DV4Server: A stable, economical and scalable interconnection of different digital voice networks.

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Abstract

This white paper analyzes different implementations of interconnecting digital voice networks. Advantages and risks are described and a new architecture is proposed.

This approach has advantages regarding stability, cost and scalability and allows direct calls between different modes and network architectures.

Introduction

Over the course of the last years, several digital voice systems have been introduced to the amateur radio community. D-Star was originally designed by the JARL (Japanese Amateur Radio League) and implemented by ICOM. These initial systems were soon interconnected through a digital reflector system, D-Plus which allowed dynamic interconnection of repeaters and direct connection through call sign routing.

Other D-Star based reflector systems have been introduced after that, such as the Xreflector system and the DCS reflector system. While using the same access technology they are run by different groups and are administered differently.

While initially intended to interconnect only repeaters to reflectors, dongles have been introduced which allow a direct connection to a reflector (and partly repeater) systems. These dongles come with and without RF components and initially supported D-Star only. Access to different reflector systems was controlled by logging into the different reflector systems through the dongle software. At repeater sites the IRCDDB software by G4KLX allows access to both D-Plus and DCS reflectors.

In the meantime, other modulation schemes and networks have been implemented, for DMR (DMR-MARC, DMR-Plus and Brandmeister), C4FM Fusion (X-Wires and FCS), P25, NXDN/iDAS, dPMR, etc. Each modulation scheme has multiple networks supporting it and the digital landscape became more fragmented.

This development adversely effects the main purpose of amateur radio, by inhibiting communications instead of enabling them. Reflector systems and repeaters need a critical mass of users to be attractive and this "digital diversity" is counterproductive.

Local Repeater administrators, amateur radio operators and reflector system operators have tried to overcome these issues by using different ways to interconnect the networks. Very soon the risks of these uncoordinated ad hoc bridges became evident: Not only reflector rooms, but complete reflector systems crashed and left all participants frustrated.

Obviously a common signaling system comparable to SS7 (https://en.wikipedia.org/wiki/Signalling_System_No._7)
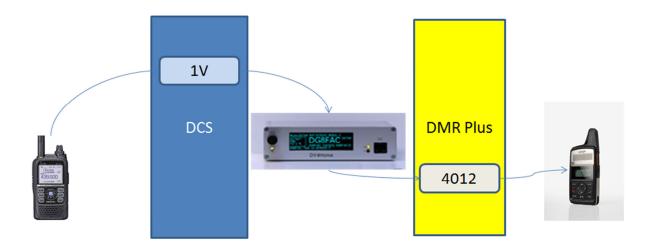
would be an ideal solution. However, our digital radio systems are not mature enough to implement such a complex system. Therefore we propose DV4Server as a stable and economical solution for the time being.

Simple shared room solutions

The earliest ways to interconnect D-Star to DMR were shared rooms in DMR Plus and DCS. (Similar links have been established between Echolink and DCS)

A D-Star operator links his repeater station or his dongle to room DCS001 V. A DMR station links his repeater to room number on TS2, room number 4012.

There is a bridge, made with a DV4home which contains 2 AMBE chips, transcoding the audio between DMR and D-Star and the 2 stations can communicate.
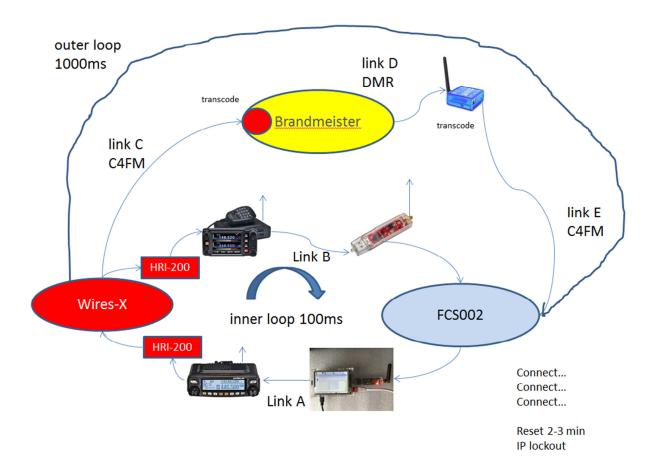

The solution is easy to implement and reliable.

It will not generate any loops and all participants in the system know of each other.

However, only one link in the reflector system is available at the time. Both parties have to agree that they will meet at this room at a certain time. Advanced functions such as call routing are not possible.

Complex Bridge Implementations

Currently we see ad hoc implementations as well as solutions offered by network providers. The following chart shows 3 different ways to bridge traffic between networks and illustrates the risks. There are other flavors as well, but they illustrate the fundamental approaches and issues.

In this example a Raspberry Pi with a DV4mini connects to a room in the Fusion reflector in the DMR Plus system. This acts as a local Hotspot.

A Yaesu Radio, in this case a FTM-100D is connected to a HRI-200 unit, which, through its PC connects to a room in the Wires-X system, establishing link A.

Everybody connected to the Wires-X room can talk to anybody in the FCS002 room. Everything works fine up to this point.

The problem starts when a second station establishes a similar bridge, in this example link B. The operator of link B does not know about the existence of link A. The network operators do not know about either link. As the links are dynamic, they can connect to any room on both reflector systems at any time.

