Ham Radio VoIP

and the Digital VoIP Multimode Interlink System

Jeffrey Kopcak - K8JTK
ARRL Ohio Section Technical Coordinator

Technical Coordinator

The ARRL Technical Coordinator (TC) is a section-level official appointed by the Section Manager to coordinate all technical activities within the section.

- Supervise and coordinate the work of the section's Technical Specialists (TS)
- Refer amateurs in the section who need technical advice to local TS
- Encourage amateurs in the section to share their technical achievements with others through the pages of QST, at club meetings, hamfests, and conventions

Technical Coordinator

- Be available to assist local technical program committees in arranging suitable programs for local club meetings, ARRL hamfests, and conventions
- Promote technical advances and experimentation at VHF/UHF and with specialized modes, and work closely with enthusiasts in these fields within the section

Technical Specialist

For a section team to be effective in one of the most important arenas in Amateur Radio, technology, there must be a cadre of qualified, competent Technical Specialists (TS).

"Advancement of the radio art" is a profound obligation we incur under the rules of the FCC.

TSes help meet this obligation.

Technical Specialist

TS supports the TC in two main areas of responsibility:
Radio Frequency Interference and **Technical Information**.

Technical Specialist can specialize in certain specific technical areas, or can be generalists.

https://www.arrl.org/technical-specialist

Outline

- What is VoIP?
- Analog systems
- Digital systems

- DVMIS
- Software used
- Connection links
- Dashboards & diagrams
- Problems
- Nets

What is VoIP?

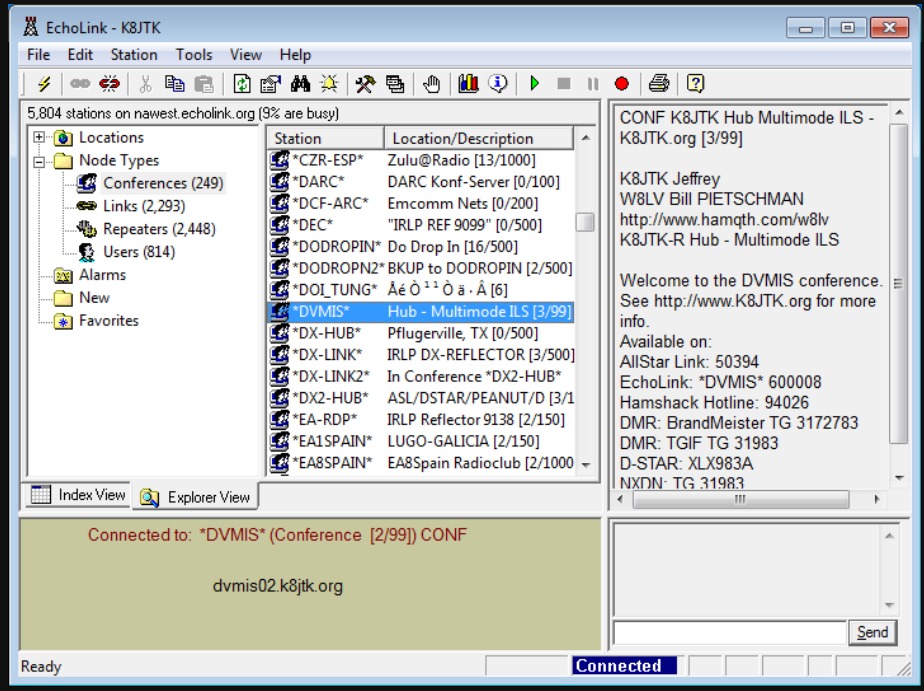
Voice over Internet Protocol (VoIP), also called IP telephony, is a method and group of technologies for the delivery of voice communications and multimedia sessions over Internet Protocol (IP) networks, such as the Internet.

