Getting Started with Yaesu Digital FM (aka System Fusion/C4FM)

by KG5ZNJ (Frank)

Introduction

- This presentation is geared towards the beginner who wants a primer on getting started with Yaesu Digital FM (System Fusion/C4FM) as an end user.

- The main focus will be geared towards getting up and running quickly with minimal equipment, and also getting a solid understanding of the Yaesu Digital FM landscape.

What is System Fusion/C4FM/Wires-X ?

- **System Fusion** is a specification released by Yaesu in 2013 that supports digital voice and data (GPS/APRS/Photo/Voicemail/txt msg etc) in a 12.5kHz narrow band channel at 9600bps using digital modulation
- **C4FM** stands for Continuous 4-level Frequency Modulation (FM), and is the actual digital modulation of the radio signal used in System Fusion over VHF/UHF.
- **Wires-X** is the node linking/voip technology that allows nodes to link across the Internet.
- System Fusion is Yaesu's Digital FM offering, and is a direct competitor to DMR and D-Star.

Why choose Yaesu System Fusion?

- Yaesu Digital Radios are by far the easiest to use out of box. Turn the radio on, enter your callsign, and tune to a Gateway, Repeater or Hotspot.
- There is no need to register a user ID (unlike D-Star or DMR).
- There is no need to configure your radio with a code plug (DMR).
- Yaesu has broad line of radios from inexpensive, mid range and high end for every budget.
- DMR radios tends to be in the inexpensive to mid range only. D-Star radios tend to be very high end only.
- C4FM is considered to have the best voice quality (although they are all very close)

The "Pros" of Digital FM

- No loss of signal quality over great distance
- Easily integrates into Internet VOIP networks for around the world communication
- Only requires a Technician License
- Unaffected by Solar Cycle
- There are always people on, 24/7/365 (far more users than Echolink)
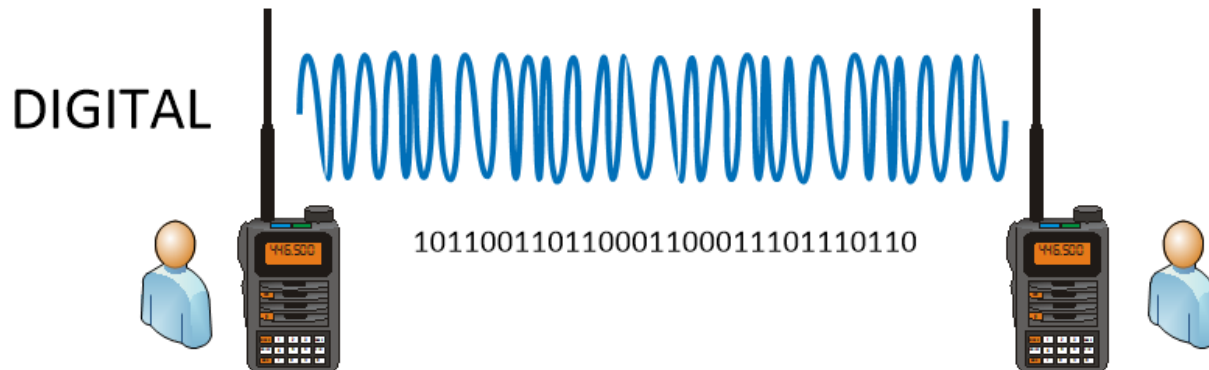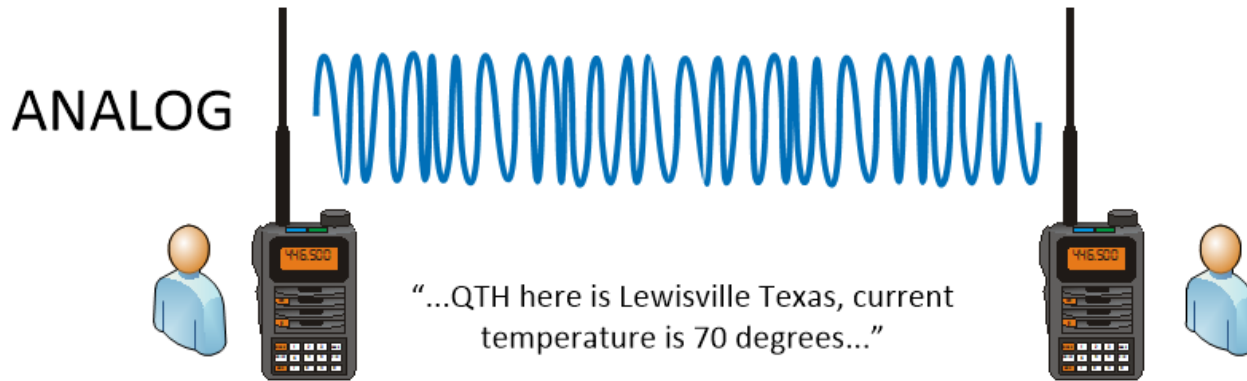- Traditional antenna can be replaced with an internet connection and a hotspot

