Trust in Waves

An introduction to packet radio with AX.25
and elliptic curve cryptography

https://brannon.online/sec-shell.pdf

Data over Radio

Most people associate “radio” with voice transmissions, but from the beginning, radio has always been about transmitting arbitrary data from one place to another.

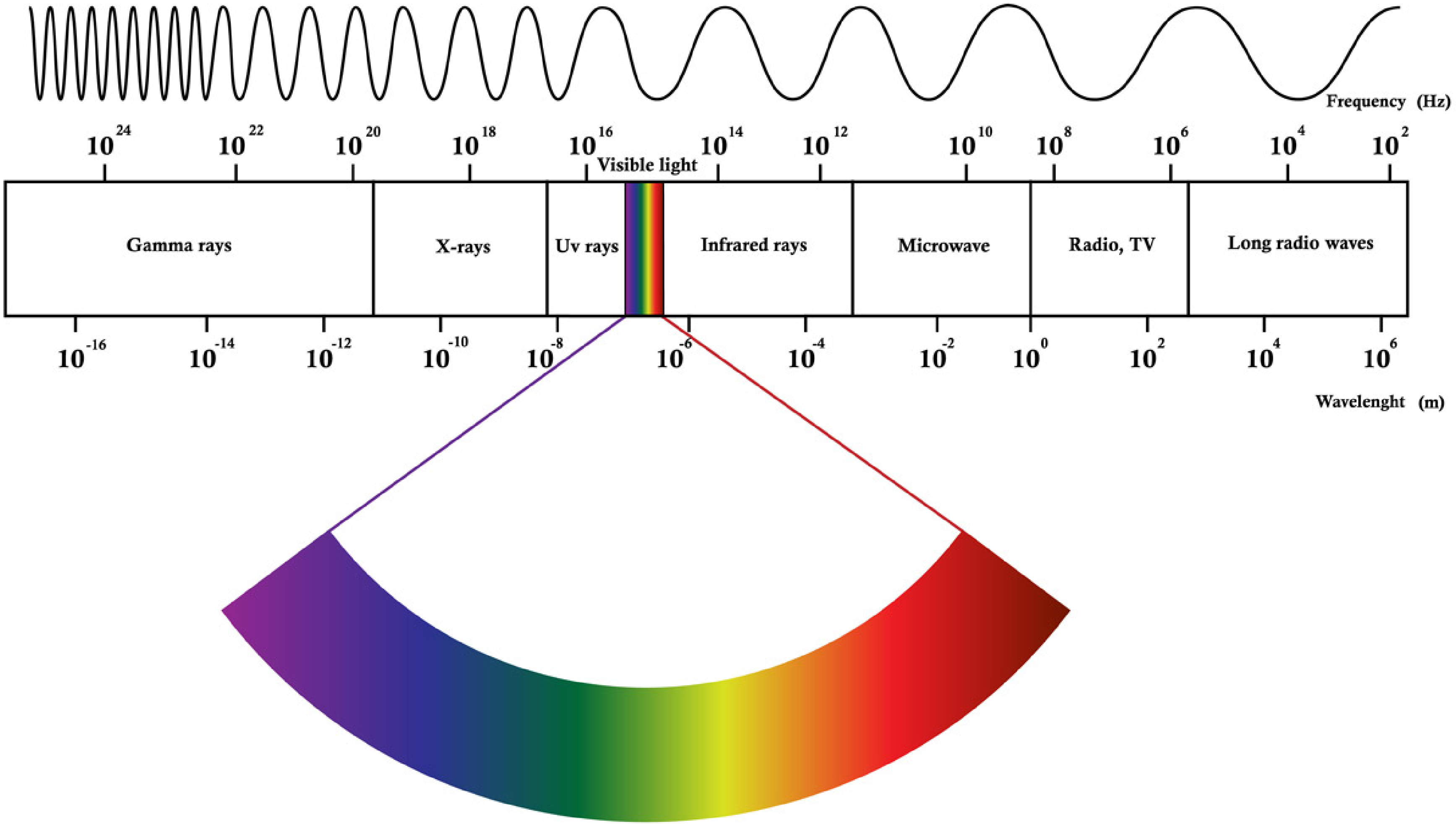
This started with with experiments in “wireless telegraphy” (which actually predate radio) that lead to standard protocols like Morse code. Today, we have a diverse range of digital radio networks like cellular CDMA + GSM, 802.11 WiFi, Bluetooth & BTLE, XigBee, GPS, Digital broadcast television, etc.

In this talk/workshop, we’ll be taking a look at some older, inefficient, and cheap means of transmitting data over radio by encoding it first as audio.

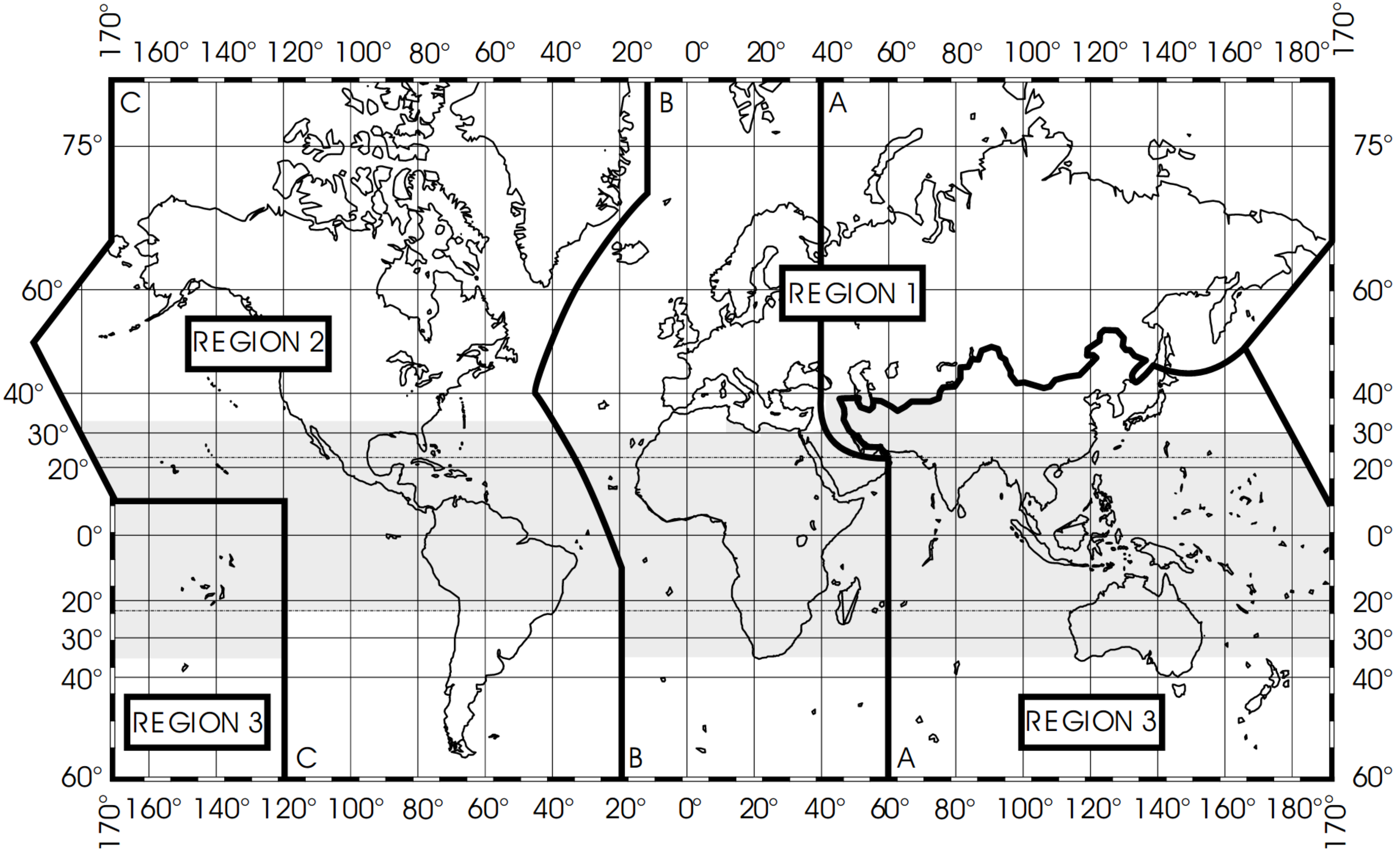
Electromagnetic Spectrum

"Radio is the technology of using radio waves to carry information, such as sound and images, by systematically modulating properties of electromagnetic energy waves transmitted through space, such as their amplitude, frequency, phase, or pulse width."

