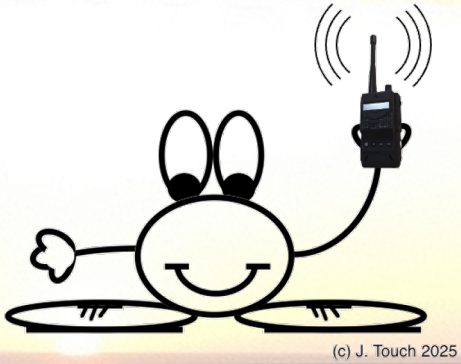
D-Star Simplified



Dr. Joe Touch / AK6MB

October 9, 2025

A little about the speaker…

- Dr. Joe Touch (strayalpha.com)
  - Prof. of CS and EE at USC for 25 yrs
  - Currently at the Aerospace Corporation
  - Focus in computer networking
  - Includes optical comms/signal processing
  - Authored 150+ papers, 5 US patents, and 22 RFCs (incl. mods to IP, TCP, UDP)
- AK6MB
  - Tech/Gen/Extra in March 2025
  - GLAARG VE #3985E since March 2025
  - Queen Mary crew since Aug 2025, radio operator second Sundays 9a-1p
  - Supporting 2025 tech pool revision
  - Daughter in the UK is M7OTL (Foundation)
- Other hobbies
  - Electric guitar, cooking (pasta, cookies, marmalades)
- My shack
  - ICOM ID-52a Plus HT
  - ICOM IC-705 HT/base
  - Hardrock 50 amp w/tuner
  - Diamond X300A UHF/VHF
  - Ultimax 100 66’ end-fed HF
  - Buddipole mini for park ops
  - ICOM AH-705 tuner for park ops
  - WPSD simplex & duplex hotspots
  - NanoVNA-H4 analyzer
  - iPad SDR Control for FT8
- My experience so far
  - 860+ QSOs (incl. nets)
  - Guest op at Bletchley Park
  - Voice to Italy
  - FT8 to everywhere except India, mid-east
  - Constitution Day, Fire Prevention special events operator

D-Star background

- Digital mode
  - Open specification
  - Proprietary voice compression algorithm (because an open one did not exist at the time)
  - Digital message with each transmission
  - Supports location tracking (like APRS)

- For hams, by hams
  - Requested by gov't of Japan in 1998
  - Designed by Japan Amateur Radio League
  - First standard approved 2001
  - ICOM registered the name "D-Star" (as protection?)

Who supports D-Star?

ICOM

KENWOOD

FlexRadio

D-Star is expensive

Brand	Model	Price	Power	Type
ICOM	ID-50a	$400	5W	HT
Kenwood	TH-DX75	$640	5W	HT
Yaesu	FT-70DR	$190	5W	HT/C4FM
Anytone	ATD168UV	$200	6W	HT/DMR
Baofeng	DM-1701	$35	5W	HT/DMR

Over the air, it has advantages

- Digital encoding
  - GMSK: Gaussian minimum shift encoding (variant of FSK)
  - Modulation index of 0.5 (the smallest possible)
  - 6.25 kHz bandwidth
  - Similar to GSM phone, Bluetooth
  - “Constant envelope”: fade, interference, noise resistant
- Supports all bands
  - 2m (144 MHz), 70cm (440 MHz), 23cm (1.2 GHz)
  - 1.25m (220 MHz) US Kenwood, not ICOM (not in Japan)
  - HF on ICOM IC-705, IC-7100, IC-9100, Flex

Some details

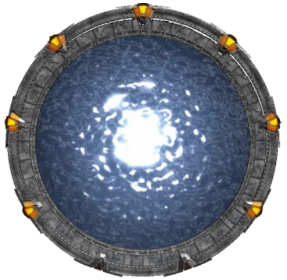
- 4,800 bits/sec
  - 3,600 bits/sec voice, proprietary CODEC
  - Other bits are data and error correction
- Runs a private network
  - Users assigned 10.x.x.x address blocks
  - Callsigns mapped to IP addresses

Digital mode comparisons

	Who?	Voice	Code	Other	Channel	Band
D-Star	Public	3.6 kbps	GMSK	Data, message, location, image, video	6.25 kHz	Any
C4FM (Fusion)	Yaesu	4.4 kbps	FSK	Data, message, location, image	12.5 kHZ	UHF/VHF
DMR	Public	2.45 kbps	FSK	Message, location	12.5 kHZ	UHF/VHF
P25	Public	4.4 kbps	FSK	Packet IP, location	12.5 kHZ	UHF
NXDN	Public	4.8 kbps	FSK	Message, location	2x 6.25 kHZ	UHF/VHF
Phone	Public	56 kbps	PCM, PAM	Data	64 kbps	n/a

What makes D-Star special?

- It's a system of gateways (like Stargates)
  - Enter at your local stargate
  - Pop out at any other stargate!
  - Even find someone at *any* stargate!



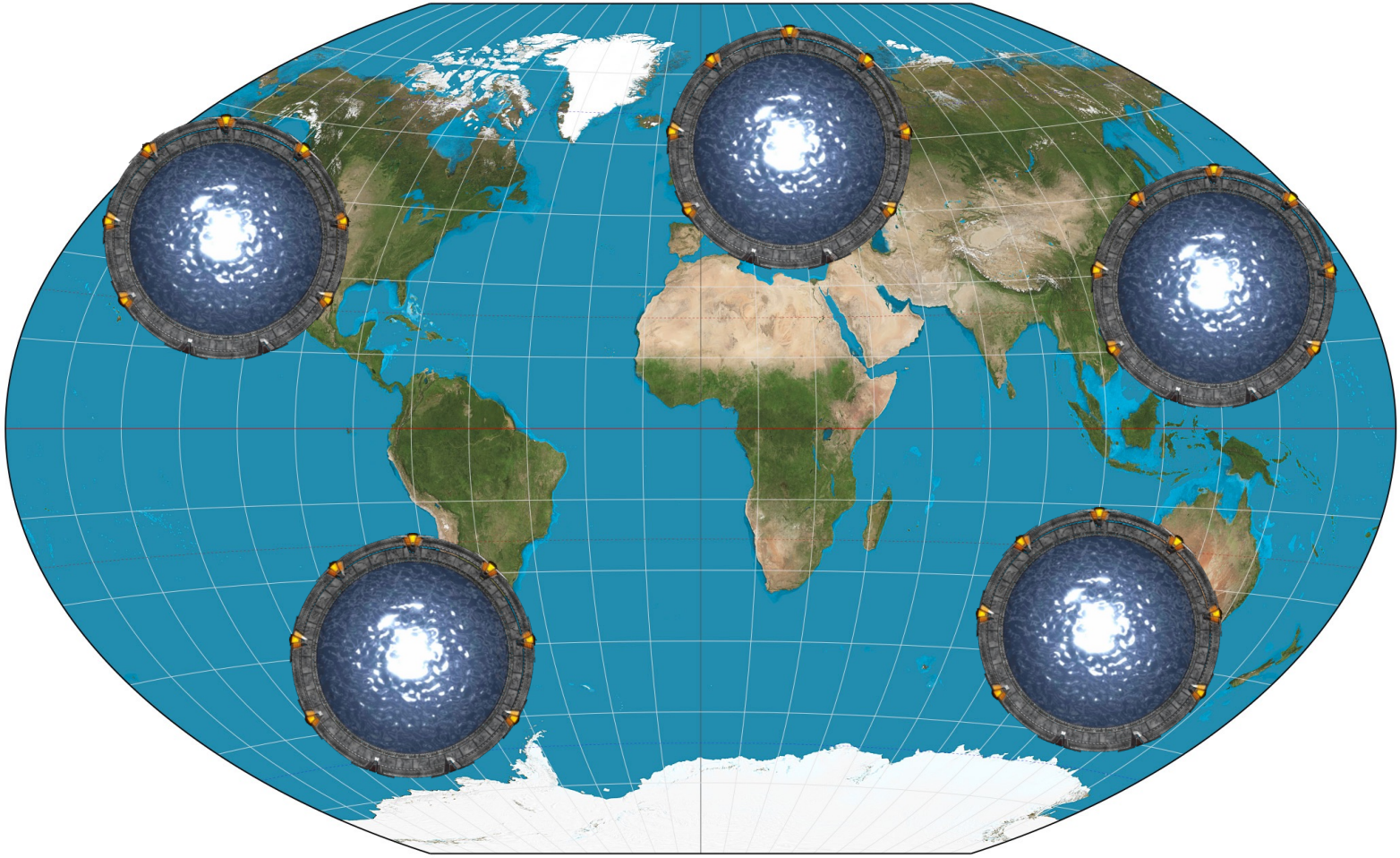
- Stargates connect via the Internet @
  - SOME hams consider that "cheating"
  - To others (me), it's just a different way of linking repeaters (vs. cables, microwave links)