The "Cons" of Digital FM

- Digital makes for a more complex and expensive radio (cost more, more things that can break)
- Extra digital components make the radios extremely power hungry (shorter battery life than analog)
- Shorter usable range compared to analog (but not much shorter)
- Long range (greater than VHF/UHF) requires an internet connection somewhere.
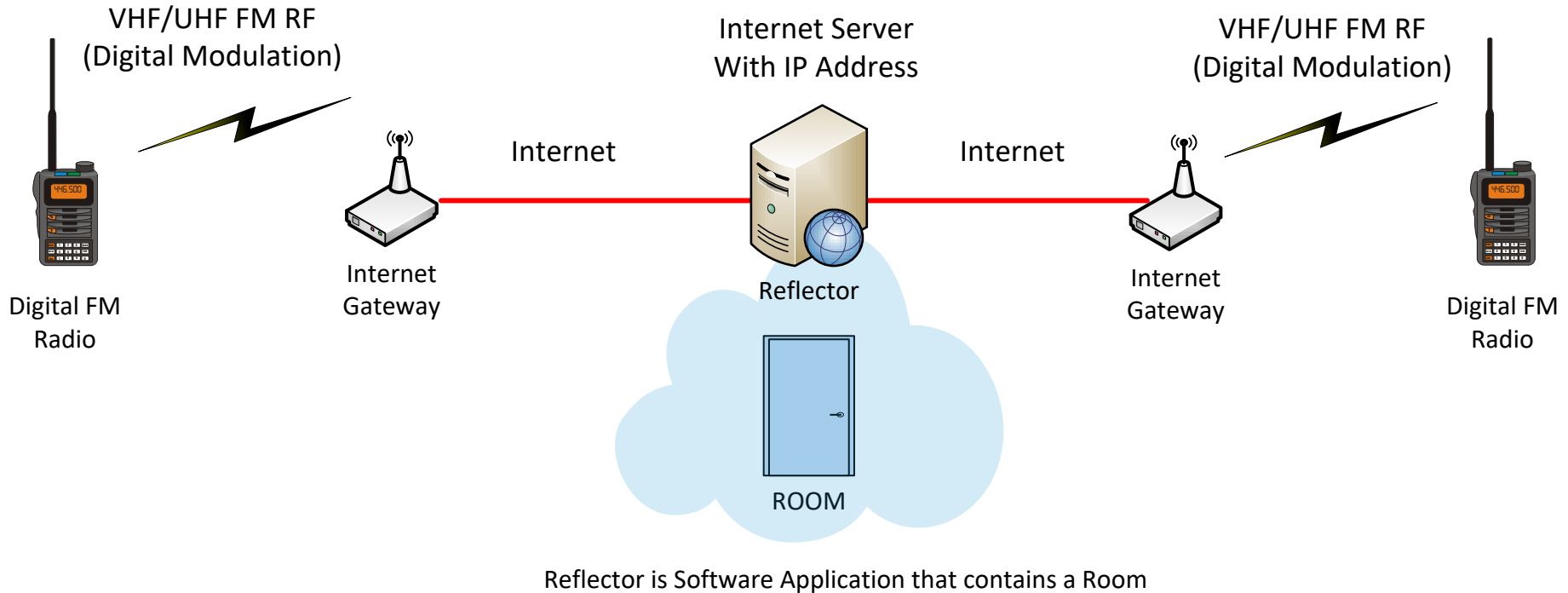- Digital FM is new. It is changing rapidly.

What else can you do with it ?

- Use the radio in traditional analog mode.
- Use the radio as-is to connect to a System Fusion Gateway or Repeater. These in turn can be connected to other Nodes or Rooms over the Internet using Wires-X.
- Get a Hotspot and connect to the FCS Reflector Network or the YFS Reflector Network.
- You can also use a Hotspot to crossover to DMR Servers/Talkgroups on the Brandmeister Network.

Analog vs Digital FM Modulation

ANALOG

"...QTH here is Lewisville Texas, current temperature is 70 degrees..."

DIGITAL

10110011011000110001110110110

The Architecture of Digital FM

VHF/UHF FM RF
(Digital Modulation)

Internet Server
With IP Address

VHF/UHF FM RF
(Digital Modulation)

Internet

Internet

Digital FM
Radio

Internet
Gateway

Reflector

Internet
Gateway

Digital FM
Radio

ROOM

Reflector is Software Application that contains a Room

If both Internet Gateways are configured to go to the same Reflector, and the same Room, then both parties may talk to each other. This architecture is used for System Fusion, D-Star and DMR.