- 469 editors on Wikipedia 



Frequency (Hz)
10 24
10 22
10 20
10 18
10 16
Visible light
10 14
10 12
10 10
10 8
10 6
10 4
10 2
Gamma rays
X-rays
Uv rays
Infrared rays
Microwave
Radio, TV
Long radio waves
10 -16
10 -14
10 -12
10 -10
10 -8
10 -6
10 -4
10 -2
10 0
10 2
10 4
10 6
Wavelenght (m)



170° 160° 140° 120° 100° 80° 60° 40° 20° 0° 20° 40° 60° 80° 100° 120° 140° 160° 180° 170°
75°
60°
40°
30°
20°
0°
20°
30°
40°
60°
C
B
A
REGION 1
REGION 2
REGION 3
REGION 3
C
B
A

UNITED STATES FREQUENCY ALLOCATIONS

THE RADIO SPECTRUM

RADIO SERVICES COLOR LEGEND

- AERONAUTICAL MOBILE
- AERONAUTICAL MOBILE SATELLITE
- AERONAUTICAL RADIONAVIGATION
- AMATEUR
- AMATEUR SATELLITE
- BROADCASTING
- BROADCASTING SATELLITE
- EARTH EXPLORATION SATELLITE
- FIXED
- FIXED SATELLITE
- INTER-SATELLITE
- LAND MOBILE
- LAND MOBILE SATELLITE
- MARITIME MOBILE
- MARITIME MOBILE SATELLITE
- MARITIME RADIONAVIGATION
- METEOROLOGICAL AIDS
- METEOROLOGICAL SATELLITE
- MOBILE
- MOBILE SATELLITE
- RADIO ASTRONOMY
- RADIODETERMINATION SATELLITE
- RADIOLOCATION
- RADIOLOCATION SATELLITE
- RADIONAVIGATION
- RADIONAVIGATION SATELLITE
- SPACE OPERATION
- SPACE RESEARCH
- STANDARD FREQUENCY AND TIME SIGNAL
- STANDARD FREQUENCY AND TIME SIGNAL SATELLITE

ACTIVITY CODE

- GOVERNMENT EXCLUSIVE
- GOVERNMENT/NON-GOVERNMENT SHARED
- NON-GOVERNMENT EXCLUSIVE

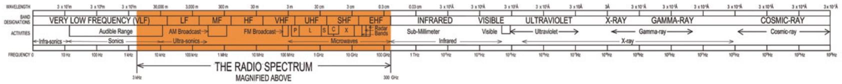
ALLOCATION USAGE DESIGNATION

SERVICE	EXAMPLE	DESCRIPTION
Primary	FIXED	Capital Letters
Secondary	Mobile	1st Capital with lower case letters

This chart is a graphic single-point-in-time portrayal of the Table of Frequency Allocations used by the FCC and NTIA. As such, it does not completely reflect all aspects, i.e., footnotes and recent changes made to the Table of Frequency Allocations. Therefore, for complete information, users should consult the Table to determine the current status of U.S. allocations.

U.S. DEPARTMENT OF COMMERCE
National Telecommunications and Information Administration
Office of Spectrum Management
October 2003

* EXCEPT AERO MOBILE (R)
** EXCEPT AERO MOBILE



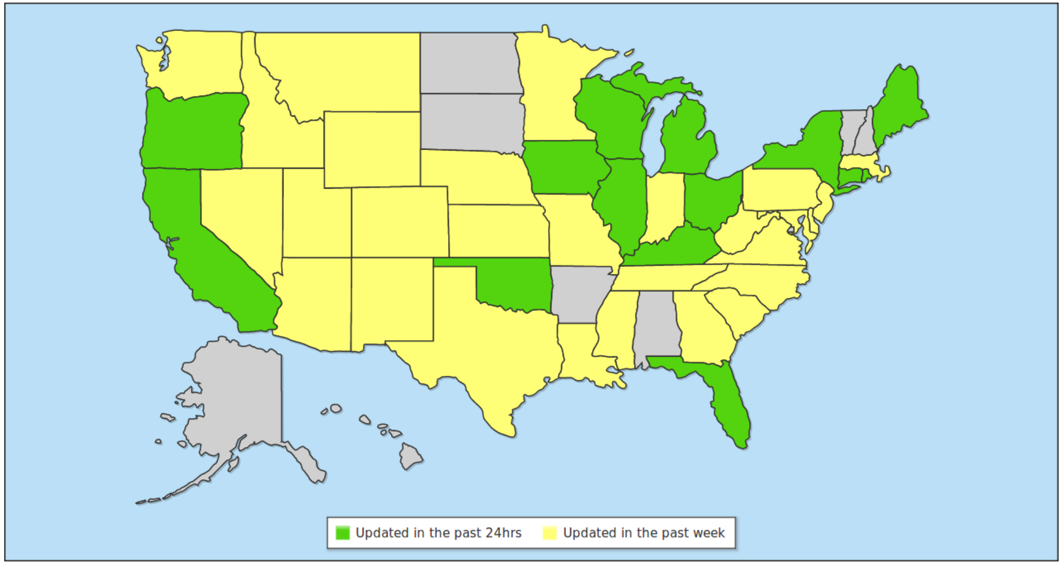
PLEASE NOTE: THE SPACING ALLOTTED THE SERVICES IN THE SPECTRUM SEGMENTS SHOWN IS NOT PROPORTIONAL TO THE ACTUAL AMOUNT OF SPECTRUM OCCUPIED.


ISM – 13.560 ± .007 MHz
117.975
121.9375
123.0875
123.5875
128.8125
132.0125
136.0
137.0
137.025
137.175
137.825
138.0
144.0
146.0
148.0
149.9
150.05
150.8
152.855
154.0
156.2475
157.0375
157.1875
157.45
161.575
161.625
161.775
162.0125
173.2
173.4
174.0
216.0
AERONAUTICAL MOBILE (R)
AERONAUTICAL MOBILE
AERONAUTICAL MOBILE
AERONAUTICAL MOBILE (R)
AERONAUTICAL MOBILE (R)
AERONAUTICAL MOBILE (R)
AERONAUTICAL MOBILE (R)
MET. SAT. (S-E)
SPACE OPN. (S-E)
SPACE RES. (S-E)
MOB. SAT. (S-E)
Mob. Sat. (S-E)
MOBILE
FIXED
AMATEUR SATELLITE
AMATEUR
MOBILE SATELLITE (E-S)
LAND MOBILE
MARITIME MOBILE
MOBILE
FIXED
Land Mobile
BROADCASTING
(TV CHANNELS 7-13)
We’re using this today

RadioReference.com
Your Complete Reference Source

The Radio Reference Database (United States)

Choose Country: United States



Retrieve by Location

Retrieve by State

Alabama

Retrieve

Retrieve by Metro Area

Albany-Capital District

Retrieve

Search for a US City/Location

Enter City or Location

Search

Retrieve by US zipcode

Zip

Retrieve

Search Identified Frequencies

FCC Licenses for FRN: 0011839677 (DREXEL UNIVERSITY)

Entity	Callsign	Frequency	Units	Pag	CODE	Svc	City	County	State
DREXEL UNIVERSITY	KLZ411	451.27500	80	0	MO	IG	PHILADELPHIA	PHILADELPHIA	PA
DREXEL UNIVERSITY	KLZ411	451.27500	30	0	MO	IG			PA
DREXEL UNIVERSITY	KLZ411	451.27500	1	70	FB2	IG			PA
DREXEL UNIVERSITY	KLZ411	451.27500	30	0	MO	IG			
DREXEL UNIVERSITY	KLZ411	451.27500	30	0	MO	IG	PHILADELPHIA	PHILADELPHIA	PA
DREXEL UNIVERSITY	KLZ411	451.27500	80	0	MO	IG			PA
DREXEL UNIVERSITY	KLZ411	451.27500	1	70	FB2	IG			
DREXEL UNIVERSITY	KLZ411	451.27500	1	70	FB2	IG	PHILADELPHIA	PHILADELPHIA	PA
DREXEL UNIVERSITY	KLZ411	451.27500	80	0	MO	IG			
DREXEL UNIVERSITY	KLZ411	451.51250	80	0	MO	IG			PA
DREXEL UNIVERSITY	KLZ411	451.51250	30	0	MO	IG			PA
DREXEL UNIVERSITY	KLZ411	451.51250	80	0	MO	IG			
DREXEL UNIVERSITY	KLZ411	451.51250	30	0	MO	IG			
DREXEL UNIVERSITY	KLZ411	451.51250	80	0	MO	IG	PHILADELPHIA	PHILADELPHIA	PA
DREXEL UNIVERSITY	KLZ411	451.51250	30	0	MO	IG	PHILADELPHIA	PHILADELPHIA	PA
DREXEL UNIVERSITY	KLZ411	452.28750	80	0	MO	IG			PA
DREXEL UNIVERSITY	KLZ411	452.28750	30	0	MO	IG			
DREXEL UNIVERSITY	KLZ411	452.28750	30	0	MO	IG	PHILADELPHIA	PHILADELPHIA	PA
DREXEL UNIVERSITY	KLZ411	452.28750	1	0	FB2	IG			PA
DREXEL UNIVERSITY	KLZ411	452.28750	80	0	MO	IG			
DREXEL UNIVERSITY	KLZ411	452.28750	80	0	MO	IG	PHILADELPHIA	PHILADELPHIA	PA
DREXEL UNIVERSITY	KLZ411	452.28750	1	0	FB2	IG			
DREXEL UNIVERSITY	KLZ411	452.28750	1	0	FB2	IG	PHILADELPHIA	PHILADELPHIA	PA
DREXEL UNIVERSITY	KLZ411	452.28750	30	0	MO	IG			PA
DREXEL UNIVERSITY	KLZ411	452.45000	80	0	MO	IG			
DREXEL UNIVERSITY	KLZ411	452.45000	30	0	MO	IG			
DREXEL UNIVERSITY	KLZ411	452.45000	80	0	MO	IG	PHILADELPHIA	PHILADELPHIA	PA
DREXEL UNIVERSITY	KLZ411	452.45000	30	0	MO	IG	PHILADELPHIA	PHILADELPHIA	PA
DREXEL UNIVERSITY	KLZ411	452.45000	1	70	FB2	IG			PA
DREXEL UNIVERSITY	KLZ411	452.45000	1	70	FB2	IG			
DREXEL UNIVERSITY	KLZ411	452.45000	1	70	FB2	IG	PHILADELPHIA	PHILADELPHIA	PA
DREXEL UNIVERSITY	KLZ411	452.45000	80	0	MO	IG			PA
DREXEL UNIVERSITY	KLZ411	452.45000	30	0	MO	IG			PA
DREXEL UNIVERSITY	KLZ411	452.51250	1	70	FB2	IG	PHILADELPHIA	PHILADELPHIA	PA
DREXEL UNIVERSITY	KLZ411	452.51250	1	0	FB2	IG			PA
DREXEL UNIVERSITY	KLZ411	452.51250	1	70	FB2	IG			PA
DREXEL UNIVERSITY	KLZ411	452.51250	1	0	FB2	IG			
DREXEL UNIVERSITY	KLZ411	452.51250	1	70	FB2	IG			
DREXEL UNIVERSITY	KLZ411	452.51250	1	0	FB2	IG	PHILADELPHIA	PHILADELPHIA	PA