The D-Star Stargate model

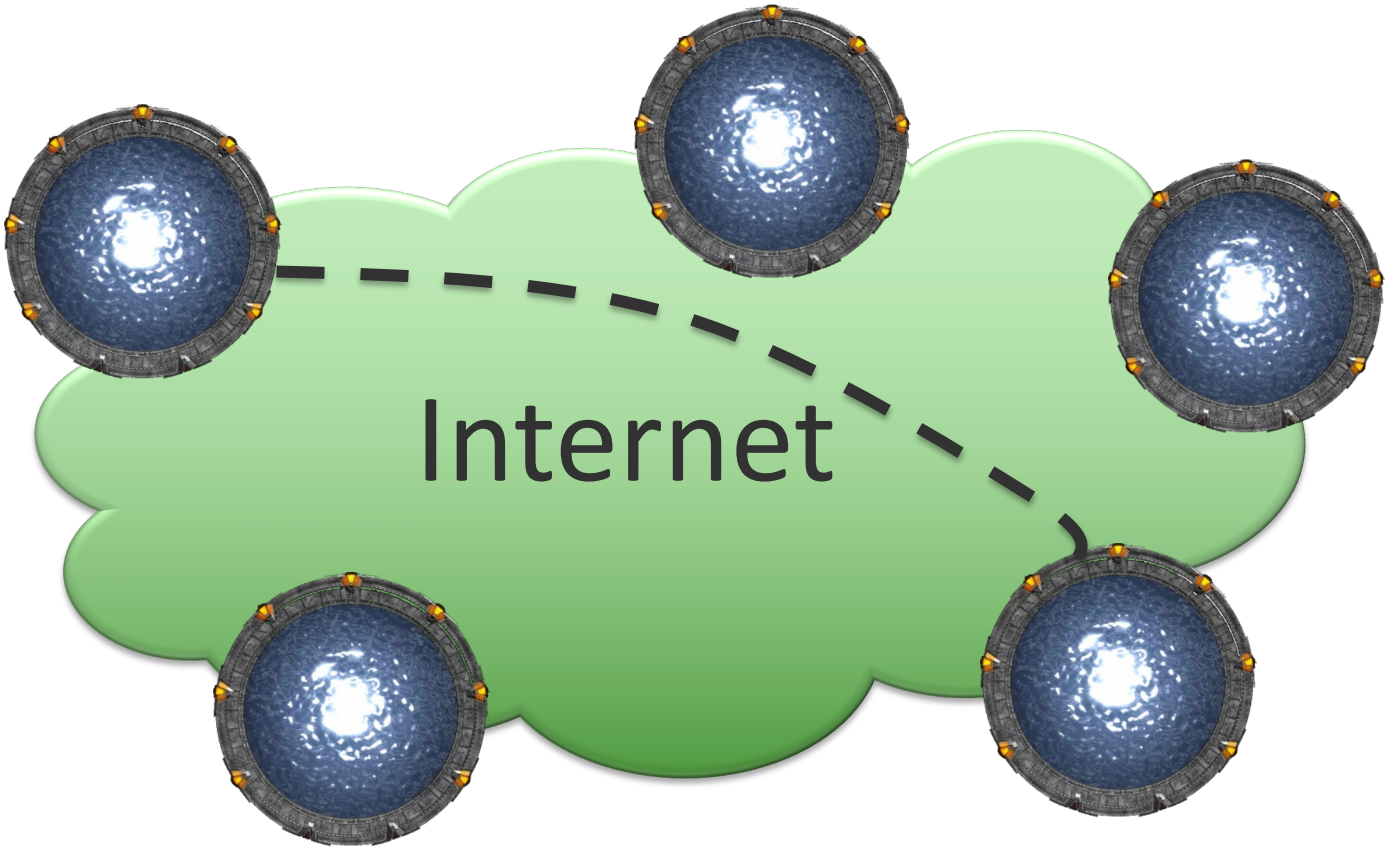
- Each D-Star is like a Stargate
  - You exchange signals on a “port”
  - A,B,C are RF
  - G is the gateway (Internet)

- Where can you go?
  - Exit that stargate via a different “port”
  - Exit a different stargate at a specific “port”
  - Exit the stargate/port pair of a specific callsign
  - Exit a group of linked stargates