# Fusion Nodes (Gateways and Repeaters)
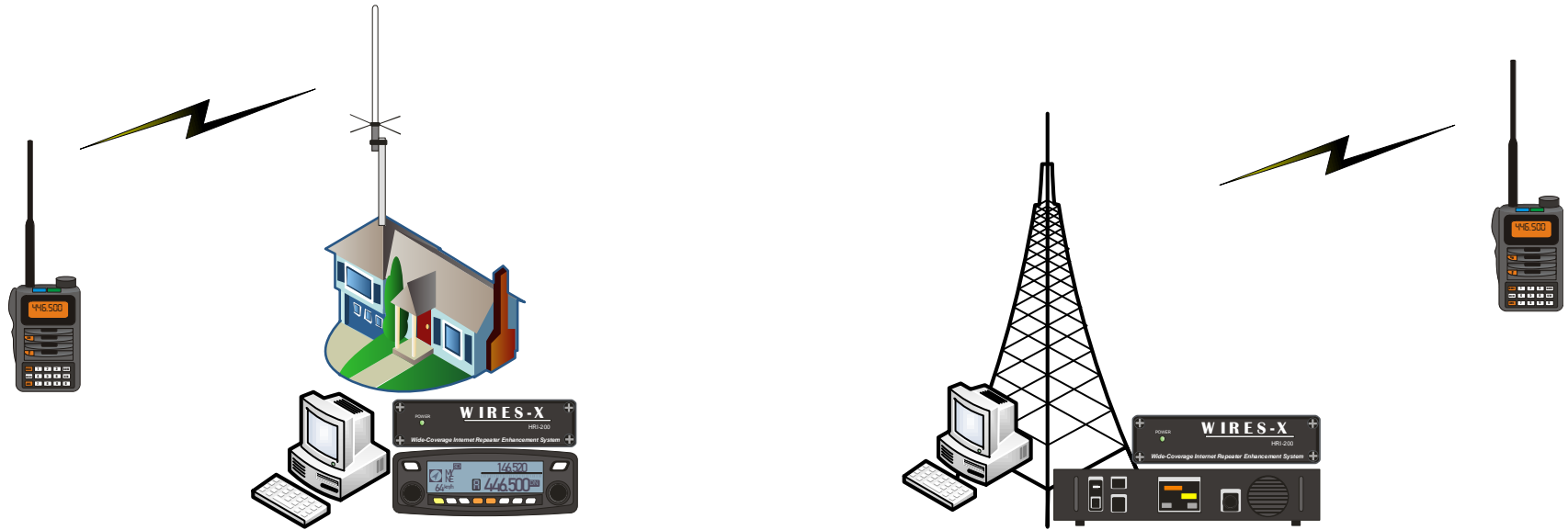
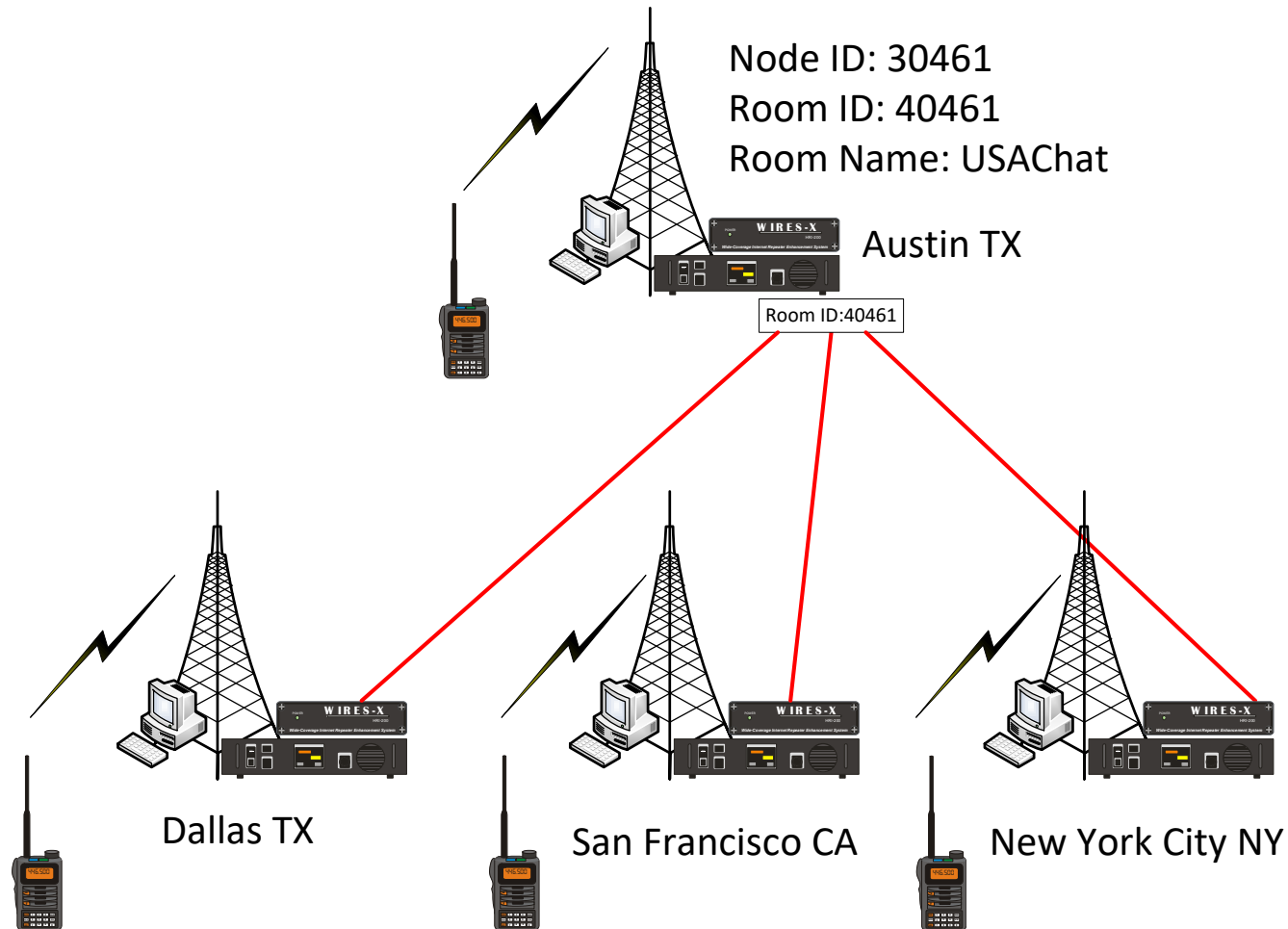## Fusion Node (Gateway)   Fusion Node (Repeater)

A Fusion Gateway is a simplex gateway device. These tend to be used by home users and may have limited range and low power. A Fusion Repeater is like a traditional repeater (uplink/downlink). Either can be configured various ways, but they will generally have a Yaesu Radio or Repeater, an HRI-200 device, an antenna system and a PC running MS Windows with Wires-X software.   Both will require an Internet connection for Wires-X.