Colleges and Universities

University of Pennsylvania

The university is in the process of switching to Motorola MOTOTRBO (DMR) equipment throughout their network. At this time, most users are still utilizing the conventional analog FM system; however, the migration will begin in the near future.

Frequency	License	Type	Tone	Alpha Tag	Description	Mode	Tag
506.98750	WII480	RM	CC 10 TG 100 SL 1	UPenn PD	Police Dispatch (Encrypted)	DMRE	Law Dispatch
506.98750	WII480	RM	203.5 PL	UPenn PD 1	Police Primary (old analog dispatch)	FMN	Deprecated
508.91250	WII480	RM	203.5 PL	UPenn PD 2	Police Secondary (Special Events / Operations)	FMN	Law Tac
507.26250	WII480	RM		UPenn PD 3	Police Tertiary	FMN	Law Tac
464.36250	KFE659	RM	CC 1 TG 1 SL 1	UPenn MERT 1	Medical Emergency Response Team (M.E.R.T.) - Primary	DMR	EMS-Tac
462.00000	KFE659	RM		UPenn MERT 2	Medical Emergency Medical Response Team (M.E.R.T.) - Secondary	FMN	EMS-Tac
461.47500	WNYM895	RM	143 DPL	UPenn Sec.	Escorts and Security Operations	FMN	Security
451.88750	WQGB543	RM	723 DPL	U.C.D. Ops	University City District - Escorts / Security	FMN	Security
453.01250	WQLR715	RM	CC 10 TG 101 SL 2	UPenn Ops	Housing and Conference	DMR	Schools

Temple University

Frequency	License	Type	Tone	Alpha Tag	Description	Mode	Tag
460.40000	WQBY672	RM	CC 1 TG 1 SL 1	TempleU PD	Police Dispatch / Operations	DMR	Law Dispatch
463.23750	WQNE519	RM	CC 1 TG 1 SL 1	TempleU Security	Campus Security	DMR	Security
464.70000	WPAG964	RM	506 DPL	Temple U Maint	Maintenance and Operations	FMN	Schools

Drexel University

Frequency	License	Type	Tone	Alpha Tag	Description	Mode	Tag
452.51250	KLZ411	RM	CC 1 TG 1 SL 2	Drexel Escorts	Campus Escorts	DMR	Security
462.05000	KLZ411	RM	CC 1 TG * SL *	DrexelU Sec	Security Dispatch / Operations	DMR	Security

Bally's/Wild Wild West

System Name:	Bally's/Wild Wild West
Location:	Atlantic City, NJ
County:	Atlantic
System Type:	Motorola Type II Smartnet
System Voice:	Analog
Last Updated:	July 13, 2012, 11:48 pm (Updated Talkgroups (11 Updated))

https://bit.ly/ballys-freqs

All Talkgroups

Site	Name	Freqs						
001 (1)	Site-1	935.6375	936.725	937.1625c	937.6625c	937.700	939.225	939.2375

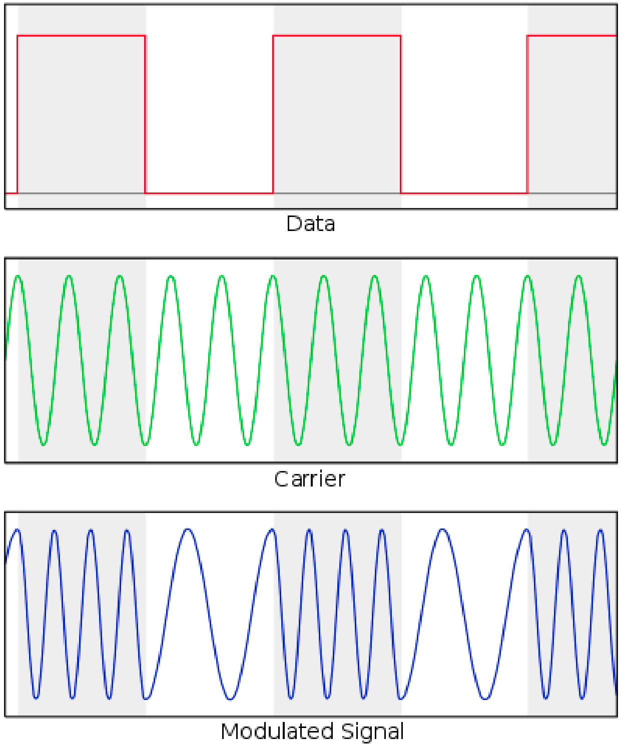
DEC	HEX	Mode	Alpha Tag	Description	Tag
112	007	A	BallySlot112	Slots	Business
144	009	A	BallySlot144	Slots	Business
176	00b	A	BallySlot176	Slots	Business
240	00f	A	Bally Eng	Engineering	Business
272	011	A	Bally Sec	Security	Security
336	015	A	BallySecSurv	Security - Surveillance	Security
400	019	A	BallySlotTch	Slot Technicians	Business
528	021	A	BallyH/K Pub	Housekeeping - Public Areas	Business
560	023	A	Bally Food	Food	Business
848	035	A	Bally Trnsp?	Transportation?	Business
1168	049	A	Bally H/K	Housekeeping	Business

Audio Frequency Modulation

Audio frequency-shift keying (AFSK) is a form of digital modulation that represents binary 1s and 0s by changes in the pitch of an audio tone.

AFSK defines the modulation technique but it doesn't define the transmission medium. Old telephone modems use the exact same type of AFSK that we'll use over radio waves.

Common bit rates for AFSK encoded data transmission of radio include 300, 600, and 1200 baud.



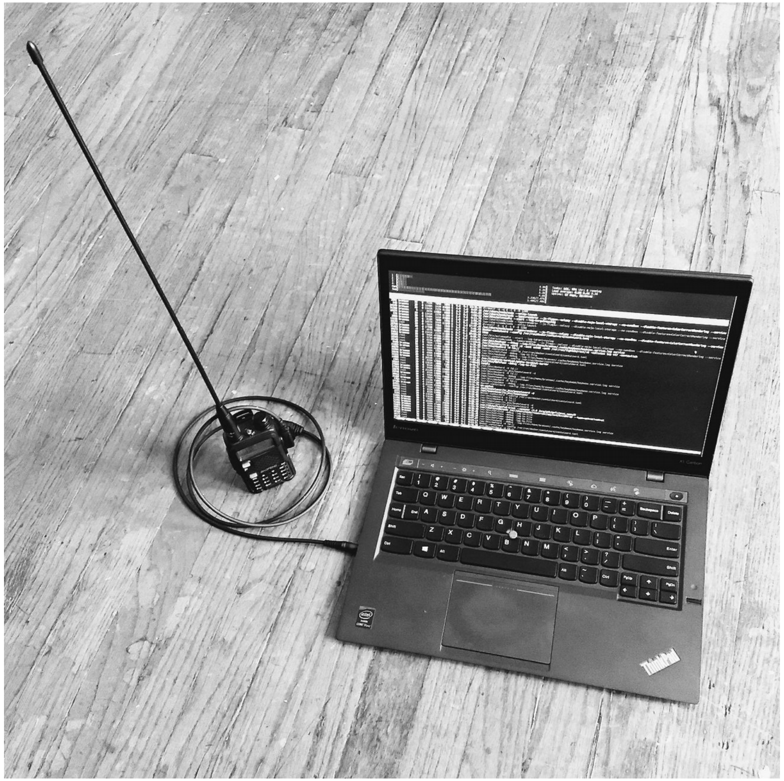
Encoding digital data as audio is slow, but it allows us to re-purpose existing systems that can receive or play audio, like cheap hand-held radios and walkie talkies.