Ham VoIP

- New, as of about 2002
- Networks or Internet for long distance communication, not ionosphere
- Mostly 2m or 440, some 220 & 6m (VHF/UHF)
- Repeaters and simplex node linking, some user/non-RF
- Internet-aided DXing for Technicians, not interested in HF, not capable
- Occasionally called "RoIP" for Radio over IP, at least one radio device has an IP connection
- Mostly independent, own islands

Ham VoIP - Analog Systems

- Echolink
- ~~iLink~~
- ~~eQSO~~
- IRLP
- ~~WIRES-II~~
- AllStar Link
- WIRES-X (both)
- Hamshack Hotline
- Hams Over IP
- AmateurWire



Uses

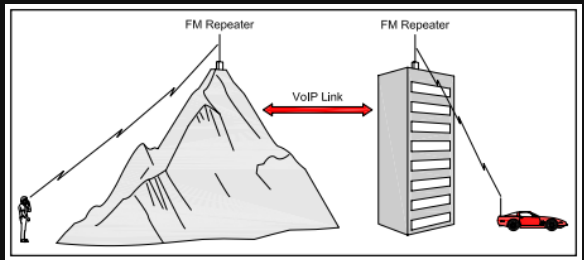


Figure 1—Two FM repeaters linked via VoIP.

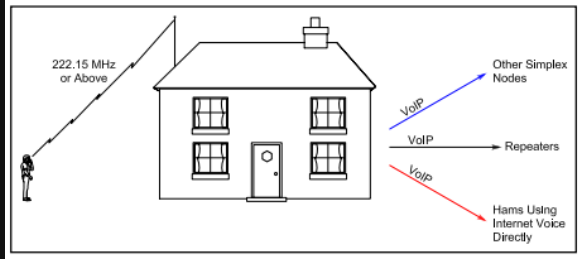


Figure 2—A diagram of a VoIP simplex node. If a control operator is not physically present at the station location and the node is functioning with wireless remote control, the control link must operate above 222.15 MHz. See the sidebar, "Is It Legal?".

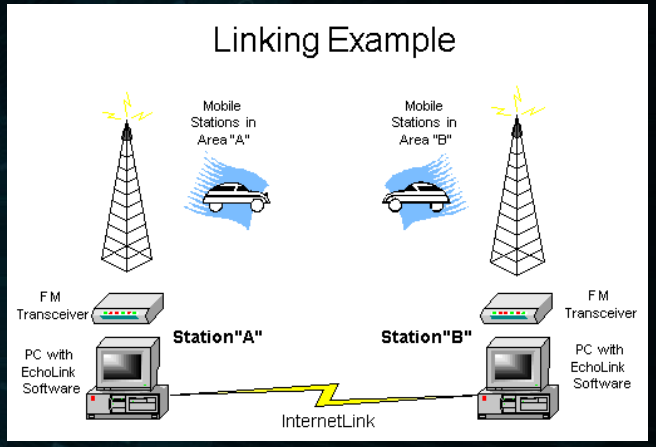
img: QST, Feb 2003

- Common install:
- PC/Pi running Windows/Linux
- Interface: circuit, audio FOB, RIM, URI, RTCM (EOL), HRI, ...
- Transmitter: repeater, link/simplex radio, or none (radio less)
- Access other nodes: DTMF

img: DMK Engineering

Echolink

- Early 2002 by Jonathan - K1RFD
- Quick adoption. 30,000 nodes ~1 yr
- User = K8JTK, Link = K8JTK-L, Repeater = K8JTK-R, Conference = *DVMIS*
- Port forwarding (firewall), specific ports. One node per IP.
- Proxies
- Closed source, reverse engineering OK
- Resurgence mobile apps
- Echolink. Windows, OS X, Qtel (Linux), SVXLink, Android, iOS



img: Echolink

IRLP

- Started 1997 by Dave - VE7LTD
- Only accessible via radios
- node -> node or node -> reflector
- Approved or specialized hardware required, source of income
- Linux install. Closed source. Network tightly controlled.
- NO experimentation. Booted reverse engineering, cross connecting modes.
- EchoIRLP - Echolink or IRLP, not both same time
- Experimental reflectors, 2018
- IRLP

AllStar Link

- AllStar - open-source PBX Asterisk, Linux
- AllStar Link - network, phone directory
- Started 2008 by Jim - WB6NIL (SK)
- app_rpt module designed as repeater controller
- Public Internet or private network
- Multiple nodes on single IP
- Every node is a reflector, multiple connections
- Can be radio-less
- Stability issues: software, network, foundation
- Native support: Echolink, IRLP (until removed), D-STAR w/ DNGL
- AllStarLink. RepeaterPhone (iOS)

HamVoIP & PTTLink (ASL forks)

