ALLEN & HEATH gigaACE, DX, SLink
A CASE FOR PROPRIETARY AUDIO-OVER-ETHERNET PROTOCOLS

What Standard?

In other whitepapers we have examined the complex world of Audio-over-IP protocols with a specific focus on de-facto industry standards like Dante and open standards like AES67.

There are a variety of other protocols in use in the pro audio industry, often part of a closed ecosystem to link devices within the same brand or product family. Of these, Audio-over-IP protocols make use of Layer 3 Ethernet, but several others stop at Layer 2 of the OSI model - most notoriously CobraNet and EtherSound, but also Roland's REAC and SoundGrid by Waves Audio.

In this white paper, we will discuss what advantages proprietary Layer 2 protocols can offer, and why Audio-over-IP is not necessarily the best solution for every audio connection.

What's with Cat cables?

It's no secret that audio transport is increasingly relying on Ethernet technology. In fact, the revolution had already started back in 1985 with the transition from analogue to digital audio transport - it was AES3 first, and its consumer (S/PDIF) and multichannel (MADI) derivatives shortly after. In the course of a decade several alternatives to multicore audio cabling appeared, offering lower cost, less sensitivity to electrical noise and crosstalk, easier routing, and crucially the ability to interconnect digital audio devices without multiple AD and DA conversions.

Engineers were quick to realise that Ethernet offered an ideal platform for audio transport in larger environments. Patching and distribution of analogue audio can be both costly and ineffective. The advent of Audio-over-Ethernet meant audio could be dynamically routed from any source to any number of destinations, with instant reconfiguration, no rewiring, and using existing network infrastructure. Cost, availability and reliability of network hardware were key to Ethernet's acceptance in the pro audio industry - Cat cables are inexpensive, easy to terminate, and ubiquitous.

100Mbps Ethernet provides the raw bandwidth to distribute 64 channels of high-quality audio on a single Cat5 cable, and with decreasing bandwidth costs, higher channel counts and sample rates can now be routed efficiently and economically, as we will see later in this paper.

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dSNAKE

Designed for the GLD and Qu series of mixers, dSNAKE is a digital snake supporting up to 64 channels of 48kHz, 24bit audio concurrently in each direction. It is a point-to-point link based on 100Mbps Ethernet, and offers excellent system-level features that make setting up and using a GLD or Qu digital mixer particularly pain free.

Low Latency

dSNAKE was designed with extremely low latency as a critical feature of the system. The transport latency of a dSNAKE link is just 4 samples (83 microseconds). Being a point-to-point link, this latency is consistent and predictable across every setup.

Configuration Free

Control of dSNAKE devices is via a responsive Layer 2 protocol, specifically designed for fast connection and instant operation. As such, dSNAKE expanders don't require any IP address or network configuration.

In fact, dSNAKE allows devices to have no local configuration at all – instead, settings are loaded from the mixer during an extremely brief connection process. Replace an I/O expander with another of the same type, and it will behave exactly as the original; routing stays the same, and audio is passed, with mic pre control, in as little as one second from the Cat5 cable being plugged in. This lack of a stored configuration is particularly useful for hire stock; racks never need to be 'factory reset' in order to be ready for the next user.

Ready Routed Architecture

Owing to its specific application to Qu and GLD, dSNAKE removes any need for manual channel routing for most scenarios. dSNAKE channels are logically mapped for ease of use, without the extra layer of network routing typical of AoIP solutions.

Automatic Firmware Matching

In a dSNAKE system, the firmware version for any attached device is known. dSNAKE guarantees compatibility in every case, by implementing automatic firmware version matching. When an expander is connected, the mixer will check the firmware version is correct, and in case of any mismatch, it will instantly reprogram the rack to the expected version. In as little as six seconds, the expander is passing audio and ready to go with the new firmware. This works just as well with an old expander in a new system as it does for a new expander in an old system.

The update process has also been designed to be totally bullet proof; power interruptions or cable disconnections during an update will simply revert the unit back to its original firmware, from where it can be reprogrammed again, once power and connection are restored.

Lower Cost

By designing dSNAKE in house we avoided licence fees or royalty costs which are typical of other proprietary protocols. As a result, digital snake technology was made available in our most cost-effective systems and accessible to a wider user base.