All you need for a simple packet radio transmission setup is:

1. A cheap VHF/UHF radio like the Baofeng UV-5R.

2. A computer with audio input and output.

3. An audio cable that connects the computer's output to the radio's input and vice versa.

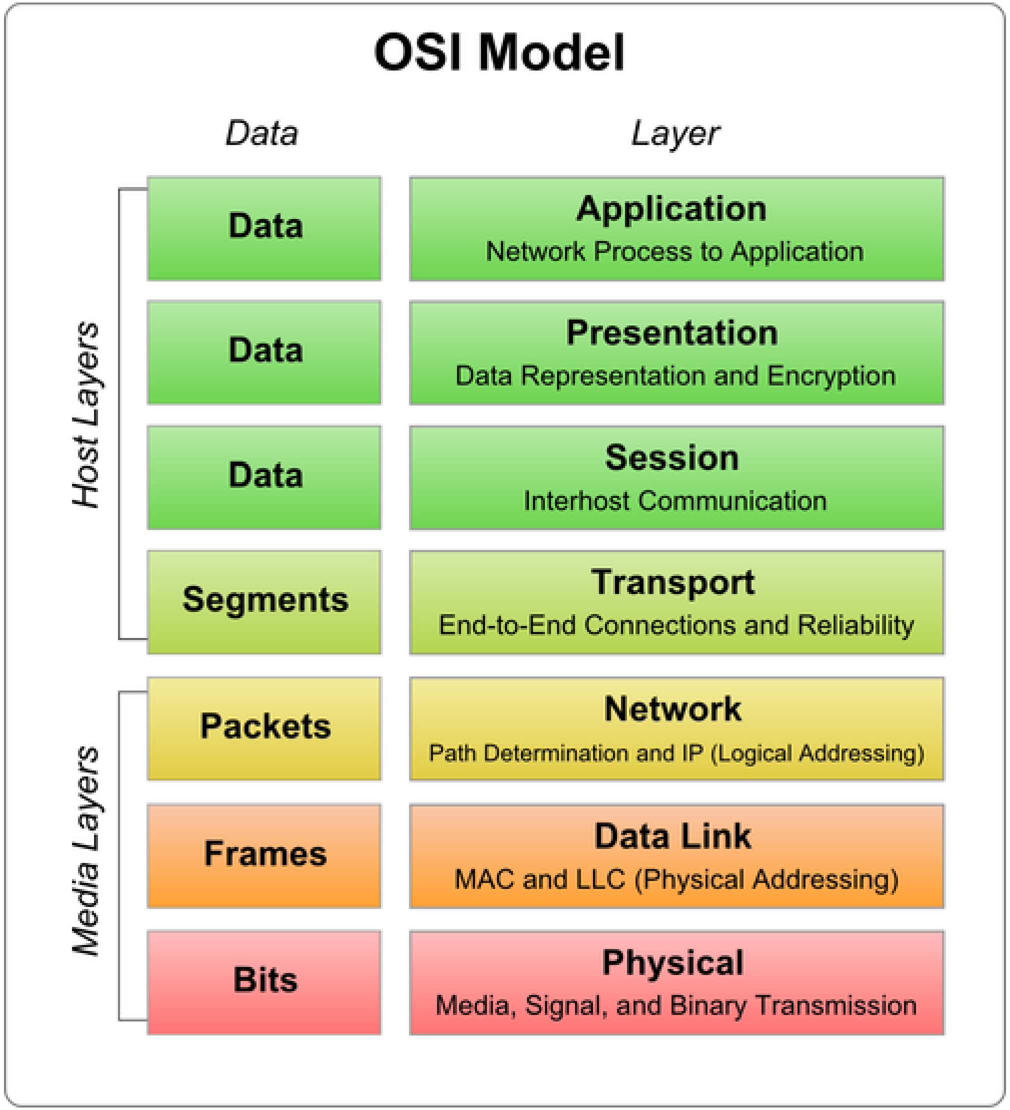


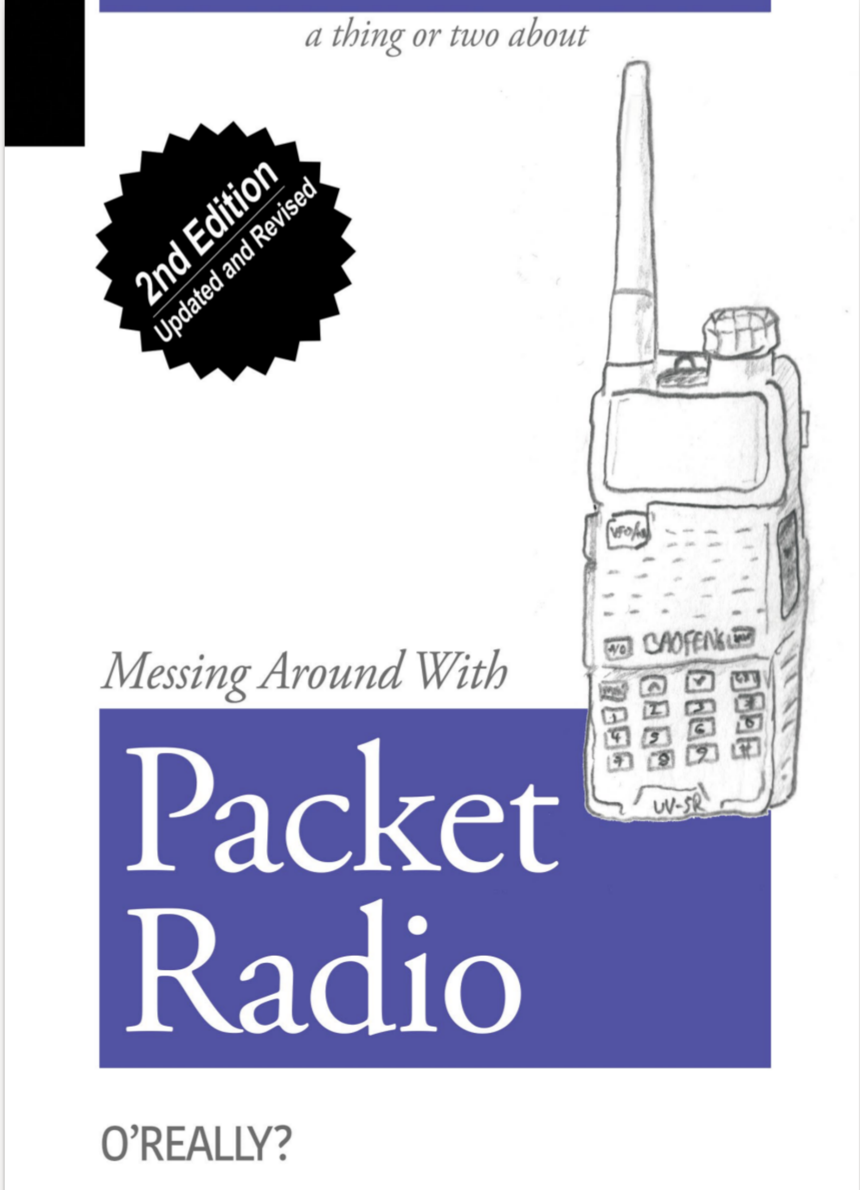
Packet Radio

Packet Radio builds on top of digital modes like AFSK to group information into logical packets and frames, similar to TCP/IP. In fact, TCP/AX.25 is very common in the packet radio scene.

AX.25 (Amateur X.25) is the link-layer protocol of choice. It provides both *connected* and *connectionless* modes and uses amateur radio call signs as addresses.

First Bit Sent						
Flag	**Address**	**Control**	**PID**	**Info.**	**FCS**	**Flag**
01111110	112/560 Bits	8 Bits	8 Bits	N*8 Bits	16 Bits	01111110


OSI Model
Data
Layer
Host Layers
Media Layers
Data
Application
Network Process to Application
Data
Presentation
Data Representation and Encryption
Data
Session
Interhost Communication
Segments
Transport
End-to-End Connections and Reliability
Packets
Network
Path Determination and IP (Logical Addressing)
Frames
Data Link
MAC and LLC (Physical Addressing)
Bits
Physical
Media, Signal, and Binary Transmission