- Low adoption AS/ASL
- HamVoIP: 2014 by Doug - WA3DSP & David - KB4FXC
- Forked project: built-on and fixed ASL issues. Now, varies significantly.
- Raspberry Pi only
- Compatible with AS & ASL
- NOT open-source!
- Grew AllStar popularity
- HamVoIP

- PTTLink: more drama
- Near as I can tell: ousted crew from ASL project end of 2020
- Forked the network
- Compatible with AllStar, not AllStar Link
- < 25 active nodes
- PTTLink

WIRES-X

- Wide-coverage Internet Repeater Enhancement System by Yaesu
- WIRES (beta), WIRES-II (until 2017), WIRES-X
- Proprietary network and hardware to Yaesu
- Analog possible non-Yaesu equipment. Digital ONLY on Yaesu C4FM capable radios & repeaters.
- Windows ONLY!
- WIRES-X

- YSF/YSFReflector = Open-source reflector & linking system
- WIRES-X/WIRES-X rooms = Closed-source system for Yaesu

Hamshack Hotline

- Not a radio linking system
- Started 2018 John – K1WIZ
- Uses Asterisk
- Requires a SIP (Cisco) phone & Internet connection
- Softphones and non-supported devices
- Full duplex, direct dialing, voice mail, conference rooms, audio services, trunks, …
- Popular in EOCs
- HH users can dial into Radio Services
- Range: $20 - $50
- Hamshack Hotline

Hams Over IP (HoIP) & AmateurWire

- Started 2022 Gescio "Jesse" – WH6AV
- Split from HH
- Similar VoIP service to HH
- Users can dial into other VoIP services
- Hams Over IP

- Started 2022 Roger - KE8LCM
- Experiment running a VoIP service
- Similar VoIP service to HH & HoIP
- AmateurWire

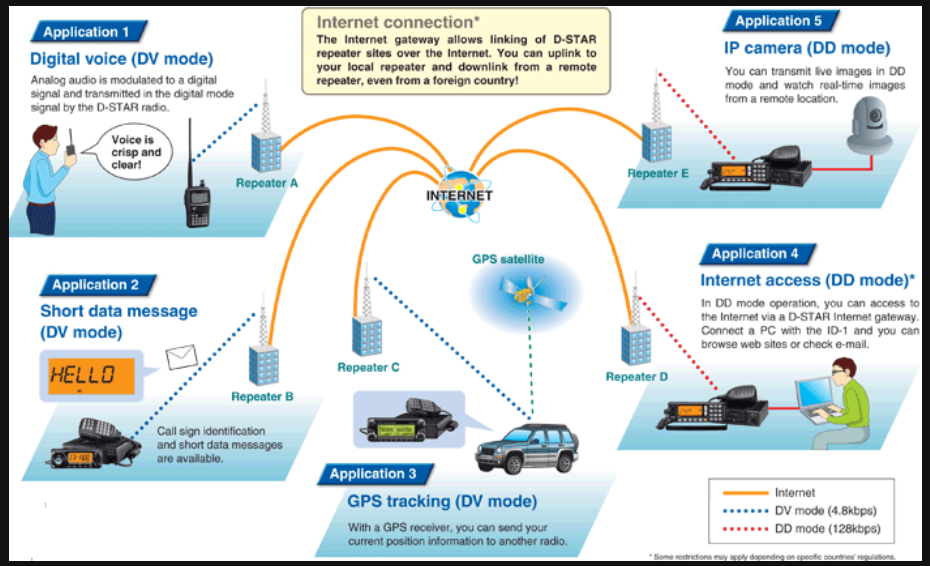
Users... HH: ~7.8K, HoIP: ~1K, AW: ~200

Ham VoIP - Digital Systems

- D-STAR
- DMR
- System Fusion
- NXDN
- P25
- M17
- POCSAG (paging)

img: QRZNow (defunct?)

Uses



img: ICOM

- Common install:
- Gateway software for routing
- Interface: controller, MMDVM board, DV4Mini, DVMega, OpenSpot, dongle, HRI, ...
- Transmitter: repeater, hotspot, link radio, or none at all (radio less)
- Access other nodes: structured control system (TG, Reflector, Room, ...)