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Extended Cable Length

Readers familiar with Fast Ethernet (more specifically, 100Base-TX) will be aware of the '100 meter' (330 feet) Cat5 cable length that is specified for most devices, and this limitation is common to most of the available digital audio snake solutions. This length is achieved by utilising an adaptive cable equalizer in the receiving part of the Ethernet interface chip, which can automatically compensate for losses and signal degradation in the Cat5 cable, allowing the Ethernet signals to be reliably decoded.

When the Fast Ethernet standard was being developed, these equalisers were predominantly analogue circuits, but more modern Ethernet interface chips use digital versions, which are better at compensating for cable losses.

Because all dSNAKE devices were designed by Allen & Heath, we were able to evaluate a variety of these interface chips and select the best one for use in every single device. This allowed dSNAKE to support 120 meters (394 feet) as a reliable Cat5 cable length to use, in combination with cables from our approved, touring grade cables list.

dSNAKE Expanders

Allen & Heath offers 3 different dSNAKE Expanders to suit the budget or application:

- AR2412 - 24in, 12 out AudioRack
- AR84 - 8in, 4out AudioRack
- AB168 - 16in, 8out portable stagebox

DX

The DX protocol is an evolution of dSNAKE running 96kHz audio. Its main purpose is to facilitate audio distribution by adding I/O expanders to the core components of a system. Each DX port can carry 32x32 channels of 96kHz audio, together with control data. As with dSNAKE, the configuration is stored in the mixer and applied to the DX Expander at connection, with automatic firmware matching also provided.

By offering multiple DX ports on the dLive MixRack / Surface and DX Hub, analogue distribution on stage or in a venue can be efficiently and economically replaced by digital distribution. The form factor of the 'stagebox' doesn't change, but deploying the preamplifiers and converters as close as possible to the source brings all the advantages of digital audio transport to the stage - an environment typically subject to high electromagnetic and RF interference.

DX ports can work in either redundant mode, with each socket / cable pair providing seamless audio redundancy, or in cascade mode, allowing up to 2 DX Expanders to be daisy chained.

DX Expanders

Allen & Heath offers 4 different DX Expanders to suit the budget or application:

- DX168 - 16in, 8out portable stagebox
- DX164-W - 16in, 4out wall-mount
- DX012 - 12out output expander
- DX32 - modular rack with a choice of analogue/digital cards and redundant power supplies

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Additionally, the DX capabilities of a system can be expanded through the usage of a remote hub or I/O card depending on application:

DX Link is an option card available to extend the number of I/O devices in a dLive or Avantis system. Multiple cards can be fitted, bringing the total DX count to over 40 discrete I/O points.

DX Hub moves the physical distribution point to a remote location, with a gigaACE trunk to the AHM-64 matrix mixer; dLive MixRack or Surface; Avantis mixer; or SQ mixer. As such, a single cable can be run to a different floor or building, where the DX Hub branches out to multiple DX lines.

GX4816 is a 48in, 16out expander rack with a single connection to an SLink port or gigaACE card, and 2x DX sockets for connection of up to 4 DX Expanders.

For details on these products please visit www.allen-heath.com. The DX and GX System Guide is also available for details on GX and DX connections, topologies and system examples.

gigaACE

gigaACE is a point-to-point link based on Gigabit Ethernet and running 96kHz, 24bit audio.

It is an evolution of ACE (Audio and Control over Ethernet), the first implementation of Audio-over-Ethernet by Allen & Heath back in 2009. Due to the increased I/O requirements, the 48kHz, 64-channel ACE protocol was adapted to take advantage of Gigabit Ethernet and offer 128 bidirectional channels at 96kHz, with the main backbone between dLive MixRack and Surface carrying in excess of 300 channels.

The core benefits of ACE and dSNAKE are still present, including the ultra-low latency and plug-n-play architecture.

Plug & Play

Channel routing and clock synchronization is managed by the mixer interface, and indeed self-managed for surface to rack connections. This makes gigaACE a truly plug 'n play system, with no computer or external routing software required.

Ethernet Tunnelling

Control data over ACE and gigaACE is TCP/IP embedded in the Layer 2 packets.

In addition to proprietary control messages between Surface and MixRack, both protocols allow bridging or 'tunnelling' of generic TCP/IP data in each direction. This enables control messages for other network-enabled devices in the system e.g. networked amplifiers, wireless receivers or DMX over Ethernet, with the convenience of a single cable connection between stage and FOH.

On a gigaACE link, over 100Mbps are available for third party data. Since the TCP traffic is encapsulated in Layer 2 packets, audio is unaffected even when saturating the bandwidth.