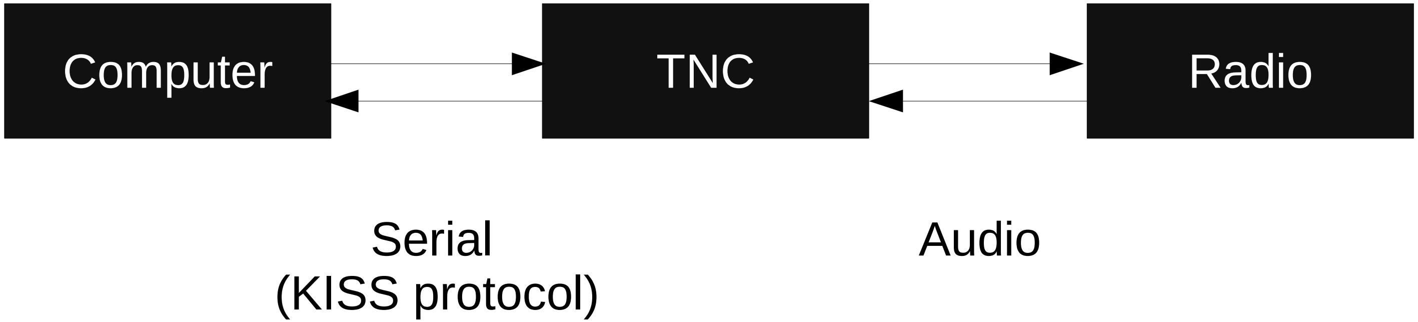


Dennis de Bel and
Roel Roscam Abbing

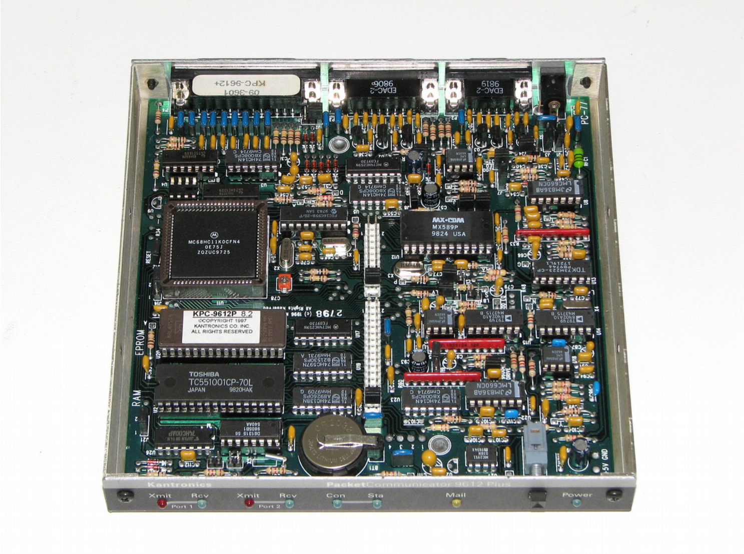
TNC

A *Terminal Node Controller* (TNC) is required for packet radio operation. The TNC is the modem that converts data to audio and vice versa.

A TNC also acts like a network switch, assembling and dissasembling frames and packets. You send the TNC a packet of data, and it monitors the simplex channel and decides when to send that packet over radio.




METRIC MEASURES UP
NIST Special Publication 376
Revised April 1993
COMMON UNITS
COMMON PREFIXES
THE MODERNIZED METRIC SYSTEM
NIST
Advanced Electronic Applications, Inc.
Model PK-232MBX
THRESHOLD
TUNE
STATUS
MODE


Kantronics
PacketCommunicator 9612 Plus
KPC-9612P 8.2
TOSHIBA
TC551001CP-70L
EPROM
RAM
Xmit
Rcv
Con
Sta
Mail
Power

wb2osz / **direwolf**

Watch 93 | Unstar 499 | Fork 119

Code | Issues 67 | Pull requests 14 | Projects 0 | Wiki | Insights

Dire Wolf is a software "soundcard" AX.25 packet modem/TNC and APRS encoder/decoder. It can be used stand-alone to observe APRS traffic, as a tracker, digipeater, APRStt gateway, or Internet Gateway (IGate). For more information, look at the bottom 1/4 of this page and in https://github.com/wb2osz/direwolf/blob/dev/doc/README.md

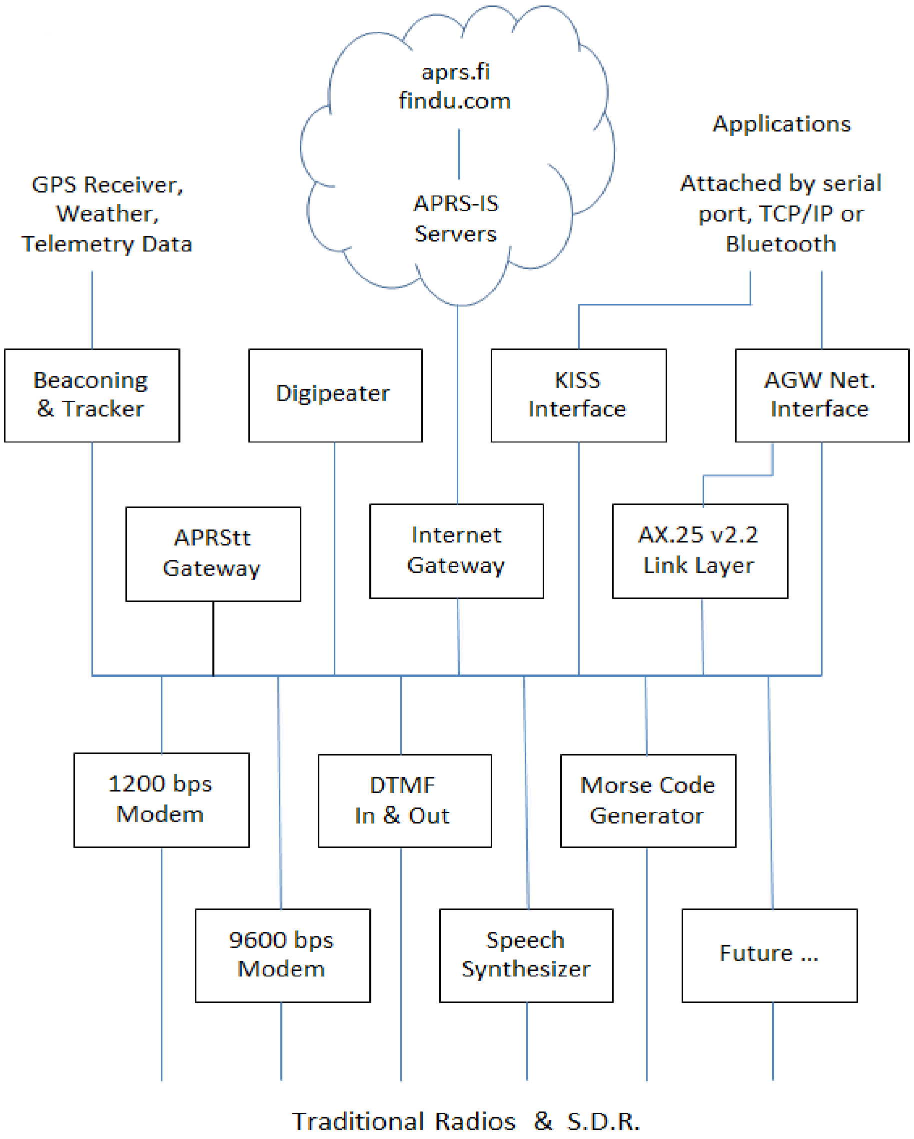
tnc | igate | ham-radio | packet-radio | raspberry-pi | digipeater | aprs | ax25

194 commits | **3** branches | **17** releases | **7** contributors | View license

Branch: **master** | **New pull request** | **Create new file** | **Upload files** | **Find file** | **Clone or download**

wb2osz Issue 196 - Compatibility with GPSD API 7. Latest commit `a1e2d1c` 7 days ago

doc	Add link to separate repository with presentations.	3 months ago
geotranz	Uninitialized variables found by static analysis.	a year ago
man1	Time stamps and documentation for kissutil.	a year ago
misc	Compatibility with minGW gcc 5.3.0	2 years ago
regex	Fix compile warnings found when adding -Wall and others.	2 years ago
telemetry-toolkit	Add script to generate telemetry sequence numbers.	3 years ago
.gitattributes	Rewrite GPS handling. Lots of other clean up.	3 years ago
.gitignore	ignore file tweaks	11 months ago