- Apps: DroidStar Win & Android non-Play store, Android Play store

D-STAR

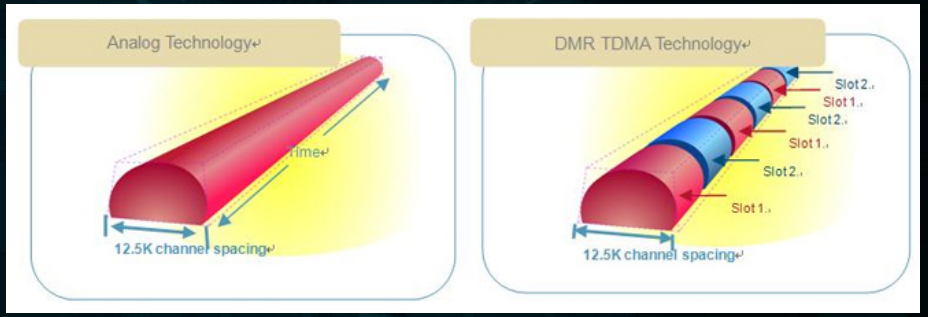
- Digital Smart Technologies for Amateur Radio
- Developed late 1990s by Japan Amateur Radio League
- First designed for ham radio
- Open protocol, proprietary codec
- Simultaneous voice & data
- Network, D-RATS
- High-speed data (128 kbps), not used
- Registration

- HF, VHF, UHF, SHF. Satellites.
- DPLUS, XRF, DCS/XLX?
- ICOM & Kenwood (back in)
- Useless manual
- Range: $300 - $1300

img: ICOM

DMR

- Digital mobile radio
- Developed by European Telecommunications Standards Institute (ETSI), published 2005
- Business
- Adopted by ham radio
- Talkgroup, RX group, contact, scan list, channel, zone
- 2 "slots" per repeater
- Open protocol, proprietary codec



img: Hytera

DMR

- Registration required
- DMR-ID is NOT a callsign!
- Programming requires computer
- VHF & UHF (inc 900 MHz)
- TYT, Connect Systems, Bridgecom, Alinco, Motorola, or any Tier-2 radio
- Range: $90 - $750

img: Amateur Radio Guide to Digital Mobile Radio

System Fusion

- Released in 2013 by Yaesu
- Easiest to use
- Proprietary standard & codec
- "Eternal beta" - redesigns, repeater issues, firmware, ...
- Compatible with analog
- VHF & UHF
- Yaesu - single manufacturer
- Cheap repeaters, "promo"
- WIRES-X linking
- Range: $175 - $1300

img: Yaesu System Fusion

NXDN & P25

- NXDN: ICOM & Kenwood in 2005
- Business

- P25: collaboration started 1989
- Public safety
- Motorola, Kenwood, Tait, EFJohnson, ...

- Both: open standards
- Adopted by ham radio
- Used (or new) commercial radios
- DMR ID
- Pricing: varies widely

img: Wikipedia

M17

The goal here should be to kick the proprietary protocols off the airwaves, replace DMR, Fusion, D-Star, etc. To do that, it's not just good enough to be open, it has to be legitimately competitive.

- Started 2019
- Freely available and modifiable digital radio protocol, open hardware
- Codec2
- Needs ALOT of work
- M17

TeamSpeak, Zello, ...

- Non-ham specific
- Some commercial
- Don't have to be licensed
- Linked to transmitters, unlicensed violations
- Banned on some networks (Brandmeister)

Is VoIP ham radio?

- Noooooo shortage of opinions
- Both ends a radio
- Younger and older hams alike finding uses

DVMIS

Digital VoIP Multimode Interlink System

(K8JTK Hub)

Why, in the world...?

- Ham radio experimentation
- Support open source projects. Contributing back to ASL-Asterisk.
- Interlink **ham radio** VoIP modes for interoperability
- Utilize ham radio spectrum
- Reliable and resilient - hardware, power, weather
- Fairly inexpensive (COM compliant?)

Packages: AllStar Link

AllStarLink is a network of Amateur Radio repeaters, remote base stations and hot spots accessible to each other via Voice over Internet Protocol

- Open-source PBX Asterisk
- Linux (including Raspberry Pi)
- Jim Dixon - WB6NIL (SK)
- app_rpt module - repeater controller
- AllStarLink

img: luis gomes

Packages: G4KLX

Programs that support D-Star, DMR, System Fusion, P25, NXDN

- Jonathan - G4KLX
- ircDDBGateway, NXDNReflector, NXDNGateway, P25Reflector, P25Gateway, YSFReflector
- Reflectors now maintained by Doug - AD8DP
- MMDVM implemented in devices, boards, hotspots like Pi-Star and OpenSpot
- github: G4KLX