Seamless Redundancy

On dLive S Class MixRacks and Surfaces,

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and when using the gigaACE option card, two sockets are provided for redundant connections. Both links are always running so in the case of an error on either link, or the complete loss of a link, there is absolutely no loss of either audio or control information whatsoever.

Seamless redundancy of audio is also a feature of other protocols, but redundancy of arbitrary control protocols is a unique feature of ACE and gigaACE.

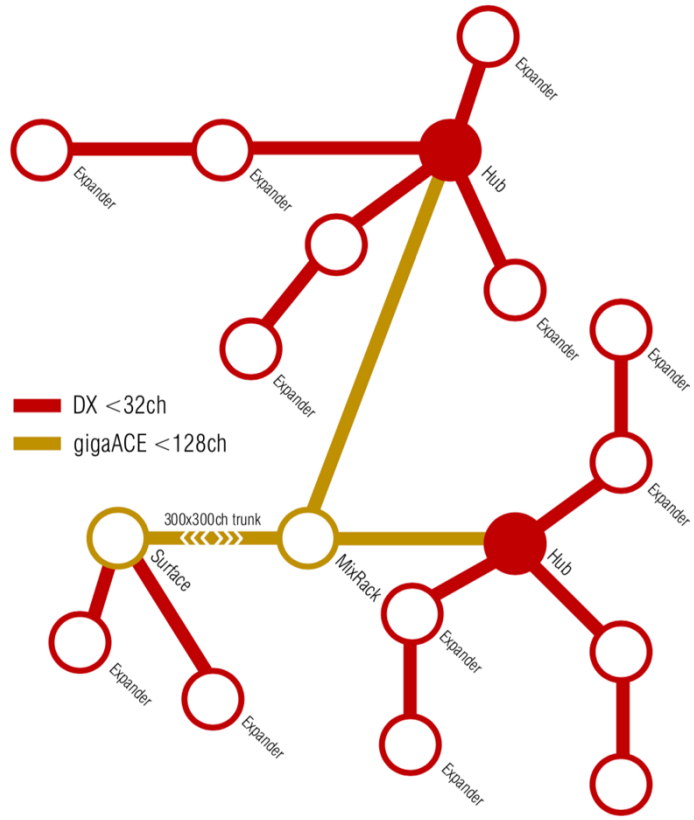
GX connections

An offshoot of the gigaACE protocol allows for gigaACE connections to a DX Hub, GX4816 expander rack, or to/from an SLink port (see later in this document). In these scenarios, gigaACE behaves like a Gigabit, high-channel count version of the DX protocol i.e. providing Layer 2 preamp control and automatic firmware matching, but no Ethernet tunnelling. 128x128 channels of 96kHz audio are transported.

Mixed topologies, scalable systems

The gigaACE and DX protocols are designed to integrate and seamlessly work together in a dLive system, allowing for flexible audio distribution and positioning of I/O devices, with Gigabit Ethernet connections where required, and taking advantage of both daisy-chain and star topologies.

Each connection can be up to 100m, or longer when using fibre optics, thus covering any size of application from small venues to a large campus. Many audio professionals are led to believe point-to-point Layer 2 protocols are not as scalable as AoIP solutions, yet an Allen & Heath dLive system can offer in excess of 800 analogue inputs across up to 48 discrete I/O points.



Layer 2 networking, fibre optics and VLANs

As we have seen, ACE, gigaACE, dSNAKE and DX are Ethernet Layer 2 point-to-point connections. Layer 2 network switches and media converters can be used, with some restrictions, to extend a cable run,

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convert to fibre optic or in some cases, make use of an existing LAN infrastructure.

General rules

The switch or media converter must support the protocol bitrate. This is 1000BASE-T (Gigabit Ethernet) for gigaACE, 100BASE-TX (Fast Ethernet) for ACE, dSNAKE and DX. Link speed negotiation on auto-switch devices can cause issues and should be disabled.

Layer 3 & 4 protocols including Spanning Tree, Tagged Egress Packets, and Broadcast Storm Protection can cause interruption to audio data or audible clicks. Smart / managed switches may allow turning off Layer 3 or 4 functions, but as a general rule, use Layer 2 devices where possible.

No other network device should be plugged into a switch carrying ACE, gigaACE, dSNAKE or DX audio, unless a dedicated VLAN is set up.