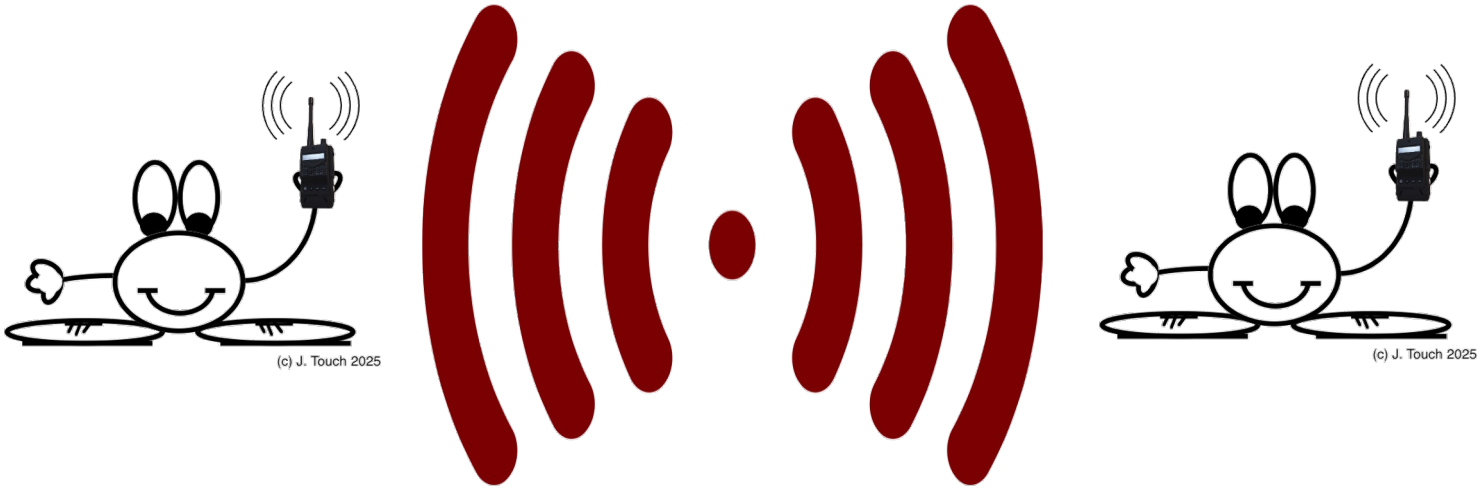
D-Star repeaters everywhere



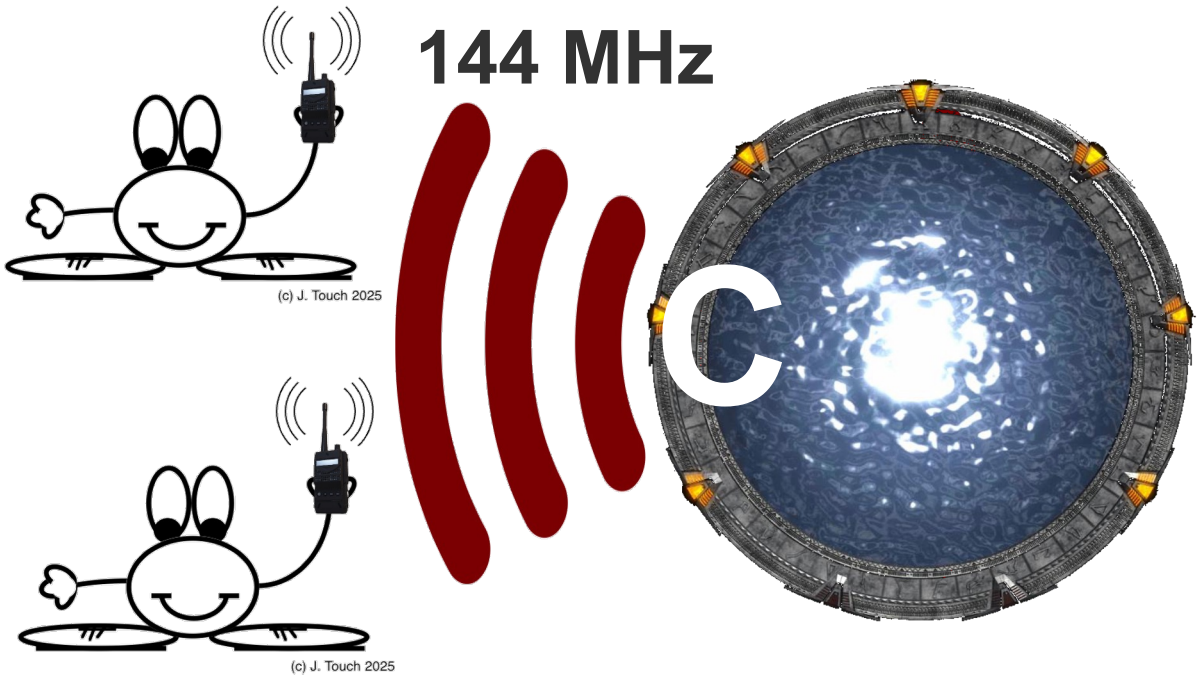
Up to one hop interconnect



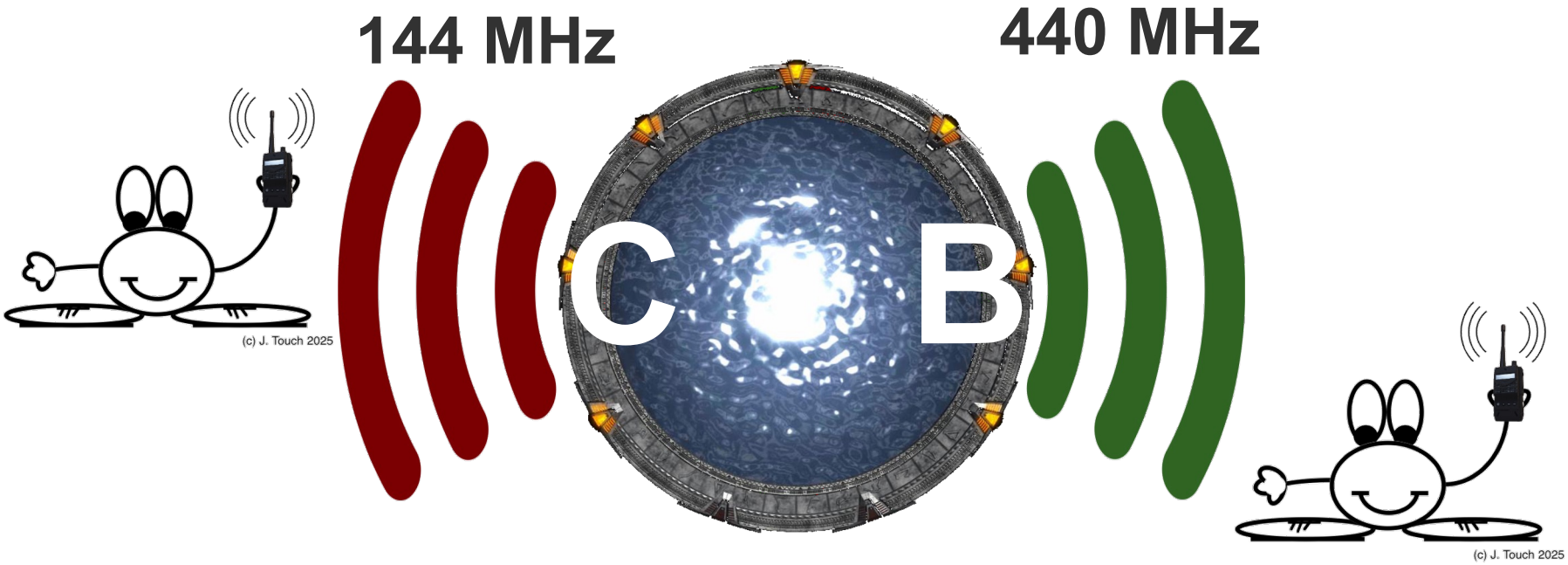
Direct



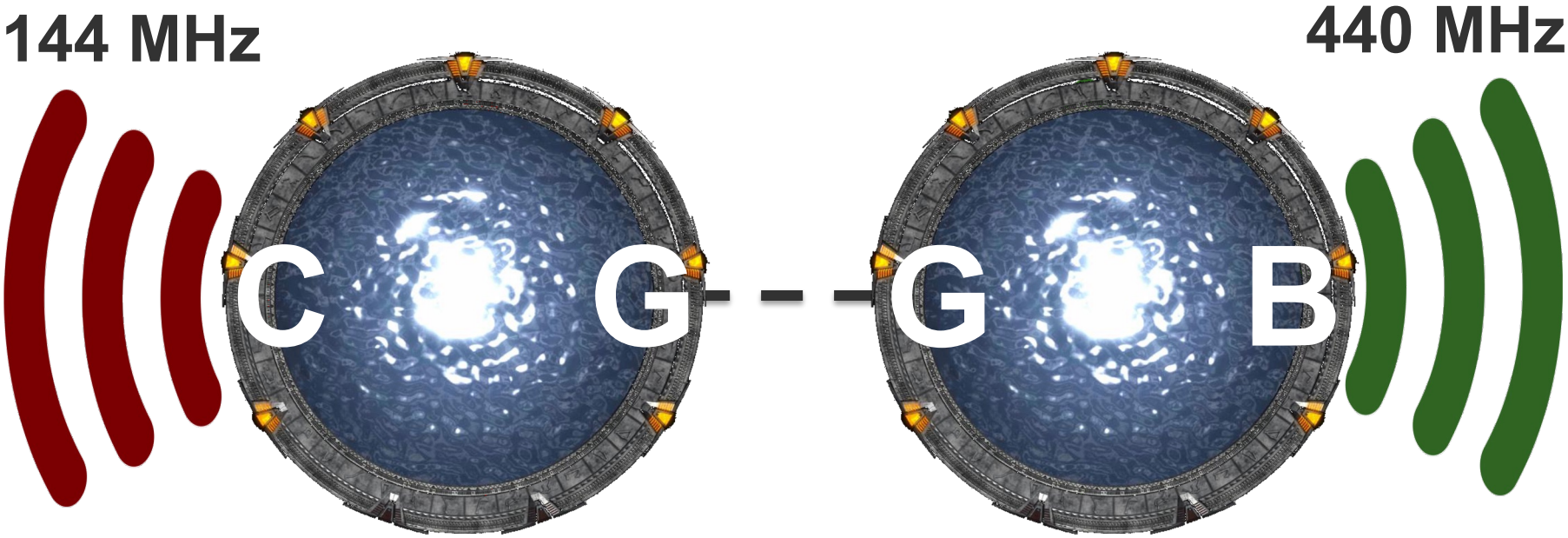
Local repeater



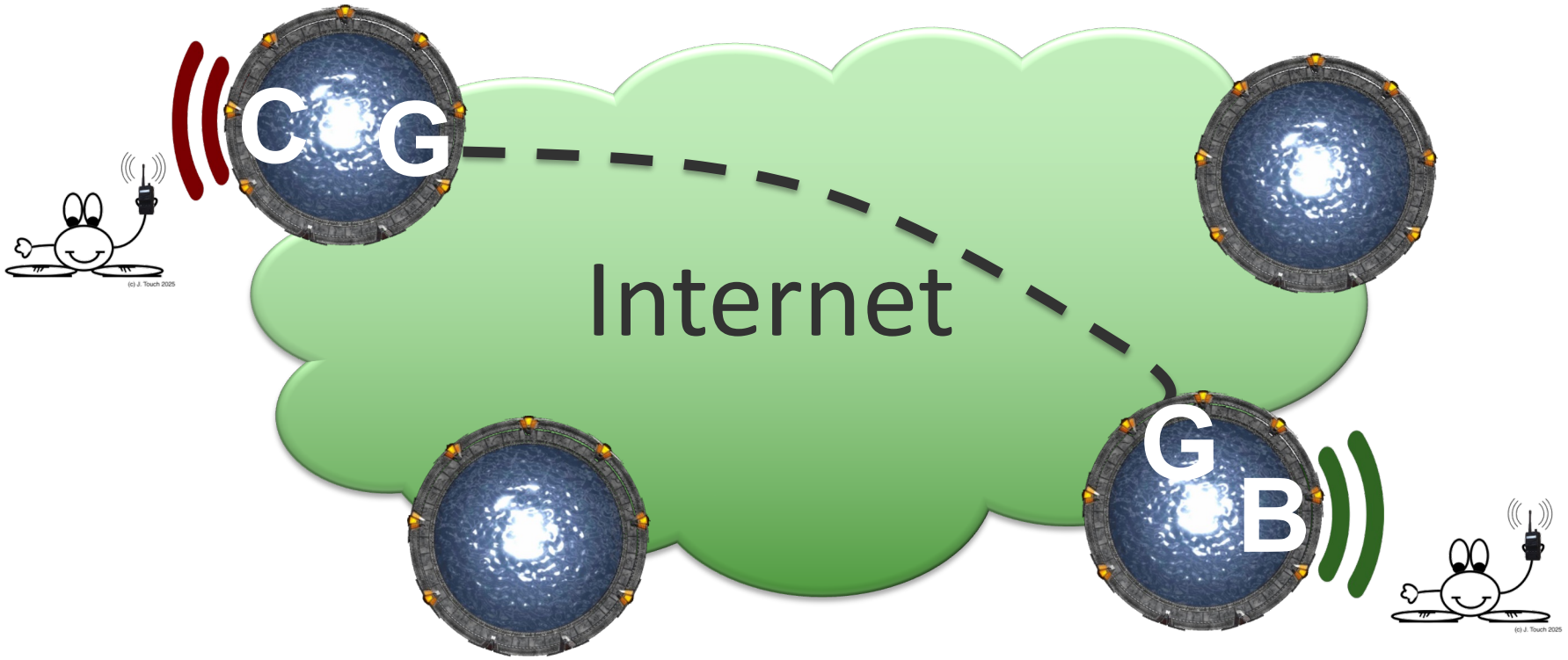
Local repeater as translator



Repeater pair as translators

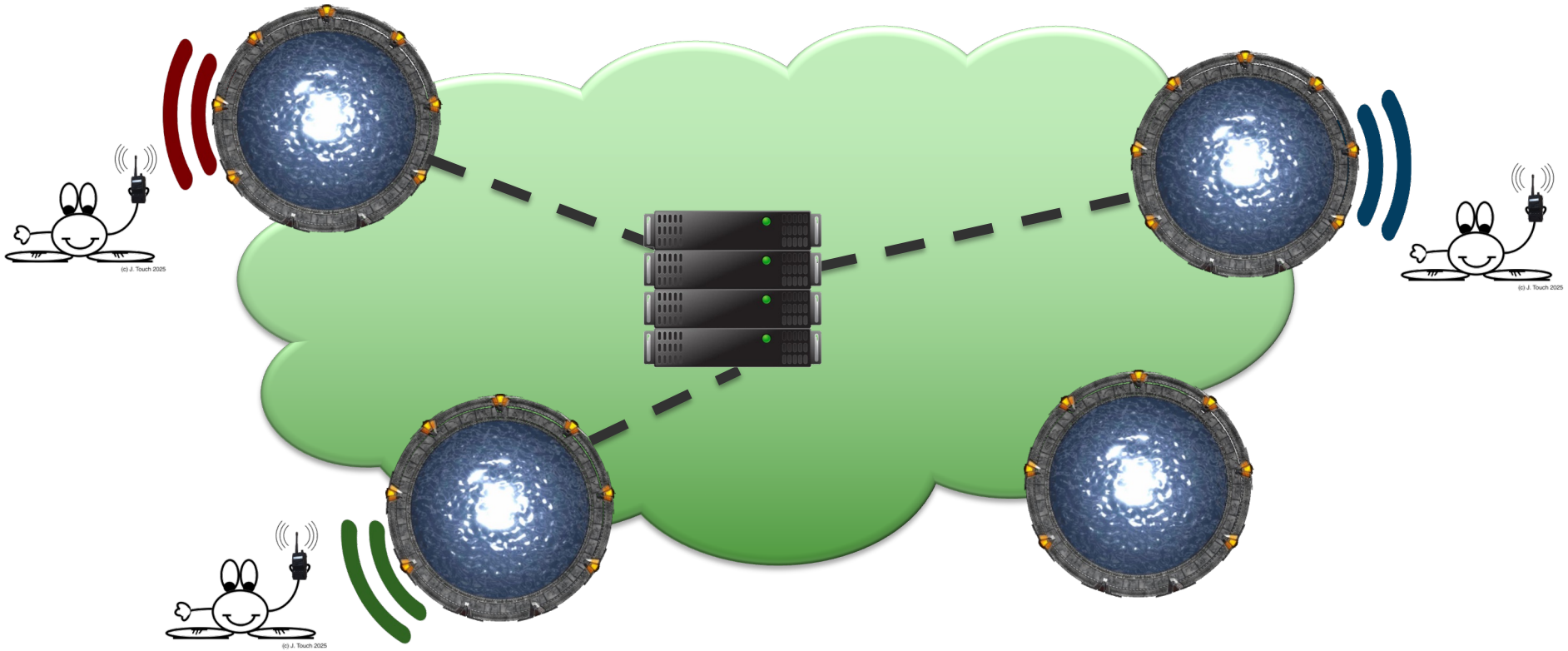


Connect to a remote port

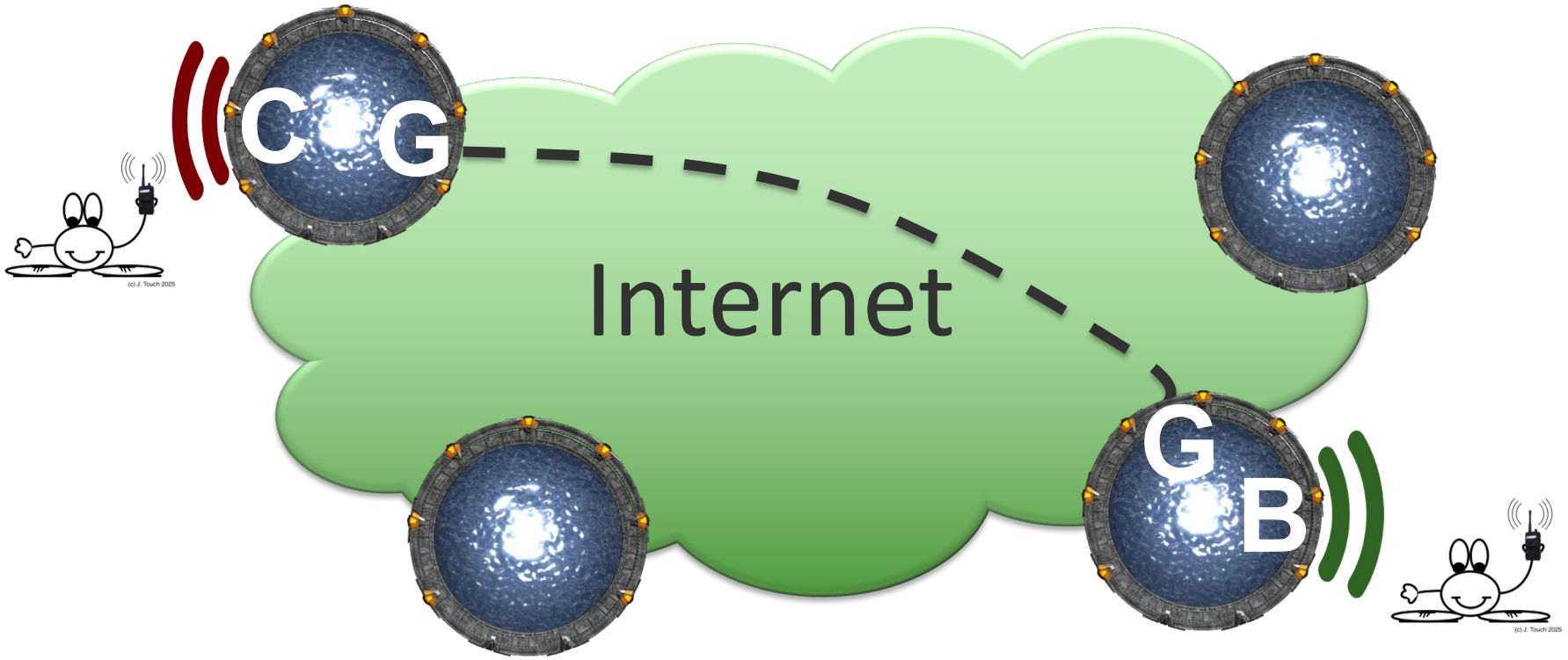


Join a D-Star reflector – REF

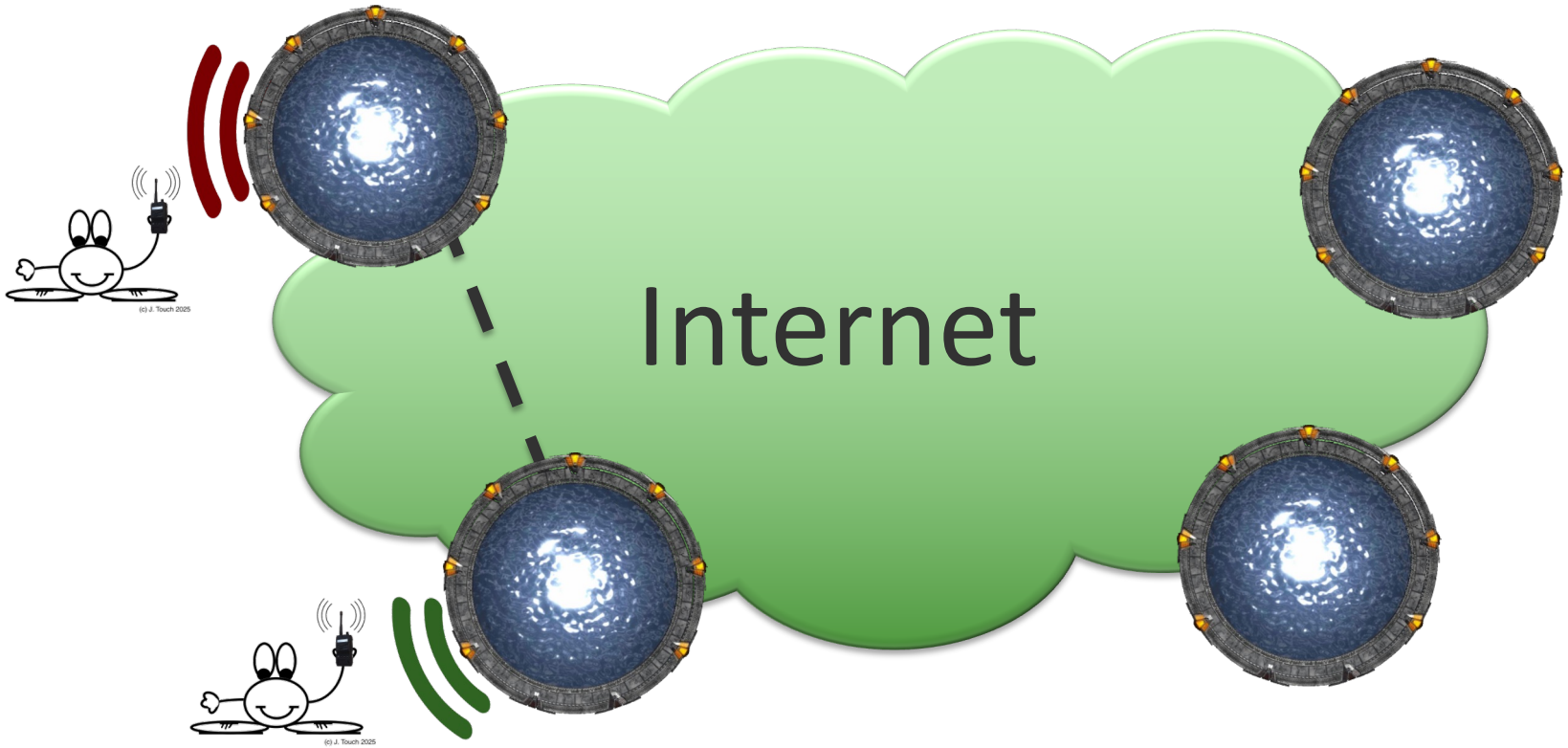
Reflectors copy the data stream



Find a callsign

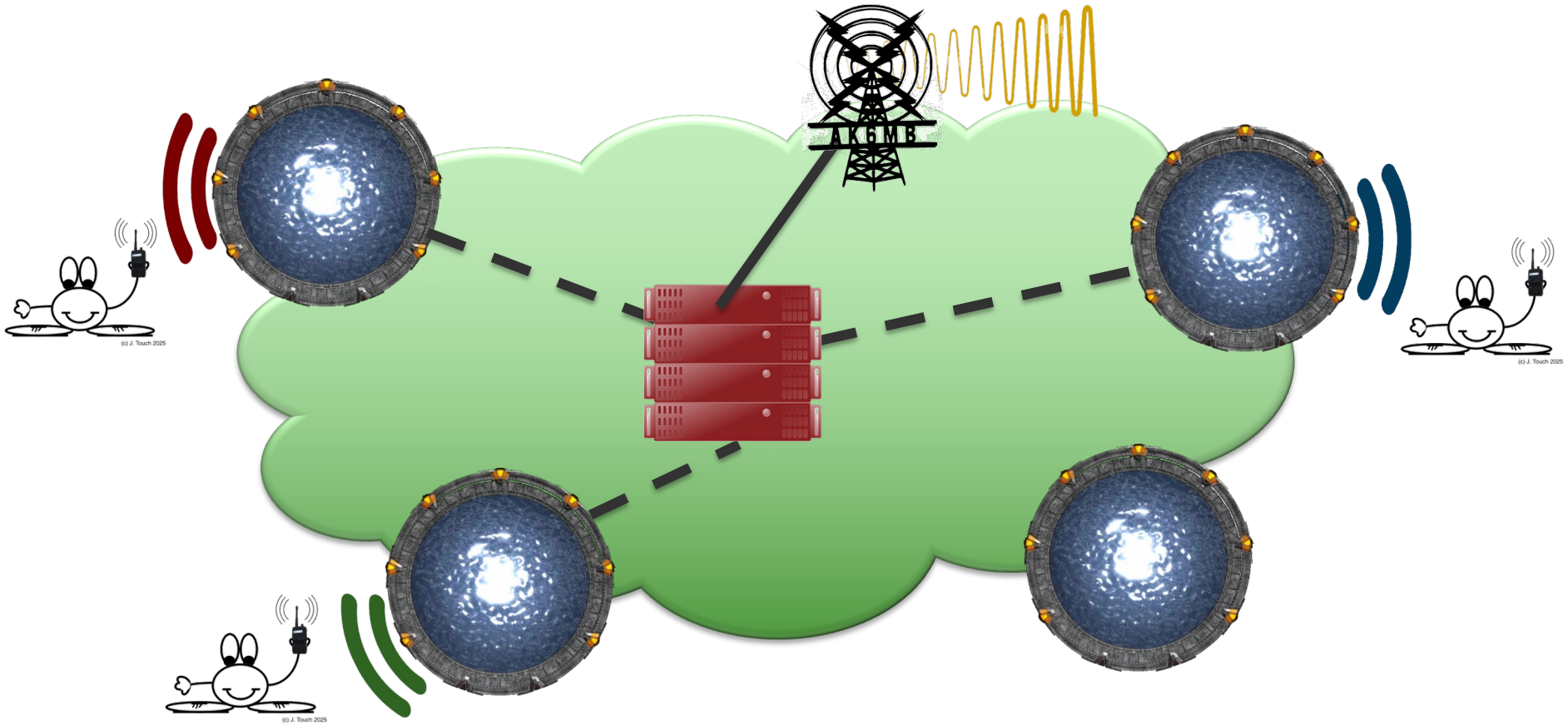


Find a callsign



Join a multimode reflector – XRF/XLX