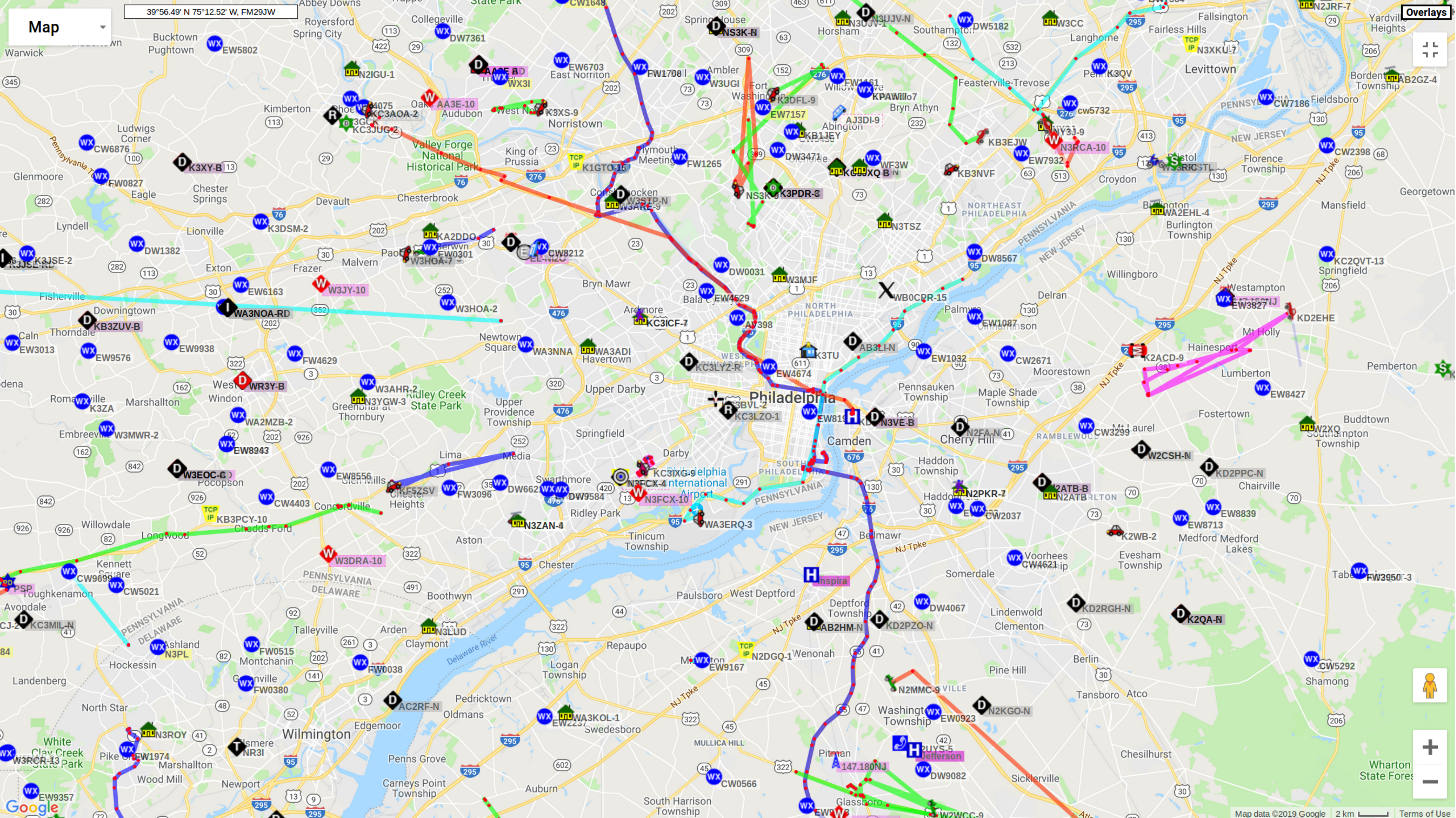

aprs.fi
findu.com
APRS-IS
Servers
Applications
Attached by serial
port, TCP/IP or
Bluetooth
GPS Receiver,
Weather,
Telemetry Data
Beaconing
& Tracker
Digipeater
KISS
Interface
AGW Net.
Interface
APRStt
Gateway
Internet
Gateway
AX.25 v2.2
Link Layer
1200 bps
Modem
DTMF
In & Out
Morse Code
Generator
9600 bps
Modem
Speech
Synthesizer
Future ...
Traditional Radios & S.D.R.

Automatic Packet Reporting System

A global packet radio network supporting GPS, weather station telemetry, text messages, announcements, bulletin boards and more. APRS data is often displayed on a map, showing stations, objects, tracks of moving objects, and direction finding data.

144.39 MHz

1200 baud



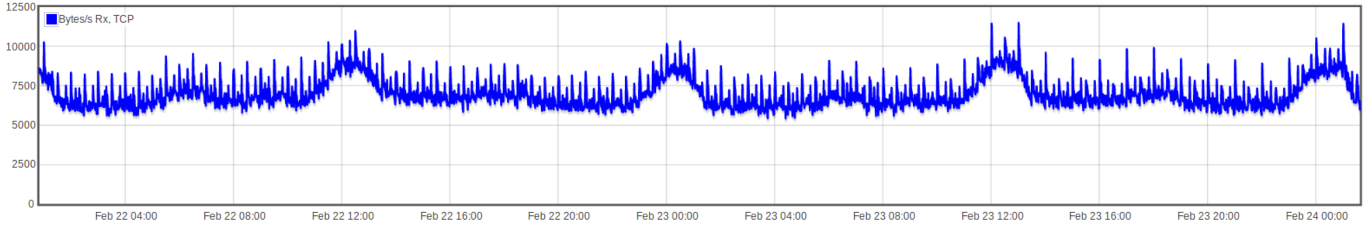
Map
39°56.49' N 75°12.52' W, FM29JW
Overlays
Philadelphia
Camden
Wilmington
Chester
Norristown
Levittown
Cherry Hill
Upper Darby
Bryn Mawr
Collegeville
Royersford
Spring City
Phoenixville
Audubon
King of Prussia
Valley Forge National Historical Park
Chesterbrook
Devault
Malvern
Exton
Downingtown
Frazer
Paoli
Berwyn
Newtown Square
Havertown
Springfield
Media
Lima
Swarthmore
Ridley Park
Darby
Tinicum Township
Philadelphia International Airport
Ridley Creek State Park
Aston
Boothwyn
Claymont
Arden
Talleyville
Hockessin
Newport
Pennsauken Township
Moorestown
Maple Shade Township
Haddon Township
Haddonfield
Bellmawr
Voorhees
Somerdale
Deptford Township
Paulsboro
West Deptford
Logan Township
Swedesboro
Glassboro
Pitman
Washington Township
Sicklerville
Berlin
Atco
Tansboro
Pine Hill
Clementon
Lindenwold
Mt Laurel
Fostertown
Lumberton
Hainesport
Mt Holly
Westampton
Willingboro
Burlington
Burlington Township
Croydon
Bristol
Florence Township
Fieldsboro
Fairless Hills
Langhorne
Feasterville-Trevose
Southampton
Horsham
Ambler
Fort Washington
Abington
Bryn Athyn
Willow Grove
Plymouth Meeting
Conshohocken
Mansfield
Georgetown
Pemberton
Buddtown
Medford
Medford Lakes
Evesham Township
Marlton
Chairville
Shamong
Wharton State Forest
Chesilhurst
Mullica Hill
Carneys Point Township
Penns Grove
Pedricktown
Oldmans
Auburn
South Harrison Township
Marshallton
Wood Mill
White Clay Creek State Park
Pike Creek
North Star
Landenberg
Montchanin
Greenville
Avondale
Toughkenamon
Kennett Square
Longwood
Chadds Ford
Concordville
Chester Heights
Glen Mills
Pocopson
Embreeville
Marshallton
West Chester
Thorndale
Lionville
Lyndell
Eagle
Chester Springs
Glenmoore
Ludwigs Corner
Kimberton
Bucktown
Pughtown
Warwick
Greenfield at Thornbury
Willowdale
PENNSYLVANIA
NEW JERSEY
DELAWARE
NORTHEAST PHILADELPHIA
NORTH PHILADELPHIA
SOUTH PHILADELPHIA
Delaware River
Google
Map data ©2019 Google
2 km
Terms of Use

T2KA aprsc status
2019-02-24 01:38:38z

APRSC

Server

Server ID	T2KA
Server admin	Bernd Strehhuber, DM8BS
Software	aprsc 2.1.4-g408ed49
Software features	epoll posix_cap clock_gettime gcc_atomics zlib ssl sctp
Uptime	83d5h
Server started	2018-12-02 20:17:48z
Operating system	Linux i686



Zoom

Totals

Clients	249	0/s
Connects	22151828	0.10/s
Bytes Tx TCP	273056815218	32780/s
Bytes Rx TCP	49563191642	6307/s
Packets Tx TCP	2677287144	329/s
Packets Rx TCP	495021523	65/s
Bytes Tx UDP	0	0/s
Bytes Rx UDP	267196	0/s
Packets Tx UDP	0	0/s
Packets Rx UDP	2404	0/s
Bytes Tx SCTP	0	0/s
Bytes Rx SCTP	0	0/s
Packets Tx SCTP	0	0/s
Packets Rx SCTP	0	0/s

Duplicate filter +

Duplicate packets dropped	22374468	3.9/s
Unique packets seen	470102173	62/s

Port listeners

Proto	Address	Name	Clients	Peak	Max	Connects	Conn/s	Packets Tx	Packets Rx	Bytes Tx	Bytes Rx	Tx/Rx bytes/s
tcp	[::]:14580	Client-defined filter	245	304	2000	22059429	0.10	693995054	31269576/20847300/2215811	77989898608	3832760900	8895 / 405
udp	[::]:14580		0	0	10	0	0	0	0/0/0	0	0	0 / 0
tcp	[::]:10152	Full feed	4	12	100	92399	0	1974593910	664178/166601/3540	194214064186	147850054	23755 / 15
udp	[::]:10152		0	0	10	0	0	0	0/0/0	0	0	0 / 0

Chattervox

Chattervox is a packet radio chat protocol with support for digital signatures and binary compression; think IRC over radio waves.

It's a new protocol with a reference implementation and command-line interface written in TypeScript.

In the United States, it's illegal to broadcast encrypted messages on amateur radio frequencies. Chattervox respects this law, while using elliptic curve cryptography and digital signatures to protect against message spoofing.

FCC Title 47 Part §97.113

Prohibited transmissions

Section (4) Music using a phone emission except as specifically provided elsewhere in this section; communications intended to facilitate a criminal act; messages encoded for the purpose of obscuring their meaning, except as otherwise provided herein; obscene or indecent words or language; or false or deceptive messages, signals or identification.

Packet Encapsulation

AX.25 Frame

Frame Type (UI)
Source Address
Destination Address
Payload:

Chattervox Packet

Magic header
Packet Version
ECDSA Signature
Payload (compressed)

Legal

It’s illegal for non-licensed individuals to transmit on amateur frequency bands. There are, however, clauses that allow *unlicensed* individuals to speak, key/type, or otherwise transmit communication on behalf of a licensed amateur while they are under the direct supervision of a licensed control operator (*Third Party Traffic)*. In other words, unlicensed peeps can group up with licensed folks.