Parallel connection of multiple dSNAKE or DX Expanders on a switch is not possible. Each point-to-point link needs its own VLAN.

Finally, check for errors and test for functionality and reliability before putting your system into service.

Fibre optics

Most off-the-shelf Cat5 to FO converters will work, provided they support the required connection type / speed (see above). The type and specification for the fibre cable will depend on the third-party device.

VLANs

It takes some trial and error to configure a VLAN for use with DX or gigaACE, and the actual configuration depends on the specific switch in use. In tests it was found that many switches do not handle the gigaACE / DX packets with the time accuracy our clock requires, particularly over trunk lines and SFP modules, resulting in sync errors and in some cases, audible glitches. Thus, use of trunked VLANs is not officially supported and these notes are given as a guideline only.

One VLAN is needed for each point-to-point connection, and no other traffic should be present on this VLAN.

The ports should be forced to the correct speed (see above) and need full 100Mbps / 1000Mbps bandwidth. If attempting a trunked VLAN between switches, the trunk must be higher than Gigabit (10 Gigabit recommended).

All Layer 3 and higher protocols must be disabled, as mentioned above. Essentially any packet on the VLAN other than audio transport is likely to cause audible glitches. The VLAN should be fully transparent to Layer 2 traffic, with no extra packet.

Also note that dLive firmware prior to V1.8 had gigaACE fixed to VLAN 1, which could conflict with the management VLAN on some switches. The VLAN tag was removed in V1.8 allowing user tagging of gigaACE traffic.

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SLink

During the design of SQ, and conscious of a strong Qu and GLD user base owning 48kHz dSNAKE expanders, the R&D team developed a multi-format, intelligent port under the project name *omniport*, which later became known as SLink. It is now available on SQ and Avantis digital mixers, as well as on the AHM-64 matrix processor. An optional SLink card for SQ is also available for more expansion and flexibility.

SLink can sense what device is connected at the other side of the cable, and auto-switch mode, bitrate, channel count and sample rate accordingly. As such, it supports 96kHz DX and GX expanders from our dLive range, as well as 48kHz dSNAKE expanders and ME personal mixers, with seamless sample rate conversion. It also supports gigaACE connections of up to 128 channels, for example for digital split applications or connection to a DX Hub.

In Conclusion

Audio-over-IP protocols such as Dante offer the best solution for applications where complex audio networking over multiple devices and interfacing with equipment from different manufacturers is necessary. Another well-known advantage of AoIP is that it can be integrated much more easily in converged networks, even with coexisting TCP/IP traffic, meaning existing switches, backbones etc. can be used. This flexibility does of course come at a cost, both the high price of the technology and the knowledge and setup required.

AHM-64, dLive, Avantis and SQ mixers all have optional Dante interfaces to cater for these requirements.

For many users the requirement is much less involved however, and the advantages of lower cost, plug 'n play proprietary Layer 2 protocols become attractive. PA providers and rental companies typically stock many consoles, often for dry hire to customers who may not be familiar with the technology behind them. In this case the simple configuration of the dSNAKE, gigaACE and DX solutions reduces the support required and potential frustration for the user and can act as a drop-in replacement for analogue multicores.

In fixed installations, features such as automatic firmware matching can cut maintenance costs and support calls.

In choosing which protocol to use, it is important to avoid unnecessary complexity by considering the real application needs, budget and ease of use for the potential user. dSNAKE, gigaACE and DX are examples of technology scaled for practical application and with excellent usability.

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	ACE	dSNAKE	gigaACE (to gigaACE)	gigaACE (to DX Hub, GX, or to/from SLink)	DX
Ethernet	100Base-TX (Fast Ethernet)		1000Base-T (Gigabit)		100Base-TX (Fast Ethernet)
Sample rate	48kHz		96kHz		
Channel Count	64	64	128* *dLive Surface to MixRack links carry over 300x300 channels.	128	32
Tunnelling	✔	-	✔	-	-
Redundancy	✔	-	✔	-	✔
Auto Firmware Matching	-	✔	-	✔	✔
Latency	5 samples (105us)	4 samples (83us)	5 samples (52us)	5 samples (52us)	8 samples (83us)
Cable Length	<120m		<100m		

For further information, application guides, and recommended products please visit https://www.allen-heath.com/installation/

Don't hesitate to contact our Install team at installedsolutions@allen-heath.com if you need assistance on which products to specify or if you have questions about an application.

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