Wires-X Node ID Connectivity

Denton, TX
Node-ID 18535

INTERNET

Austin TX
Node-ID 30461
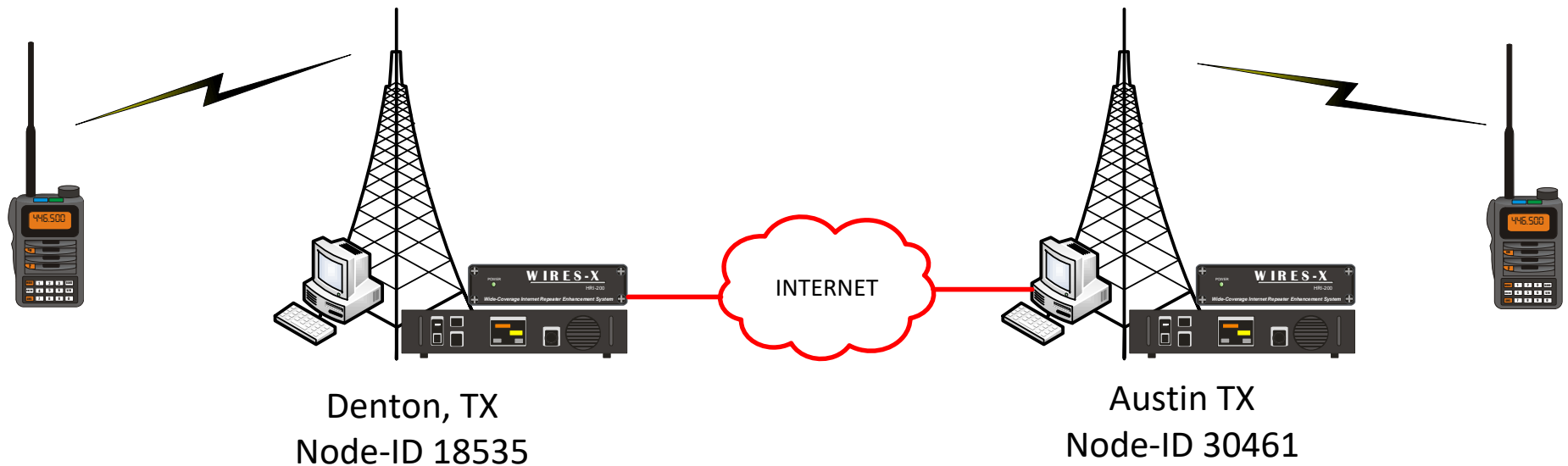
Fusion Nodes can be connected together using Wires-X and an internet connection. Nodes have ID numbers that are also DTMF codes. A node operator can allow users to control the connection via DTMF tones sent from the radio.

Wires-X Room ID Connectivity

Node ID: 30461
Room ID: 40461
Room Name: USAChat

Austin TX

Room ID:40461

Dallas TX

San Francisco CA

New York City NY

Wires-X Nodes can also have a single Room which has a DTMF Room-ID. Multiple nodes can connect to the same room. In this example the 3 nodes below are connected to the top node's Room "USAChat" Room ID:40461

So how does one get started ?

- The simplest and easiest way to start exploring Yaesu System Fusion/C4FM is to buy an entry level Radio (FT-70 $144 or Yaesu FTM-3207DR $114.95)

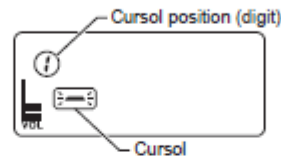- Turn on radio. It will ask you to enter your callsign. Tune to a local Fusion Repeater and start making contacts all over the world !

Yes it really is that easy !

Screen shot

Of the user Manual (FT-70)

1. When turning the power ON for the first time after purchasing, the call sign input screen will be displayed.

`ENTER CALLSIGN`

2. Press the F.

Cursol position (digit)

Cursol

3. Input the call sign.
   - Rotate the ▩▩ to select each character.
   - Press the BAND key to move the cursor to the right.
4. Repeat step 3 to input the remaining call sign characters.
   - Press MODE key to move the cursor to the left.
   - Press and hold the GM key to erase all characters after the cursor.
5. Press the PTT(⊙) switch to conclude inputting.
   Normal operation (VFO Mode) screen will be displayed

Local Fusion Repeaters

If you live in the Lewisville area you are in luck! There are three usable Fusion Repeaters within range:

Freq.	OFFSET	TONE	LOCATION	ROOM
443.300	+5.000	100.0hz	The Colony	User can change
443.525	+5.000	118.8hz	TWU Stark Hall	America Link (21080)
442.425	+5.000	110.9hz	Dallas	User can change

Note: These are all 70cm ! 70cm seems to be more used than 2m.

The Wires-X Node Listing

LATEST WIRES-X ACTIVE NODE ID LIST   Update every 20 min   11 Nov 2019 05:32:08 GMT

NODE ID ▲	DTMF ID	Call Sign	Ana/Dig	City	State	Country	Freq(MHz)	SQL	Lat	Lon	Comment
--ECHIGO-	12796	JR0ZFW	Digital	Kashiwazaki-city	Niigata	Japan					
--JE1UDL--	16671	JE1UDL	Digital(M)	Takasaki-city	Gunma	Japan					
-GLOBAL-CQ	18261	NK5CC	Analog	Copper Canyon	Texas	USA	146.080MHz+0.600MHz	TSQ:107.2Hz			----Global-CQ Fusion Network
-IWAKUNI-	15403	JH4VIZ	Analog	Iwakuni-city	Yamaguchi	Japan	144.560MHz	TSQ:118.8Hz			
-JM3UGH-ND	32173	JM3UGH	Digital(M)	Kashiwara-city	Osaka	Japan			N:34 35' 32"	E:135 37' 25"	
-KT-TOJI-	39015	JR3VC	Analog	Kyoto-city	Kyoto	Japan	439.66MHz	TSQ: 88.5Hz	N:34 58' 38"	E:135 44' 45"	TEST MODE/RP-NODE 439.66MHz/FREE Access/Open Node/AUTO DISCONNECT 30min/CTCSS:88.5Hz FM 10W/MINAMI Ward KYOTO JAPAN/Supported by N M and JL3ZGV GROUP
											FREE Access/Open Node/430.82MHz/C4FM DG-ID 00

- To get a listing of active Wires-X Nodes to go: https://www.yaesu.com/jp/en/wires-x/id/active_node.php.