Copies the data to digital and FM



Command types

Suffix	Command	Meaning
L	Link	Connect stargates via a reflector (REF) or stargate
O	Link (extra/exper)	Connect stargates via an X-reflector (XRF/XLX)
U	Unlink	Unlink from a reflector, X-reflector, or stargate
I	Info	Report current status and other information
E	Echo	Play back this (brief) recording

Basic commands are 8 characters

Callsign routing

Always your local repeater

This is where most errors occur; most of the power is in URCALL

	CSR	URCALL	RPT1	RPT2	Notes
simplex		(callsign)			Transmit to a receiver directly
local		CQCQCQ^^	AK6MB B	AK6MB B	(or RPT2 blank) Local repeater one band
Local x-band		CQCQCQ^^	AK6MB B	AK6MB A	Local repeater cross-band
Use repeater		CQCQCQ^^	AK6MB B	AK6MB G	Use the linked reflector (to anyone)
Link to REF		REF012AL	AK6MB B	AK6MB G	Link to a D-Star reflector
Link to XRF/XLX		XRF012AO	AK6MB B	AK6MB G	Link to a cross-mode reflector
Unlink		^^^^^^^U	AK6MB B	AK6MB G	Unlink the local repeater (if any)
Info		^^^^^^^I	AK6MB B	AK6MB G	Local repeater sends a report (content varies)
Echo		^^^^^^^E	AK6MB B	AK6MB G	Local repeater records and plays back a transmission
Call an individual	X	AA6AAA	AK6MB B	AK6MB G	Use remote repeater where last heard **or registered**
Call to the repeater	X	/AA6AAA	AK6MB B	AK6MB G	Route **TO** a repeater (/=repeater), presumably useful as remote LOUIE?