Note: active Pi-STAR image W0CHP-PiStar-Dash (WPSD)

Packages: DVSwitch

Tools and programs related to provisioning and operating Amateur Radio digital voice networks

- Steve - N4IRS & Michael - N4IRR
- MMDVM_Bridge (hacked MMDVM), Analog Bridge, and md380-emu (KK4VCZ md380tools) / OP25 (Osmocom, others) codecs
- Linux based
- DVSwitch Mobile Android app + Pi/Linux server = multimode HT
- ASL to DMR documentation (groups.io account required)
- Groups.io: DVSwitch

Packages: XLXD

XLX Multiprotocol Gateway Reflector Server is part of the software system for the D-Star Network

- Jean-Luc - LX3JL & Luc - LX1IQ
- Four D-STAR reflector protocols: REF, XRF, DCS, XLX
- XLXD speaks all four protocols +
- DMR and YSF transcoding (not used, additional hardware)
- github: XLXD

Packages: thebridge

CQiNet is a family of programs that combine Ham Radio with the Internet using Voice over IP (VoIP) technology

- Skip - WB6YMH & others
- EchoLink compatible conference bridge
- Sourceforge: Thebridge

Packages: HBLink3

This is a piece of software that implements an open-source, amateur radio networking protocol. It is not a network. It is not intended to be a network. It is not intended to replace or circumvent a network.

- Randy - AA6RH
- Open Source HomeBrew Repeater Protocol Client/Master
- github: HBLink3

Packages: mrefd

The mrefd reflector is for connecting M17 clients together.

- Tom - N7TAE
- Open Source M17 reflector based on XLXD
- github: mrefd

Packages: USRP2M17

... connect the various modes to an AllStar node or AllStar enabled repeater via USRP.

- Doug - AD8DP
- Part of MMDVM_CM - cross-mode conversion for some digital voice protocols, based on Jonathan G4KLX's MMDVM software.
- github: USRP2M17

Putting it together

Chicago data center

- Three VPSes (virtual private servers)
- Linux Debian OS
- Low latency to remote hardware

Remote hardware

- Raspberry Pi & NW Digital Radio DV3000
- Wires-X: HRI-200 & FTM
- Hardware in data center = $$$

- **Thirteen different networks! Nine full-time modes!**
- Any user on one network can communicate with users on any other
- AllStar is the "Hub", individual nodes for control

img: Pixabay

DVMIS: The Nodes

- AllStar Link: 50394
- AmateurWire: 90004 *99 - TX, # - RX
- DMR: HB_US_K8JTK-HUB-DVMIS_DMO TG: 31983 TS: 2
- DMR: Brandmeister Talkgroup (TG) 3172783
- DMR: TGIF Talkgroup (TG) 31983
- D-STAR: XLX983A - "A" for **A**nalog Bridge
- EchoLink: *DVMIS* 600008
- Hams Over IP: 15010 *99 - TX, # - RX
- M17: M17-983A
- NXDN: TG 31983
- P25: TG 31983
- YSF: K8JTK-Hub 31983
- Wires-X: K8JTK-ROOM 40680

Info on connecting, systems, radios, status, and more: DVMIS @ K8JTK.org

DVMIS: Dashboards

- AllStar Link & Hamshack Hotline: Supermon.K8JTK.org, Bubble Chart
- DMR: HBMon3
- DMR: Brandmeister TG 3172783 Last Heard, Brandmeister TG 3172783 HoseLine, TGIF Last Heard
- D-STAR: XLX983.K8JTK.org
- Hams Over IP: BLF Dashboard
- M17: M17-983.K8JTK.org
- NXDN: NXDNReflector31983.K8JTK.org
- P25: P25Reflector31983.K8JTK.org
- YSF: YSFReflector31983.K8JTK.org