The Wires-X Room Listing

LATEST WIRES-X ACTIVE ROOM ID LIST   Update every 20 min   14 Nov 2019 02:42:15 GMT

ROOM ID▲	DTMF ID	Act	Room Name	City	State	Country	Comment
---------A0	27472	001	Bedfordshire Gateway	Dunton	Bedfordshire	UK	Covers most of West Anglia
----------LADO	40937	000	----------------LADO	San Antonio	Texas	USA	LADO - Los Amigos Digital Operators
----------NERV	22945	000	NERV-統幕司令部	Nagoya-city	Aichi	Japan	U.N.NERV 主幹通信指揮システム
----------CQ-UK	27793	021	CQ-UK	Pudsey	West Yorkshire	UK	XLX925A ALL MODES
----------UKHUB	41491	002	UKHUB Cross-links	BELFAST	County Antrim	UK	UKHUB XLX925B All Modes
---------WI-LINK	21667	003	WISCONSIN LINK	Baldwin	Wisconsin	USA	Open to any users not just Wisconsin
--------XLX389Q	24117	000	YSF001	Laidley Heights	Queensland	Australia	
--------XLX925C	41280	001	Irish Scottish link	Belfast	County Antrim	UK	XLX925C XLX600C/www.mi5daw.com
-------LADO-LRD	43154	000		Laredo	Texas	USA	
------NYORKS-UK	41085	000	North Yorkshire UK	Yarm	North Yorkshire	UK	
-----2LO-LONDON	28846	000	TRANS-ATLANTIC NET	Surbiton	Surrey	UK	C4FM - LONDON AND THE HOME COUNTIES
-----BM-TG31444	21768	002	R.I. DIGITAL LINK	Warwick	Rhode Island	USA	

- To get a listing of active Wires-X Rooms to go:
  https://www.yaesu.com/jp/en/wires-x/id/active_room.php

Alternative Networks

Besides the System Fusion Network (which Yaesu tightly controls), a Yaesu digital radio can also use two other independent Reflector Networks that can be accessed with a Hotspot.
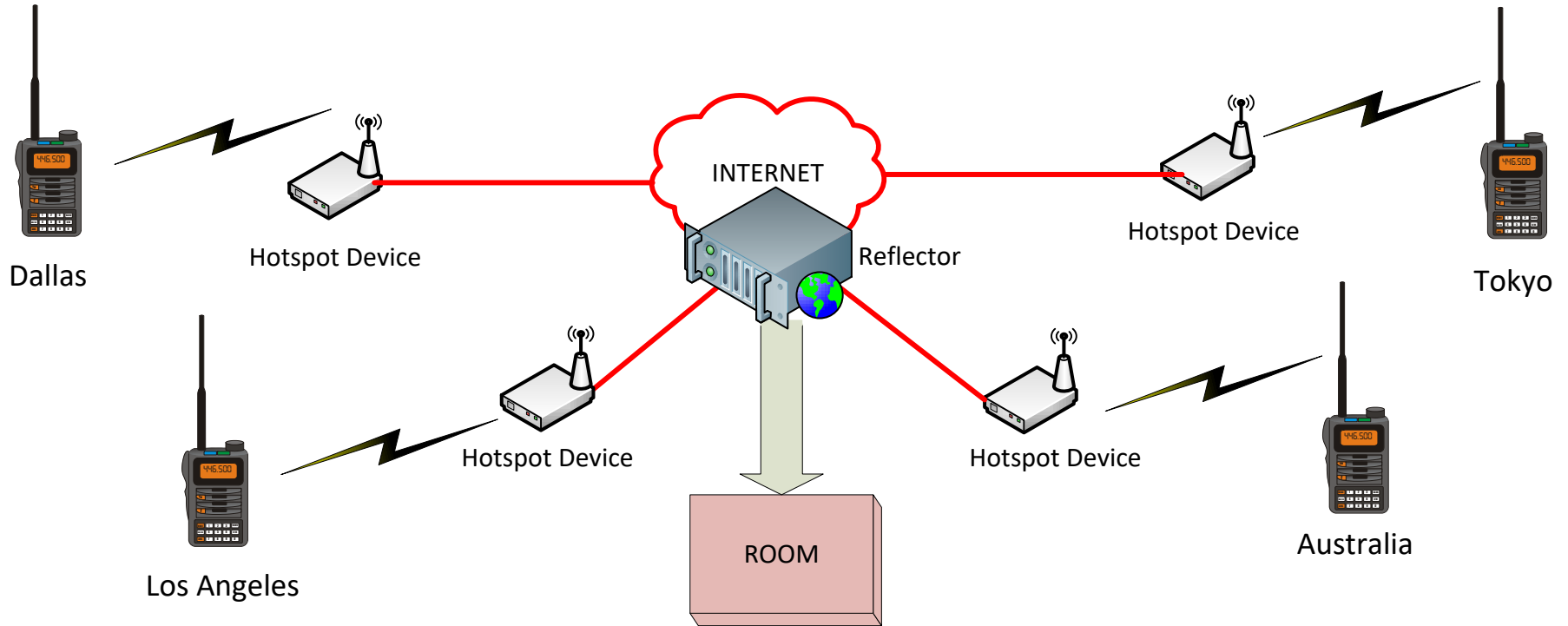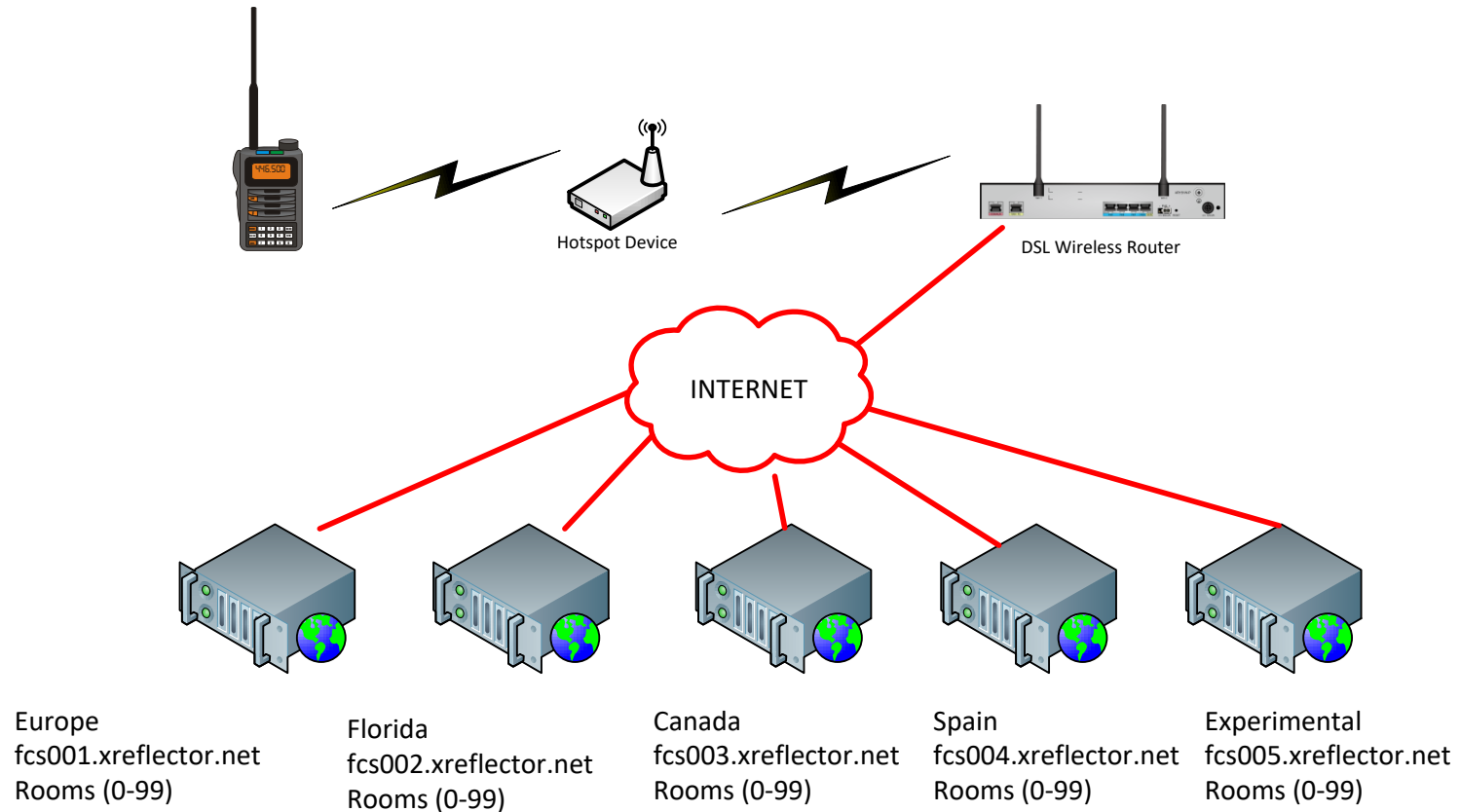
What is a Hotspot ?