Link to exit a repeater	X	AA6AAApL	AK6MB B	AK6MB G	? (defined in the specs, but unclear what it does – this looks like L in LOUIE, but lacks the "/")
Call out a repeater port	X	/AA6AAAp	AK6MB B	AK6MB G	Route to repeater's specific node (/= repeater)

NOTE: "^" indicates a space character

D-Star is inherently duplex

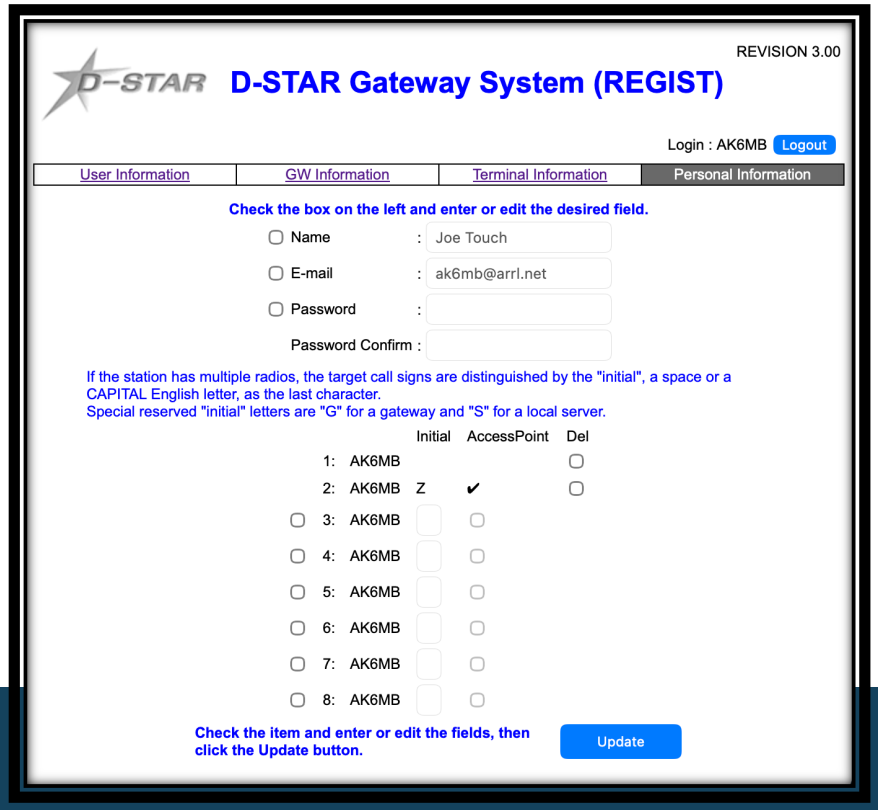
- D-Star is a repeater mode
  - Repeaters are usually duplex
- It works on a simplex channel, but…
  - You MUST configure your rig to “duplex”
  - E.g., DUP+ or DUP- with offset = 0
  - Otherwise D-Star won’t operate at all (yeah, seems like an oversight to me too)

How to GOTA with D-Star

- Register
- Setup your radio
- Go!