- AllStar Dashboard: 1XXX are private AllStar nodes
- K8JTK call seen ALOT on dashboards: "default" callsign, calls lost in analog conversion

img: freestocks.org

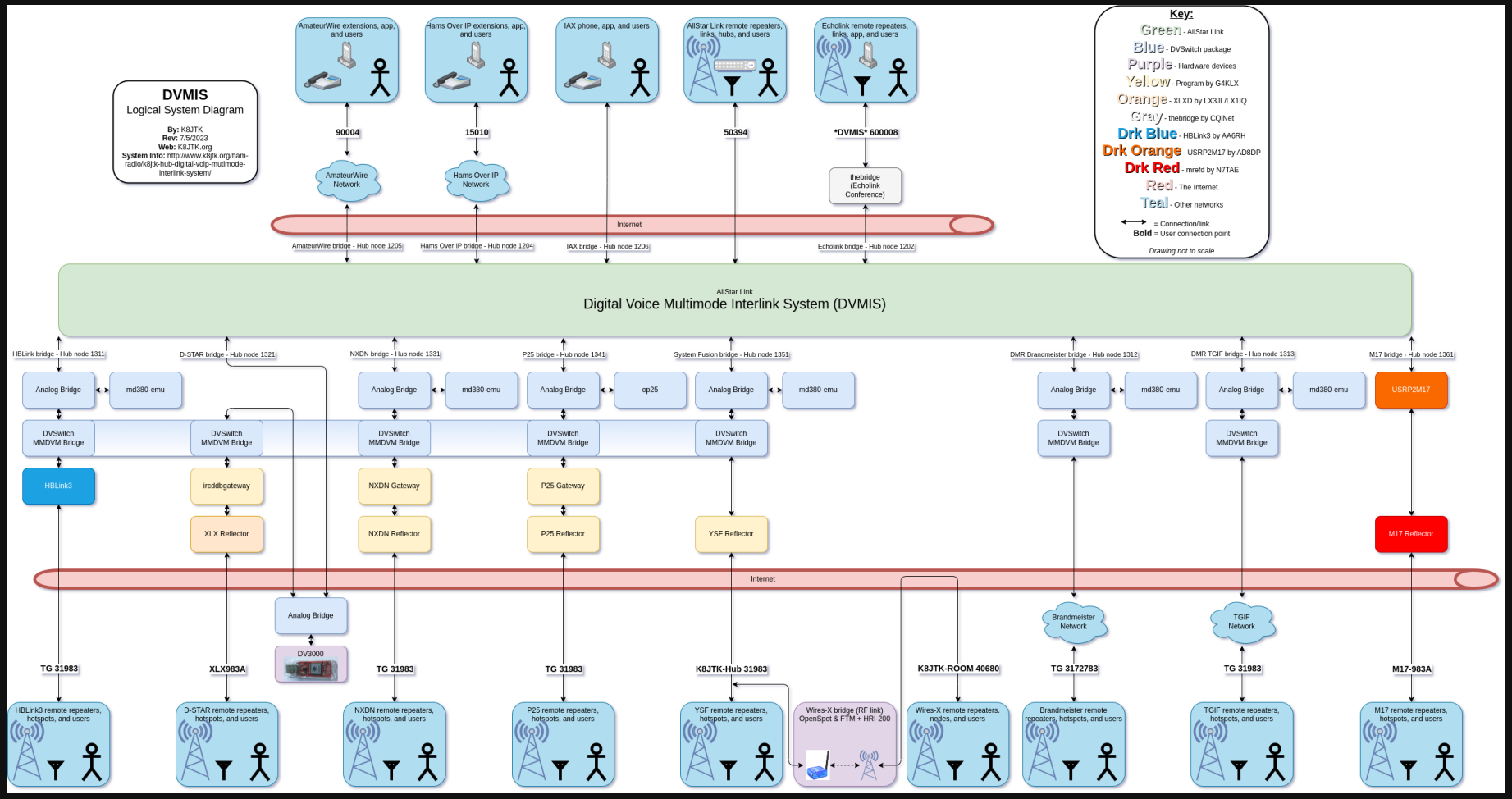
Operating

- Follow all rules of your regulatory authority
- Keep it classy
- English only
- **Identify your station by voice.** Digital stations are used to quick-keying to break-in or check-in, this will not work. IDs in data streams are lost due to analog and cross-linked connections. Users on non-radio VoIP solutions tend to forget they’re on a radio system. Proper ID is required and accepted method is by voice.