Alternatively, the Multi-User Radio Service (MURS) provides 5 frequency channels in the VHF band that are *licensed by rule*, meaning anyone can use them without a license, provided they follow the rules.

Some MURS rules:

Blue Dot MURS-4, 154.570 MHz
Green Dot MURS-5, 154.600 MHz

2 Watts Power
Minimize interference

Voice, data, image, telemetry allowed
Repeaters & signal boosters NOT allowed

Frequencies

144.39 MHz	145.0 MHz	145.5 MHz
APRS	**Chattervox 1**	**Chattervox 2**

APRS CTVX 1 CTVX 2 MURS 4 MURS 5

154.57 MHz	154.6 MHz
Blue Dot MURS 4	**Green Dot MURS 5**

Baofeng UV-5R

The best (and only) RX/TX radio money can buy for $25.

Made by a Chinese company that doesn't have to manufacture their radios to US standards.

Probably the most controversial radio on the scene. People either love them or hate them. In August 2018 the FCC issued citations to US distributors on Amazon.

Frequency Ranges:
- 136-174MHz (VHF)
- 400-520MHz (UHF)

Bandwidth:
- 25KHz on WIDE
- 12.5KHz on NARROW

Power Output:
- 5W on HIGH
- 1W on LOW

Features:
- VOX & PTT
- 128 Programmable Channels
- Flashlight

VOX & Squelch

Simplex radios like the Baofeng can't receive and transmit at the same time. They can either be listening or speaking, but not both. All transmitters in a conversation share one frequency and they have to take turns speaking.

VOX stands for *Voice Operated Transmit*. It uses a radio's microphone to conditionally trigger transmit functionality as soon as input is detected. This is in contrast to *Push to Talk* (PTT) operation where the user (or computer) explicitly signals that they'd like to transmit.

Squelch sets a noise floor that must be broken by a transmitter in order for a receiving radio to sonify the signal.

If VOX is on squelch must be on as well.

Installing Chattervox

Chattervox is currently fully supported on Linux, *kind of* supported on MacOS*, and ~~not yet~~ probably supported on Windows. Chattervox requires a software or hardware TNC to operate.

*https://bit.ly/chattervox-macos

```
# clone, build, and install the Direwolf TNC
git clone https://github.com/wb2osz/direwolf
cd direwolf
make
sudo make install
make install-conf

# install node via the node version manager
curl -o- https://raw.githubusercontent.com/creationix/nvm/v0.34.0/install.sh | bash
source ~/.bashrc # or ~/.bash_profile
nvm install v8 # install node version 8

# install chattervox
npm install -g --cli chattervox
```

pi@cherry: ~

```
pi@cherry:~ $ chattervox send
Welcome! It looks like you are using chattervox for the first time.
We'll ask you some questions to create an initial settings configuration.


What is your call sign (default: N0CALL)? KC3LZO
What SSID would you like to associate with this station (press ENTER to skip)? 2
Do you have a dedicated hardware TNC that you would like to use instead of direwolf (default: no)? no
{
  "version": 3,
  "callsign": "KC3LZO",
  "ssid": 2,
  "keystoreFile": "/home/pi/.chattervox/keystore.json",
  "kissPort": "/tmp/kisstnc",
  "kissBaud": 9600,
  "feedbackDebounce": 20000
}
Is this correct [Y/n]? y
Generating ECDSA keypair...
Public Key: 04880e488c96d7fb55e7070dc46328fa206bbcacff9f5aa5dccdfd5a9aaf2591ba152ed751875cb593cec947866f4ad579

Settings saved to /home/pi/.chattervox/config.json
Error opening a serial connection to KISS TNC that should be at /tmp/kisstnc. Are you sure your TNC is running?
If you have direwolf installed you can start it in another window with "direwolf -p -q d -t 0"
pi@cherry:~ $
```

```
pi@cherry:~ $ direwolf -p -q d -t 0
Dire Wolf version 1.5 (Feb 16 2019) Beta Test 4
Includes optional support for:  cm108-ptt

Reading config file direwolf.conf
Audio device for both receive and transmit: plughw:1,0  (channel 0)
Channel 0: 1200 baud, AFSK 1200 & 2200 Hz, E+, 44100 sample rate / 3.
Note: PTT not configured for channel 0. (Ignore this if using VOX.)
Ready to accept AGW client application 0 on port 8000 ...
Ready to accept KISS TCP client application 0 on port 8001 ...
Virtual KISS TNC is available on /dev/pts/2
Created symlink /tmp/kisstnc -> /dev/pts/2
[0L] KC3LZO-2>CQ:z9<0x01><0x02>705<0x02><0x18>=n}o<0x17><0x03>#.0x02><0x19><0x00>0x0
a>)6atla<0x0d><0x1c>.UThis is an example chattervox message!
[0L] KC3LZO-2>CQ:z9<0x01><0x02>705<0x02><0x19><0x00><0x07>z<0x14><0x17>zKx'<0x1c>D<0
x02><0x18>2b?Dm4<0x16>DGI0x1b>0x0c>WDYou'll see that longer messages usually get com
pressed.
[0L] KC3LZO-2>CQ:z9<0x01><0x03>604<0x02><0x18>s?<0x0e>0x0a>grV<0x13>nU%7Rw<0x02><0x
18>P<0x12><0x08>HNh!i]<0x13>G<0x13><0x01><0x7f><0x0b>,QKUH/H*-Q(,<0x06><0x0b><0x16><
0x14>%&*g(($<0x16><0x14><0x16><0x17>0x01><0x00>
[0L] KC3LZO-2>CQ:z9<0x01><0x03>604<0x02><0x18>F<0x1c>K<0x02><0x18><0x0d>lkiMbv<0x18>
QKs-(J-.JTN.-*VS(U0x05>J%*d<0x16>+<0x14><0x16><0x01>U%*$C0x01><0x00>
[0L] KC3LZO-2>CQ:z9<0x01><0x03>604<0x02><0x18><0x09>G1<0x13>.S?<0x1a>jpz<0x02><0x1e>
<0x02><0x18>{<0x00>ri<0x1d>!<0x17>gk<0x18><0x1d>0x1a>~x-*NUH,)I-* <0x00>2S<0x15>K<0x
14>J0x15><0x0b>R<0x15>j<0x15>rT=<0x00>
```

```
KC3LZO-2: This is an example chattervox message!
KC3LZO-2: You'll see that longer messages usually get compressed.
KC3LZO-2: That one didn't, but this one probably will get compressed.
KC3LZO-2: Compression only occurs if the message is smaller once compressed.
KC3LZO-2: Otherwise chattervox chooses not to compress the message.
KC3LZO-2:
```

```
[0] 0:node*                                                "cherry" 20:41 24-Feb-19
```

Basic Usage

```
# open the chat room
chattervox chat

# send a packet from the command-line
chattervox send "this is a chattervox packet sent from the command-line."

# receive *all* packets and print them to stdout
chattervox receive --allow-all

# generate a new public/private key pair, and use it as your default signing key
chattervox genkey --make-signing

# add a friend's public key to your keyring, so that chattervox can verify their messages
chattervox addkey KC3LZO \
044da0d4c38bed6e5bc418231cb2dca4f690d858d36c38a032732553b76262a1adfccf588b6c1f9d7734b1bbce90914f82

# remove a friend's public key if it has become compromised
chattervox removekey KC3LZO \
0489a1d94d700d6e45508d12a4eb9be93386b5b30feb2b4aa07836398781e3d444e04b54a6e01cf752e54ef423770c00a6

# print all keys in your keyring
chattervox showkey
```

Chattervox Key Registry

Discussion on GitHub issues lead to the creation of a centralized “key server” where hams can register and share their keys via a secure channel.

For now, keys are added via pull requests to the chattervox-keys repository. (https://bit.ly/chattervox-keys)

The list of active and revoked keys is maintained and hosted on GitHub.

Future versions of Chattervox may allow you to automatically sync your local key store with these lists. Non-centralized key servers may also be explored in the future.

Chattervox Examples

I’ve created a collection of example applications and use cases for the Chattervox protocol @ https://bit.ly/chattervox-examples

- **Low-Fi Time Server**: Broadcast a time stamp beacon at regular intervals
- **A weather broadcast station**: Pulls local weather data from the Internet and broadcasts it via Chattervox
- **Breaking news headlines**: Pulls breaking news headlines from the Internet and broadcasts them via Chattervox (technically illegal on Amateur Frequencies)
- **Remote shell**: Use Chattervox to control a remote computer via Bash
- **Zork**: Play the famous text adventure game over packet radio

Byte Offset	# of Bits	Name	Value	Description
0x0000	16	Magic Header	0x7a39	A constant two-byte value used to identify chattervox packets.
0x0002	8	Version Byte	Number	A protocol version number between 1-255.
0x0003	6	Unused Flag Bits	Null	Reserved for future use.
0x0003	1	Digital Signature Flag	Bit	A value of 1 indicates that the message contains a ECDSA digital signature.
0x0003	1	Compression Flag	Bit	A value of 1 indicates that the message payload is compressed.
[0x0004]	[8]	[Signature Length]	Number	The length in bytes of the digital signature. This field is only included if the Digital Signature Flag is set.
[0x0004 or 0x0005]	[0-2048]	[Digital Signature]	Bytes	The ECDSA digital signature created using a SHA256 hash of the message contents and the sender's private key.
0x0004-0x104	0-∞	Message	Bytes	The packet's UTF-8 message payload. If the Compression Flag is set the contents of this buffer is a raw DEFLATE buffer containing the UTF-8 message.