Register

- Create a login and register on D-Star
  - On your local repeater if possible



Setup your radio

- Digital
  - Your call sign
    - Select S
    - Name Joe
    - Callsign AK6MB

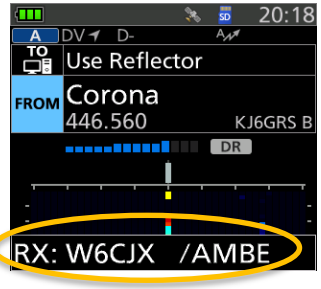
    } *This is the only required part*
  - My station
    - My call sign
      - Select S
      - Callsign AK6MB
      - / I705
    - TX message
      - Select S
      - Message Manhattan Beach, CA
- GPS
  - GPS Setting
    - GPS TX
      - GPS TX Mode D-PRS
    - DPRS info
      - Item, info

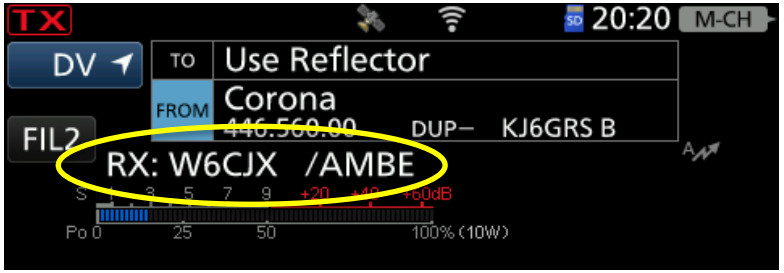
Kerchunk away!

- On D-Star, kerchunk sends a message
  - Always sends your callsign
  - Optionally also:
    - Your name
    - A 4-character note (typically your radio model)
    - A text message
    - Your GPS location, with an object icon you select
- Kerchunk sends commands too
  - To link, unlink, get info, test echo

Examples…

- Introduce yourself
  - Callsign, 4-character code (rig ID, e.g., I705)
    AK6MB / I705
    AK6MB / Joe

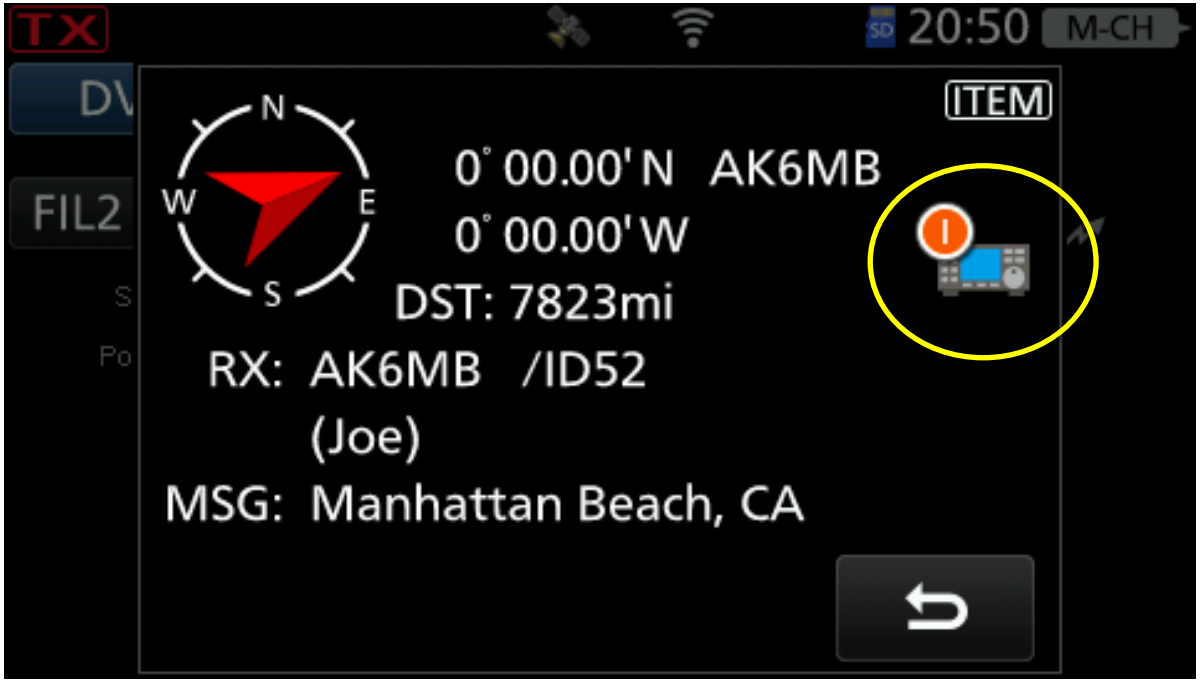




  - 20 Character message (location, message)
    Manhattan Beach, CA
    Surf's up, dude!

Provide your location and info

- Info:
  - Object
  - Item
  - Weather



Configure – DV

- This might already be done
  - Most D-Star rigs have an initial DV repeater list
- Add to DV list if needed
  - One entry for each port (band) per repeater
  - Each call/port pair can appear only ONCE
  - E.g., some PAPA DV repeaters are already in ICOM's list … so change them rather than adding a new entry (as you would for FM repeater lists in regular memory)
- DV list has advantages
  - Search by 'nearest' (works for FM too)
  - Select local repeater,/port remote repeater/port, and command independently

Configure – memory

- Add to memory list (with FM stations)
  - No limit on call/port duplicates
  - One entry per <local repeater/port, remote repeater/port, command> tuple
- No independent selection
  - Entire tuple in each memory slot
  - Usually use at least 3 slots each: link, unlink, 'use repeater'

DV list vs. memory list

- Both can include FM and D-Star entries
- DV list is primarily for D-Star
  - Can be searched by GPS location
  - Allows DV entry with easily changing URCALL, RPT1, RPT1 parameters
- Memory list is similar to non-D-Star rigs
  - D-Star repeaters typically use one entry for each URCALL, RPT1, RPT2 parameter set, because changing those parameters is awkward from the rig

Why hotspots?