Hotspot Device

A Hotspot is a small low power digital radio Internet gateway device. It takes your digital RF signal, and converts it to VOIP and streams it over the Internet to a Reflector. It can be bought as a finished product, or can be constructed out of a Raspberry Pi with a 3rd party RF Modem daughterboard and antenna.

What is a Reflector ?

Reflectors are servers on the internet that allow hotspots to talk to each other. A Reflector is a piece of software and will have a 1 or more rooms. Users connected to the same room will be able to talk.

FCS Reflector Network

| Europe
fcs001.xreflector.net
Rooms (0-99) | Florida
fcs002.xreflector.net
Rooms (0-99) | Canada
fcs003.xreflector.net
Rooms (0-99) | Spain
fcs004.xreflector.net
Rooms (0-99) | Experimental
fcs005.xreflector.net
Rooms (0-99) |

The FCS (Fusion Connect System) Reflector Network is made up of five (and counting) internet servers that host 99 Rooms (called "Modules") each. You can only connect to an FCS Reflector Server using a Hotspot via the Internet. Two (or more) end users connected to the same server and room, will be able to talk. The FCS Reflector system was created by Torsten Schultze (DG1HT) of Germany.

FCS Reflector Network Room Listing

Go to http://xreflector.net/ and click the FCS Server name on the left side menu. Clicking USER will show last heard which helps in finding rooms with recent activity.