As soon as such a loop is established the last frame (about the last 100ms) circles through both reflector systems and everybody hears a repetitive sound and both rooms are unusable until one of the stations is shut down or a reflector administrator analyzes the situation and disables the CCS7 numbers of the stations that creates the loop. It took hours in the past to resolve these inner loops. The admins are frustrated because of the lost time, the other users could not use the system and the stations establishing the links loose access credentials, starting a discussion who did what why and when.

However, the situation becomes worse when a loop is created through a third reflector system which transcodes the audio and has an independent authentication system which is compromised.

In this example, a Brandmeister link in C4FM is established with the Wires-X system. Brandmeister is using the credentials of a HRI-200 box which is read out earlier without being part of the installation later. Therefore the source cannot be traced reliably.

The packets created in the inner loop (between link A and link B) are now propagated into the Brandmeister system and transcoded into DMR. A SharkRF unit is connected to the same room and receives the traffic as DMR but transcodes it again and forwards it to another room in FCS002 with about 1000ms total loop time.

The traffic overload crashes FCS002, not only a single room, but the whole US Fusion system with all rooms.

As the admins of the reflector systems work independently, the cause cannot be found through a complete situation analysis, but through a restart of the FCS002 reflector (in this example), which automatically takes place and takes about 2-3 minutes.

After each crash, the IPs involved are locked out. This process is repeated multiple times until the situation is resolved.

This is a hypothetical example which can happen any day and illustrates the risks of the current chaotic approach we take.

We therefore suggest using an architecture which uses a distributed access system with a common authentication and distributed transcoding to allow the use of the existing installed hardware in all modes.
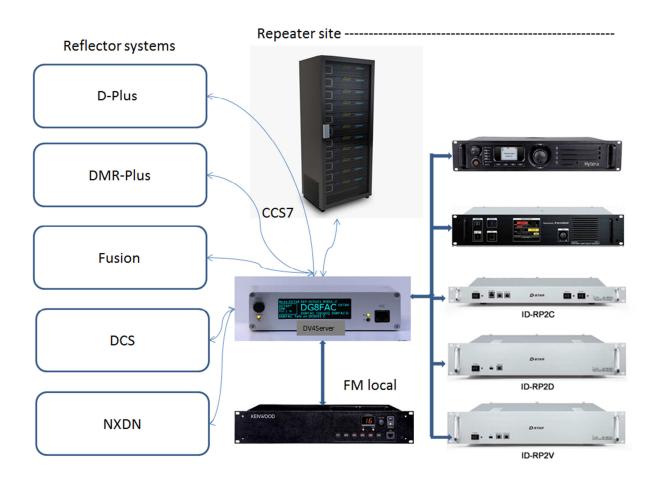
DV4Server

The **DV4server** solution is a multiprotocol Gateway at the repeater site which can access all reflector systems in all modes with the existing radios.

The existing digital and locally analog repeaters can be used. Existing mobile radios such as D-Star radios can be used to access i.e. Fusion reflectors.

Using CCS7 as common authentication and routing system allows call sign routing and its location at the edge of the network avoids loops.

It is located similar to a G2/G4KLX Gateway in an ICOM stack:

The DV4Server is an optimized embedded LINUX system, which uses the same hardware as the DVhome with AMBE chips, but a different software package.

The analog interface allows the integration of existing FM repeaters, however the audio is not transported to the reflector systems. (unauthenticated traffic)

The CCS7 system tracks users on all reflector systems and allows direct calls across modes and reflector systems. If the access radio uses a different technology than the called user, the audio stream is transcoded with the AMBE chips and the appropriate reflector room is connected.

Internally the DV4Server uses the following application modules:

- G4KLX for DCS, XRF and D-Plus
- AMBE transcode as in DV4home
- Internal multiprotocol reflector system with 8 rooms
- CCS7 sub server

In current G4KLX systems a user can select for example REF30C by typing *30C as DTMF code and gets connected. (D-Plus)

If he types DTMF D2403 he gets connected to DCS24C. (DCS)

This approach has been proven as stable and reliable. It does not generate loops. The DV4Server now extends this functional concept in several directions:

- The user can now also select Fusion, DMR or NXDN, P25 and other reflector systems by allowing additional access codes.
- There is no need to have repeaters of the other modes on site.
- However, if other repeaters are on site, they can be used as access repeaters as well.
- For example, a Fusion user can use his Fusion radio to connect to a DCS reflector using the same access code as a D-Star user uses to get to this reflector.
- A common access scheme simplifies the usage of multiple modes with multiple access technologies and preserves the existing investment in digital infrastructure.

The internal reflector system limits the usage to 8 simultaneous communication paths. As there is only one AMBE pair available, only one path can be transcoded at a time. Given that the current traffic is low and the fact that i.e. DMR can be connected to NXDN without transcoding this appears to be sufficient. The solution can be scaled up by using multiple devices though.

Conclusion

The development of diverse digital voice systems pose significant challenges regarding reliability, connectivity, ease of operation and cost for ham radio operators, repeater site owners and network operators alike.

These challenges can be met by using the DV4Server at the network edge. The solution also allows the integration of legacy analog systems to attract new users into the digital world.

Links:

http://75.151.47.161/MPDN_DV4.pdf

https://sites.google.com/site/darathursdaynite/d-star/d-star-ccs7-whats-that

http://xreflector.net/neu3/

http://www.k6jm.com/downloads/W6CX-Linking.pdf