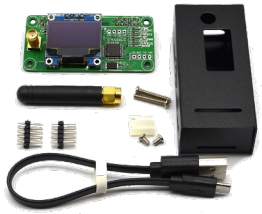
- Too far away
  - No local D-Star repeater
- Practice
  - Learn how to link, unlink, connect
  - Reduce impact on shared resources

Hotspots

- Commercial
  - ZUMspot 1.3 $175
  - ZUMspot 2.4 $190
  - OpenSPOT 4 Pro (batt) $375

- Assembled
  - Ebay elecdesign2015 $75

Hotspots on the cheap - $62



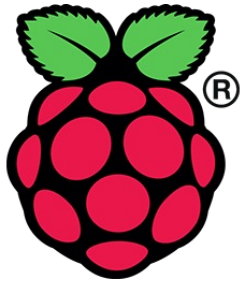
- DIY
  - MMDVM modem + case $32
    - Walmart MMDVM hotspot hat oled case

  - Raspberry Pi Zero 2 W $25
    - Amazon raspberry pi zero 2 w pre-soldered
  - 8GB SDHC card $5

- Bigger display // Raspberry Pi 3/4 // Duplex
  - Available, but increase the cost

DIY hotspot

- Assemble the parts
  - Watch out for static
  - Be patient and careful
- Program the SD card
  - Download wpsd or pi-star to your computer
  - Use Raspberry Pi Imager to load it
  - Unmount the SD card and remove it
  - Insert the SD card into your hotspot



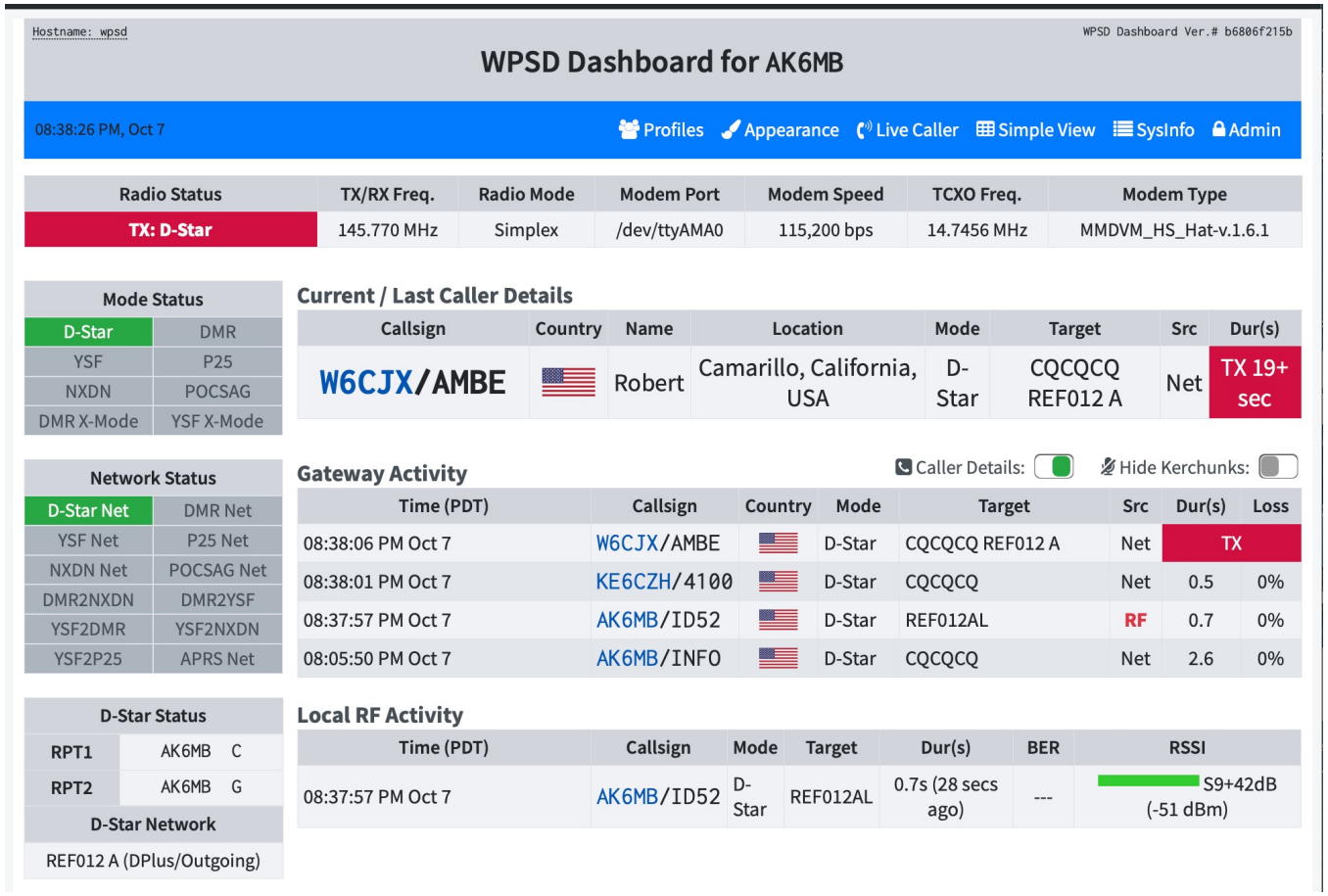
- Configure your hotspot
  - Wait for it to boot (via its display) - a few minutes the first time
  - Join its WIFI net
  - Pull up its web page
  - Configure via that web page

My hotspots

- Simplex
  - 145.770 (-0)
  - MUST use DUP
    (+ or -, set offset=0)

- Duplex
  - 449.4625 (-)
  - Requires send/recv separate by 5 MHz
    (2m band is only 4 MHz wide,
    but 70cm is 30 MHz wide)

Hotspot website monitoring



Hostname: wpsd

WPSD Dashboard Ver.# b6806f215b

WPSD Dashboard for AK6MB

08:38:26 PM, Oct 7 — Profiles | Appearance | Live Caller | Simple View | SysInfo | Admin

Radio Status	TX/RX Freq.	Radio Mode	Modem Port	Modem Speed	TCXO Freq.	Modem Type
TX: D-Star	145.770 MHz	Simplex	/dev/ttyAMA0	115,200 bps	14.7456 MHz	MMDVM_HS_Hat-v.1.6.1

Mode Status	
D-Star	DMR
YSF	P25
NXDN	POCSAG
DMR X-Mode	YSF X-Mode

Network Status	
D-Star Net	DMR Net
YSF Net	P25 Net
NXDN Net	POCSAG Net
DMR2NXDN	DMR2YSF
YSF2DMR	YSF2NXDN
YSF2P25	APRS Net

D-Star Status	
RPT1	AK6MB C
RPT2	AK6MB G
D-Star Network	
REF012 A (DPlus/Outgoing)	

Current / Last Caller Details

Callsign	Country	Name	Location	Mode	Target	Src	Dur(s)
W6CJX/AMBE		Robert	Camarillo, California, USA	D-Star	CQCQCQ REF012 A	Net	TX 19+ sec

Gateway Activity — Caller Details: | Hide Kerchunks:

Time (PDT)	Callsign	Country	Mode	Target	Src	Dur(s)	Loss
08:38:06 PM Oct 7	W6CJX/AMBE		D-Star	CQCQCQ REF012 A	Net	TX	
08:38:01 PM Oct 7	KE6CZH/4100		D-Star	CQCQCQ	Net	0.5	0%
08:37:57 PM Oct 7	AK6MB/ID52		D-Star	REF012AL	RF	0.7	0%
08:05:50 PM Oct 7	AK6MB/INFO		D-Star	CQCQCQ	Net	2.6	0%

Local RF Activity

Time (PDT)	Callsign	Mode	Target	Dur(s)	BER	RSSI
08:37:57 PM Oct 7	AK6MB/ID52	D-Star	REF012AL	0.7s (28 secs ago)	---	S9+42dB (-51 dBm)

Things I'm still figuring out…

- Modes
  - Terminal, access point (like a hotspot)
- Transfers
  - Picture, video
- Functions
  - BK (break-in), EMR* (emergency broadcast*)
- D-Star registration
  - Use of other suffix letters
  - Whether 2+ hotspots can use one callsign
- Callsign routing
  - Safely, without tying up others' repeaters (see *)
- Exactly how reflectors pick sources
  - I think xmiters "capture" the reflector until it goes idle (seems true?)
  - Or do reflectors "sum" their inputs? (hard to tell – not heard yet)