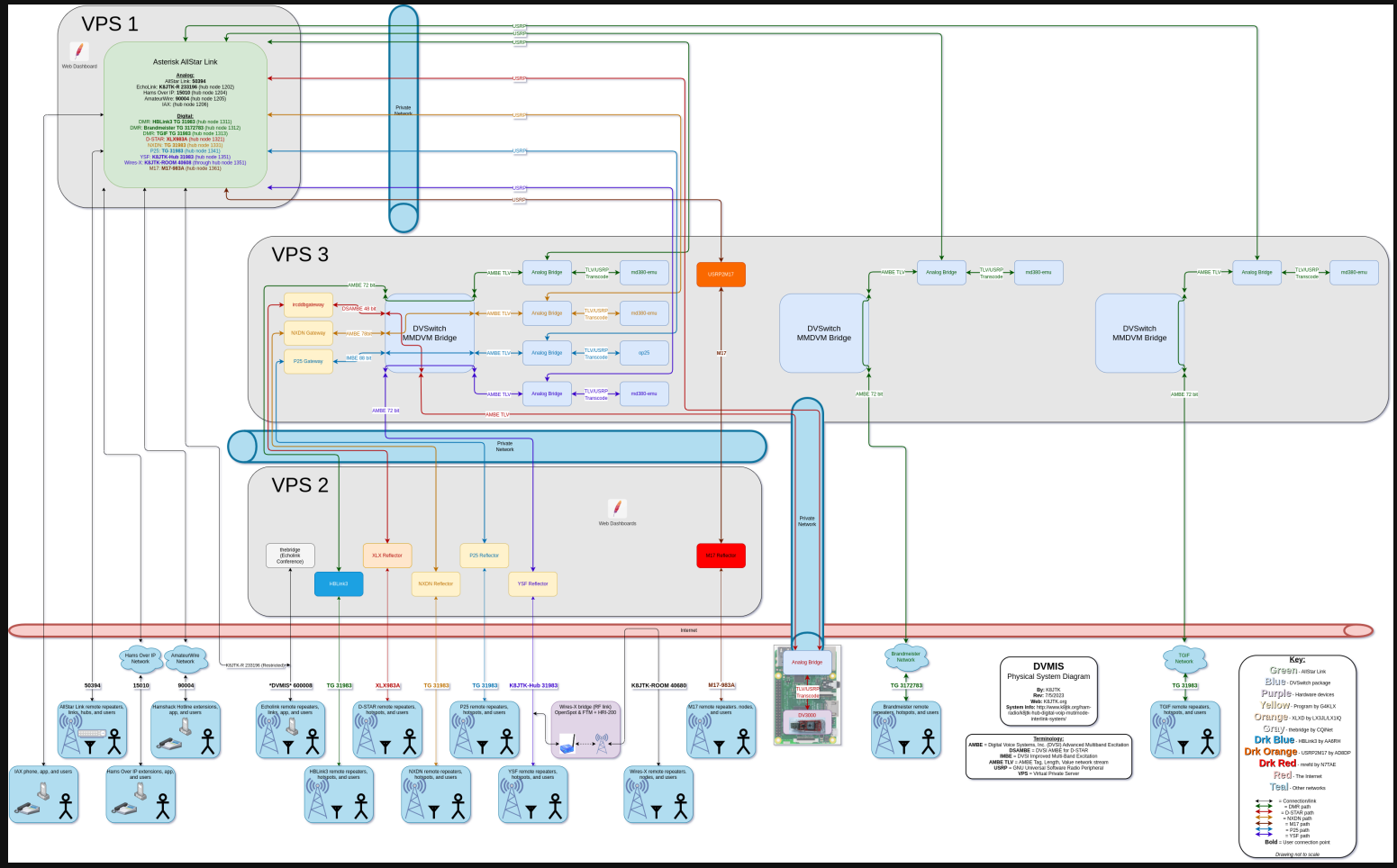
Operating

- **Press PTT and pause for 2 seconds before speaking.** This gives time for all links to become operational otherwise, the first couple words of the transmission will be lost.
- **Pause a minimum 3-5 seconds between transmissions.** Stations cannot break-in when stations quickly key-up (or "tailgate") after the previous. System timeouts are caused when links are not given proper time to reset.

Pretty pictures: Logical connections



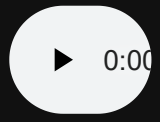
Pretty pictures: IP connections



Problems?