YSF Reflector Network

Hotspot Device

DSL Wireless Router

INTERNET

ysf.m5adi.com

ysf004.kb8zgl.net

ysf.dstar.su

socalpinoy.ddns.net
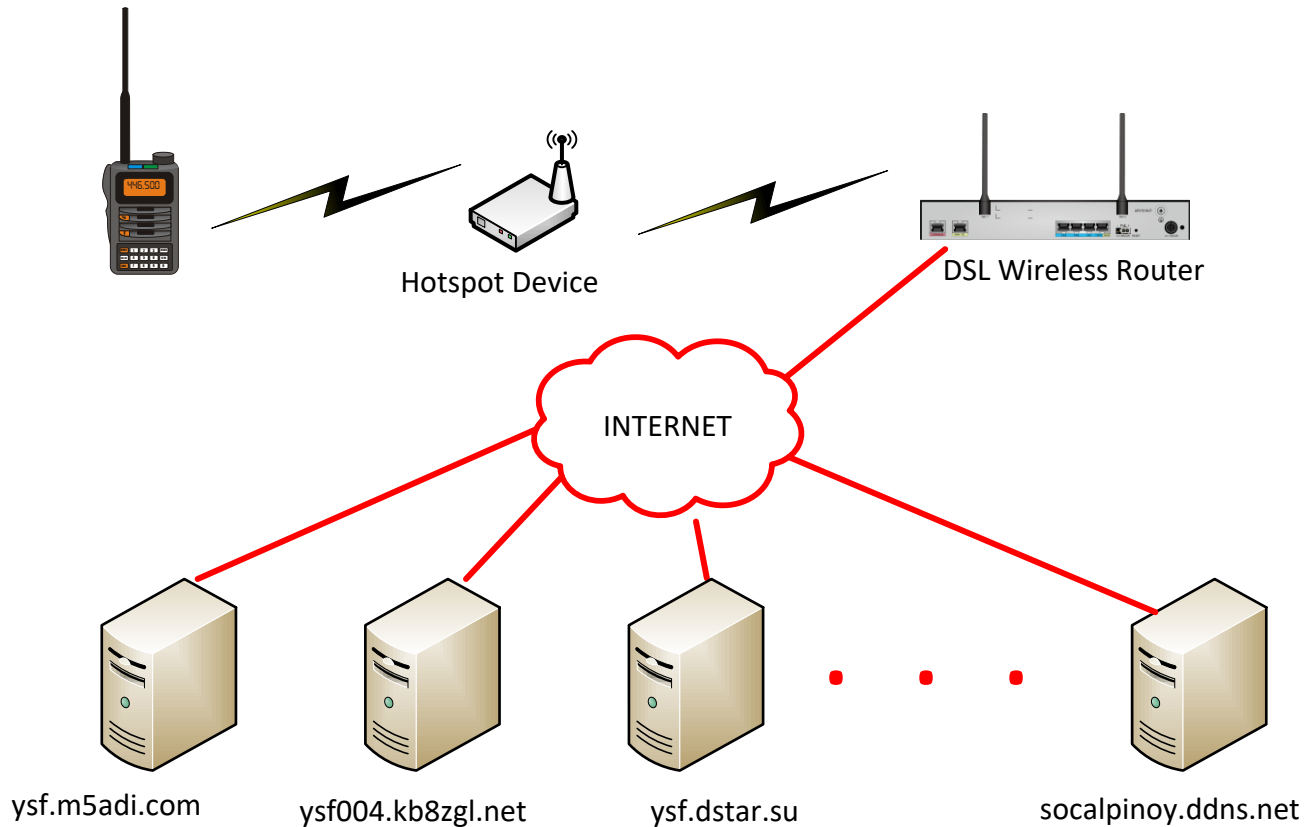
Another independent network is the YSF Reflector Network. Each YSF server has only 1 room, however there is an unlimited number servers and they are owned and operated by private individuals. A YSF Reflector can be installed on a Windows, Linux or Raspberry Pi based server.   Two or more users connected to the same YSF Reflector will be able to speak to one another. The YSF Reflector Software was created by Johnathan Naylor (G4KLX) of the UK
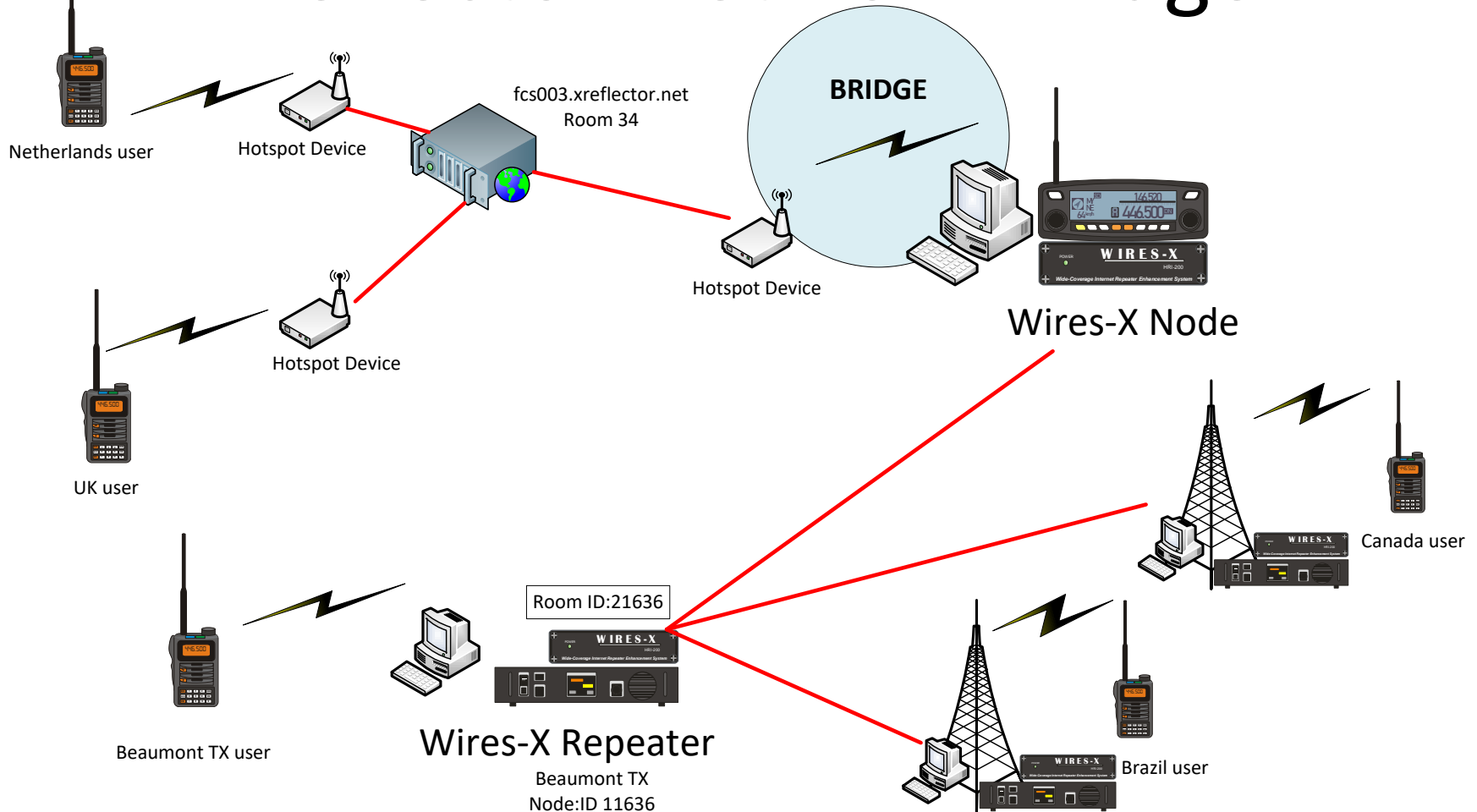
YSF Network Room Listing

Online YSFReflectors

Show 25 entries

Search:

ID	Name	Description	Host	Port	QTH	Dashboard	Bridge	Last Online (UTC)	Count	Active	
01739	00 TEXAS NEXUS	YSF001	ysf001.duckdns.org	42000	Australia (AU)	http://ysf001.duckdns.org	XLX389D, WiRES-X (GPS Data Support)	2019-11-15 15:21:02	9	✔	☑
04895	00 XLX389 YSF	XLX YSF	xlxdmr.duckdns.org	42000	Australia (AU)	http://xlxdmr.duckdns.org/db/	DIRECT to XLX server > YSF Embedded	2019-10-20 07:31:02	0		☑
76601	00 ZOMBIE-ALERT-	YSF001-VW	110.232.113.108	42002	Australia (AU)	http://110.232.113.108/vw	XLX389Q P25 TG 4, XLX389Q, NXDN505, FCS00114, WiRES-X	2019-11-15 15:21:03	4	✔	☑
38089	0077	IRLP/ DMR/ D-S	xe1dvi.crabdance.com	42002	United States (US)	http://xe1dvi.crabdance.com/html/index.php	IRLP 0077 - DMR(BM) 33450 - D-Star XLX 077	2019-11-15 15:21:03	4	✔	☑
11500	0E7XTR	Tirol Oberland	hitthi.synology.me	42000	Austria (AT)	https://inet01.synology.me:46193	OE7XTR /YSF	2019-11-15 15:21:03	4	✔	☑
02573	1004DMR	DRM C4FM CROSS	1004dmr.dvham.com	42000	South Korea (KR)	http://1004dmr.dvham.com/indexysf.php		2019-11-15 15:21:04	9	✔	☑
74652	119-YSF	TG45004 XLX170	ysf119.dvham.com	42000	South Korea (KR)	http://ysf119.dvham.com/index.php		2019-11-15 15:21:04	2	✔	☑
06690	31665 Not TGIF	Not TGIF	104.153.109.57	42000	United States (US)		Mental Ward	2019-11-15 15:21:04	1	✔	☑

Go to https://register.ysfreflector.de/ for a listing of YSF Reflectors/Rooms. Clicking on the "Dashboard" will show last heard.

Reflector Network Bridge

fcs003.xreflector.net
Room 34

BRIDGE

Netherlands user

Hotspot Device

UK user

Hotspot Device

Hotspot Device

Wires-X Node

Canada user

Room ID:21636

Beaumont TX user

Wires-X Repeater
Beaumont TX
Node:ID 11636

Brazil user

Shown here is a technique used to bridge (aka link) an FCS Server/Room with a Wires-X Room. Vast networks are bridged together using this technique. The Hotspot and the Wires-X Node (blue circle) use the same simplex frequency with each side 'tricked' into thinking the other device is a Yaesu radio.

Reflector Network Bridge (cont.)

Very large bridged Reflector Networks are out there, and it is now even possible to bridge in DMR. An example of a large Multi-Bridged Reflector Network is the
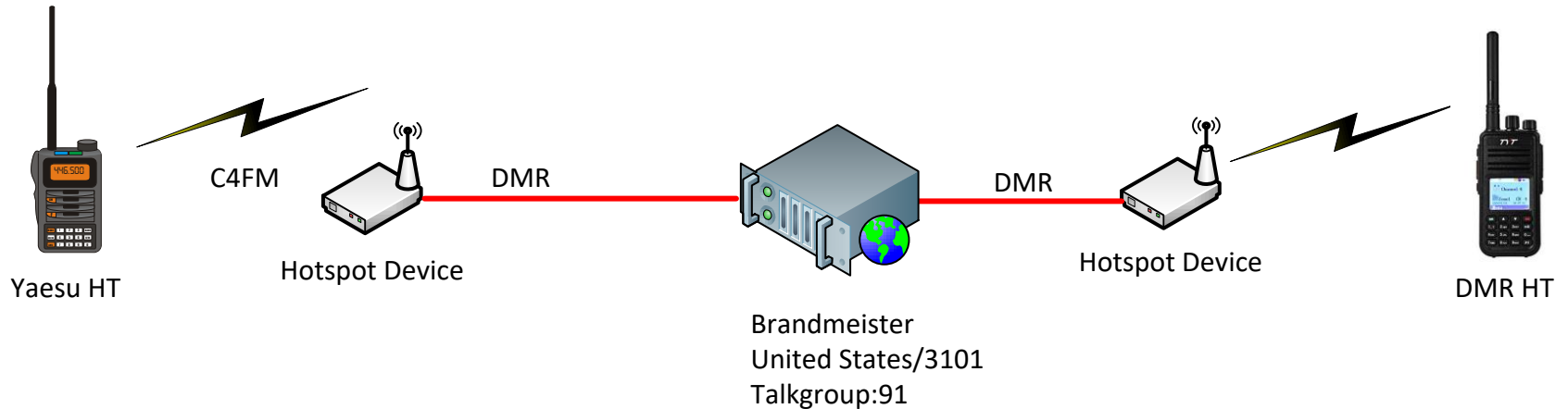**Texas Nexus**:

      Wires-X room: 21636
      FCS Reflector: FCS003 Room 34
      YSF Reflector: ysf.texas-nexus.dyndns.org
      Brandmeister DMR: 31488

Connect to any of these, and you will speak to all of these "Separate" networks.

Hotspot Cross Connect

C4FM   DMR   DMR

Yaesu HT   Hotspot Device   Hotspot Device   DMR HT

Brandmeister
United States/3101
Talkgroup:91

Since hotspots can also be used for DMR and D-Star, we are starting to see Cross Connect. This allows the Hotspot to convert one type of Digital FM, to another type. Example, an Openspot 2 hotspot can take a Yaesu C4FM signal and convert it to DMR (and vice versa).   This allows you to use your Yaesu digital FM radio on the Brandmeister DMR network.

Where to get more information

- Local Net:
Digitally Speaking Net
Sunday 2pm – 3pm CST
146.920- tone:110.9
DCARA W5NGU Repeater
(this is an analog net)

- Youtube channels with frequent Digital FM content:
https://www.youtube.com/user/bondobob
https://www.youtube.com/user/EricHofer1004
https://www.youtube.com/user/davecasler

- Great technical website on Digital FM
http://hamoperator.com