenna height and transmit power so your range doesn't exceed your Aloha circle to avoid jamming the area

1-channel Aloha for W3EOC-5



Hardware for APRS

- Kenwood D700, D710, D7, D72, D74
- Yaesu FTM-350, FT1DR, VX-8R, VX-8DR
- Any radio with data jack and external TNC
 - TNC2, MFJ, Byonics TinyTrak, Argent OpenTracker, TNC-X/TNC-Pi
- Byonics MT-AIO
- Signalink (or other sound card interface) and software in place of TNC

Software for APRS

- Web sites
 - aprs.fi
 - FindU.com
- Software TNCs
 - AGWPE (Windows)
 - UZ7HO
 - DireWolf (Mac OS X, Linux)
- Client software
 - Obsolete: APRSdos, UIView, APRSpoint
 - APRSIS32 (Windows, Linux on WINE)
 - Xastir (Linux)
 - YAAC (Windows, Mac OS X, Linux)
 - APRSdroid (Android)
 - IAPRS (Apple iOS)
 - APRS-TW
 - APRS Messenger
 - SARtrack (Windows)
 - AGWTracker (Windows)

Q/A?