[] indicates an optional field.

What is an Elliptic Curve?

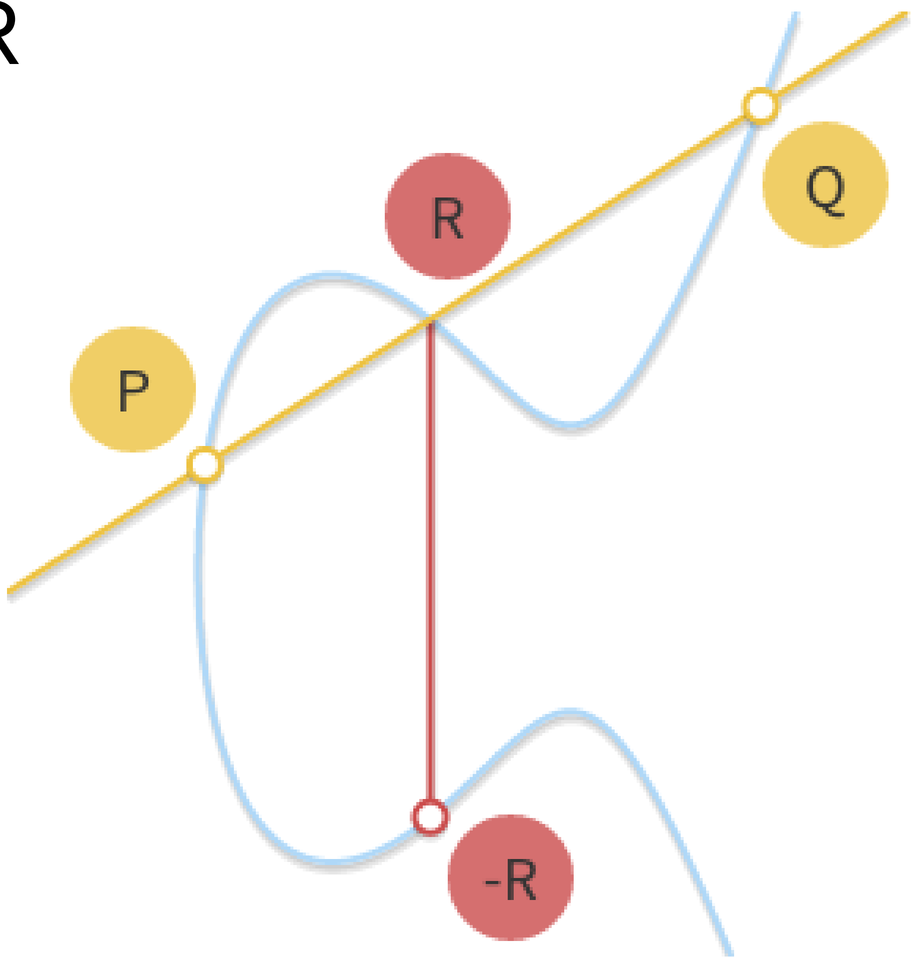
An elliptic curve is the set of points that are described by the equation...

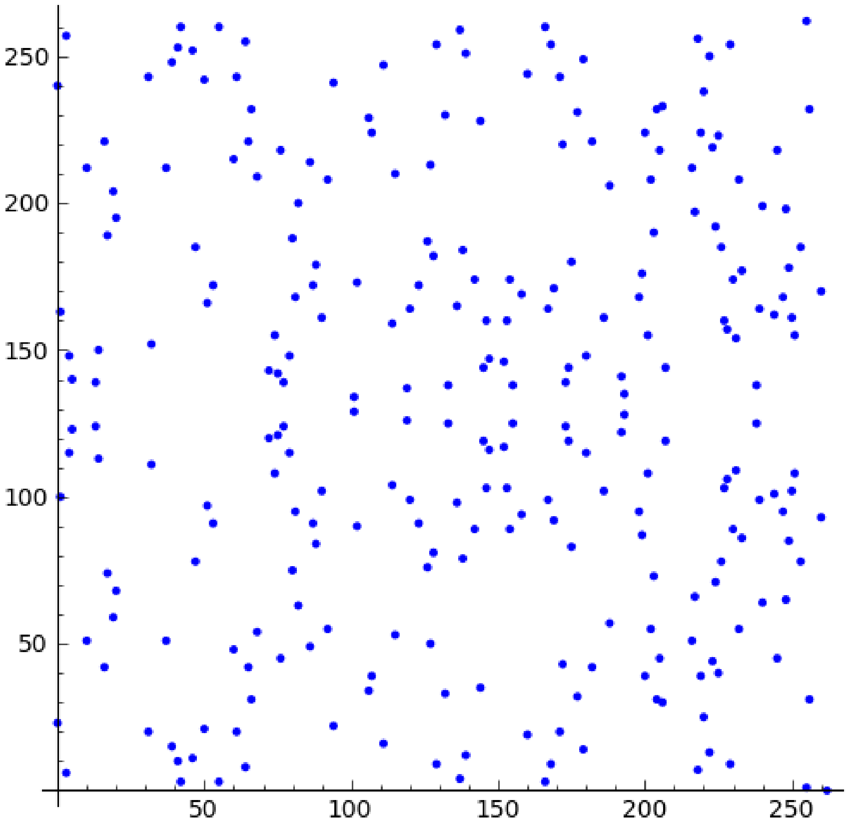
$$y^2 = x^3 + ax + b$$

Elliptic curves are defined by two variables, **a** and **b**.

Curves are more general than functions and allow multiple *y* output values to exist for each *x* input value.

$P + Q = -R$




250
200
150
100
50
50
100
150
200
250

Elliptic Curve Key Generation

Elliptic curves have a base point **G**. The private key is a random scalar d_A that is **G** multiplied by to produce the public key Q_A.

Private Key (scalar)

fccefae6a899e93b68c0ce7d6552449b6ef5b61ef0d26d78

Puplic Key (vector)

```
pubic_key = curve_base_point * private_key
```

04427306E1725abb009991a132bc5a9346de5531915d8946d591fdfa8825bbc037ad8f818b043e6d9994ad58e64a405368

```
public_key_format = concat(“04”, x, y)
```

STANDARDS FOR EFFICIENT CRYPTOGRAPHY

SEC 2: Recommended Elliptic Curve Domain Parameters

Certicom Research

Contact: secg-talk@lists.certicom.com

September 20, 2000
Version 1.0

2.5.2 Recommended Parameters secp192r1

The verifiably random elliptic curve domain parameters over $\mathbb{F}_p$ secp192r1 are specified by the sextuple $T = (p, a, b, G, n, h)$ where the finite field $\mathbb{F}_p$ is defined by:

p = FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFE FFFFFFFF FFFFFFFF

$= 2^{192} - 2^{64} - 1$

That’s an “E” 😮

The curve $E: y^2 = x^3 + ax + b$ over $\mathbb{F}_p$ is defined by:

a = FFFFFFFF FFFFFFFF FFFFFFFF FFFFFFFE FFFFFFFF FFFFFFFC

b = 64210519 E59C80E7 0FA7E9AB 72243049 FEB8DEEC C146B9B1

E was chosen verifiably at random as specified in ANSI X9.62 [1] from the seed:

S = 3045AE6F C8422F64 ED579528 D38120EA E12196D5

The base point G in compressed form is:

G = 03 188DA80E B03090F6 7CBF20EB 43A18800 F4FF0AFD 82FF1012

and in uncompressed form is:

G = 04 188DA80E B03090F6 7CBF20EB 43A18800 F4FF0AFD 82FF1012
07192B95 FFC8DA78 631011ED 6B24CDD5 73F977A1 1E794811

Finally the order n of G and the cofactor are:

n = FFFFFFFF FFFFFFFF FFFFFFFF 99DEF836 146BC9B1 B4D22831

h = 01

ECDSA

The ECDSA *Signature Algorithm* creates a point (r, s) using a message, a private key (d_A), and a **curve**.

e = SHA256(message)

z = left_bits(e, bit_length($\boldsymbol{n}$))

k = random(1, $\boldsymbol{n}$-1)

$(x, y) = k * \boldsymbol{G}$

$r = x \bmod \boldsymbol{n}$

$s = k^{-1} * (z + r * d_A) \bmod \boldsymbol{n}$

signature = (r, s)

The ECDSA *Verification Algorithm* verifies that **curve** point (r, s) was derived from a message, and the unknown private key (d_A) associated with a known public key (Q_A).

e = SHA256(message)

z = left_bits(e, bit_length($\boldsymbol{n}$))

$w = s^{-1} \bmod n$

$u_1 = z * w \bmod n$

$u_2 = r * w \bmod n$

$(x, y) = u_1 * \boldsymbol{G} + u_2 * Q_A$

is_valid if $r \equiv x \bmod n$

Thanks

https://github.com/brannondorsey

https://brannon.online

@brannondorsey