Problems:

- IP based, keeping all the ports straight!
- 😔 Dependency hell: addons and changes to programs
- Protocol and implementation changes: XLX & YSF, YSF choose reflector number
- DVSwitch implementation rewrites: 2x already
- 😠 Data Center provider: packet loss, "internal problems" - 1 move
- D-STAR hardware. Codec: "you won't be happy"
- D-STAR & M17 LOOOOOVES IP addresses
- D-STAR Analog Bridge choppy audio with AMBED
- AllStar compiling
- 😡 AllStar chan_echolink module. Kill me now.
- Brandmeister objected to cross-linking
- Hamshack Hotline ASL SMS TXT problems



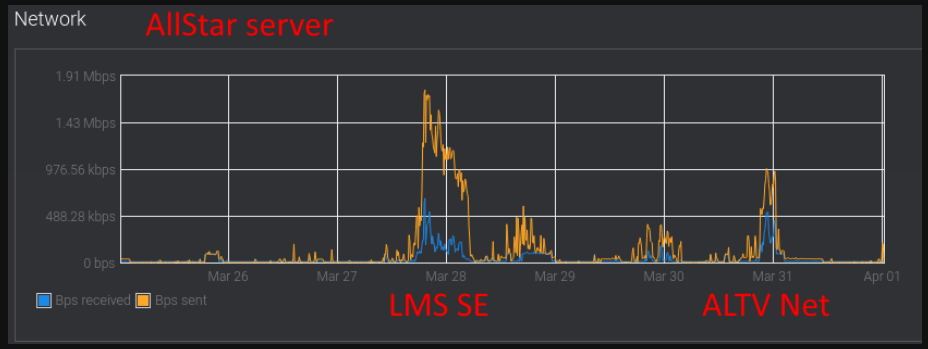
Nets

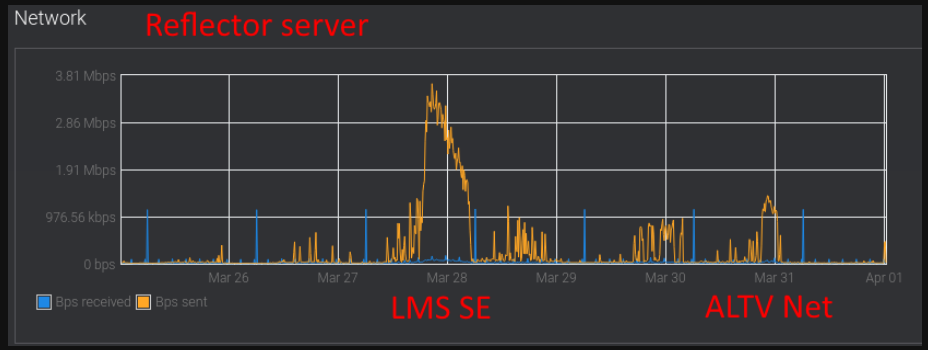
- WCARA (WC8VOA) Club net: Mondays @ 8pm-9pm, includes AR Newsline
- AmateurLogic.TV Logic Net: monthly, Tuesday after a recording of AmateurLogic (Friday), Tuesday @ 9pm-11pm

  Huge thanks for ALTV being a test of the system!

Last Man Standing SE - KA6LMS on 3/27/21

- Multimode QSO Party sponsored by AmateurLogic.TV
- Part of the week-long event commemorating nine seasons of LMS
- **WAY** more popular than anticipated! 8.5 hours!
- 300 counted stations, 500 total
- 20GB traffic
- Recap





THE END

Jeffrey Kopcak - K8JTK

ARRL Ohio Section Technical Coordinator

- K8JTK@arrl.net
- Contact me for nets or other uses of DVMIS
- This presentation is available on my website under the "Presentations" category: K8JTK.org

DVMIS: DEMO

- AllStar Link: 50394
- AmateurWire: 90004
- DMR: HB_US_K8JTK-HUB-DVMIS_DMO TG: 31983 TS: 2
- DMR: BM TG 3172783
- DMR: TGIF TG 31983
- D-STAR: XLX983A
- EchoLink: *DVMIS* 600008
- Hams Over IP: 15010
- M17: M17-983A
- NXDN: TG 31983
- P25: TG 31983
- YSF: K8JTK-Hub 31983
- Wires-X: K8JTK-ROOM 40680

Local meeting:

- Analog (ASL): 446.975 simplex, no PL
- Hotspot 1 (YSF): 433.125
- Hotspot 2 (D-STAR): 445.050

AllStar Dashboard

Info on connecting, systems, radios, status, and more: DVMIS @ K8JTK.org