TI 317
Dante audio networking 1.1 en

Contents

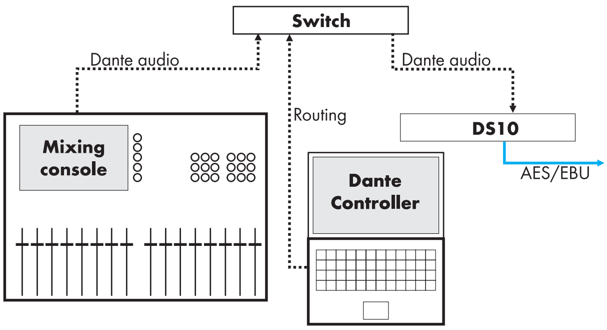
1. Audinate Dante

Audinate Dante is a combination of protocols, hardware and software, that are designed for the transport of audio over IP networks. Depending on the hardware and software used, up to 512 x 512 audio channels can be transmitted over a single Gigabit Ethernet link. Dante supports sampling rates between 44.1 and 192 kHz and bit depths between 16 and 32 Bits per sample. With the DS10 Audio network bridge, d&b audiotechnik offers an interface between Dante and AES/EBU that is designed for professional use and compatible with a vast array of third-party products.

Within devices, Dante works hardware-based. At the same time, software-based solutions or "virtual sound cards" are also available for MacOS and Windows operating systems to integrate computers into Dante audio systems. In this way, multitrack recording and playback or software audio processing is possible through the network without any media conversion.

2. Dante basics and basic operation

A Dante network consists of at least two Dante-enabled devices and a suitable network switch, if required (in the simplest possible case, the two devices are simply linked directly). To configure the audio routing between the devices, a computer running Audinate Dante Controller is required as well. Some Dante-enabled devices can provide certain routing functions even without an instance of Dante Controller.



Once all devices are connected, they are detected by Dante Controller and shown in a matrix view with all available inputs and outputs. Audio routings can be set by placing checks at the desired crosspoints within the matrix. Besides device discovery, further configuration settings such as the assignment of IP addresses or clocking also work automatically and do not normally require any user interaction, even in large systems.

Dante systems very are easy to handle, if suitable network hardware and the plethora of configuration options that the underlying technology offers are used meaningfully. Experience shows that the vast majority of problems stem from an overly deliberate network configuration. Not everything that is technically possible is actually required or meaningful.

This document aims to provide important initial information about the function, terminology and meaningful setup of Dante systems, as well information about best practices and troubleshooting. We strongly recommend the additional study of the comprehensive documentation provided by Audinate[1] on their website. Further information about Ethernet networks can be found in our TI310[2].

2.1 Networking and device discovery

Since Dante builds on the IP protocol, all devices on the network must have compatible network settings. This configuration is realised using the automatic link local / Zeroconf[3] method which is supported by all Dante-enabled devices and all relevant operating systems. The technology does not require a separate entity to assign IP addresses; instead, all devices pick a random address out of a pre-determined range and follow a procedure that ensures that this address is not already in use. Link local is automatically enabled when a Dante-enabled device or operating system is set to obtain its network configuration automatically and typically requires a couple of seconds to complete.

	Primary	**Secondary**
IP-range	169.254.*.*	172.31.*.*
Subnet mask	255.255.0.0	255.255.0.0

DHCP and manual IP address assignment can also be used. In this case, it is the responsibility of the user to make sure the settings in all devices are compatible.

Device discovery is enacted automatically using a variant of Apple's Bonjour[4] protocol. Apart from not requiring any user interaction, this enables Dante Controller to discover Dante-enabled devices even if their network configurations are not correct. Although no audio routing is possible in this case, the respective devices and their network settings are still shown in the software, allowing the user to act upon this information without having to guess.

2.2 Audio routing and transport in Dante networks

Within the network, Dante-enabled devices present their outputs and inputs as transmit (Tx) and/or receive (Rx) channels, thus acting as Dante transmitters and/or Dante receivers in accordance with this terminology. Using Dante Controller (or sometimes a routing function that is integrated in the respective device), the user can define audio routes between specific Tx and Rx channels. Dante always looks at the routing from the perspective of the receiving device – a receiver "subscribes" to certain channels of one or several transmitters. Actual network bandwidth which is dependent on the number of transmitted audio channels is used only when subscriptions have been created.

Typically, subscriptions are stored in the receiver. This means that after a temporary interruption of the network or a power cycle, all audio routes are re-established automatically.

Routing is based entirely on device and channel names. For this reason, device names within a network must be unique. Similarly, channel names must be unique within a device. In this way, one transmitter can be replaced by another – as

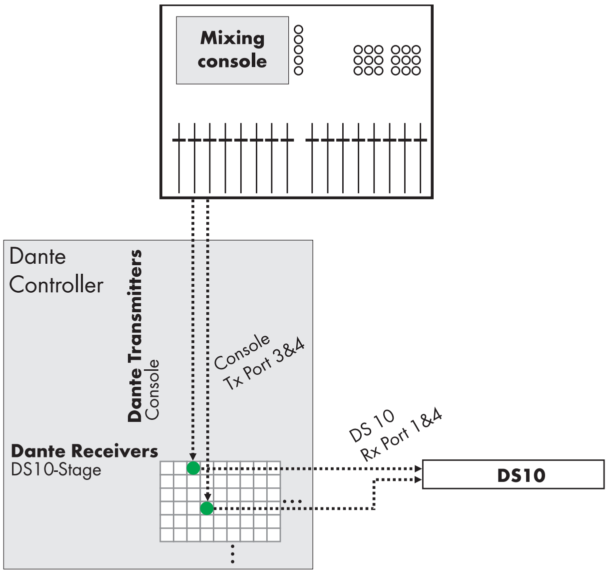
[1] http://www.audinate.com

[2] http://www.dbaudio.com/fileadmin/docbase/TI310_1.1EN.PDF

[3] https://en.wikipedia.org/wiki/Zero-configuration_networking

[4] https://en.wikipedia.org/wiki/Bonjour_(software)

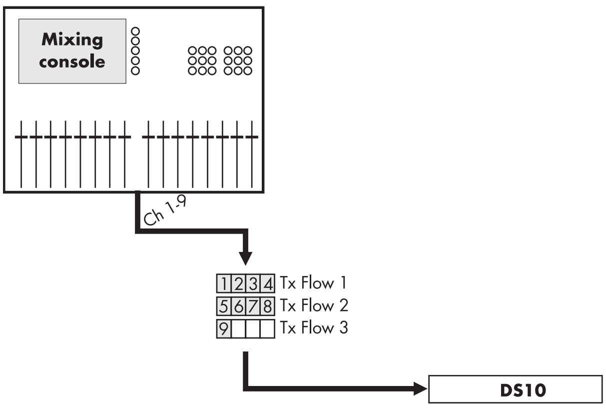
long as the device and channel names are identical to the previous ones, all previous subscriptions to that transmitter will be re-established automatically.



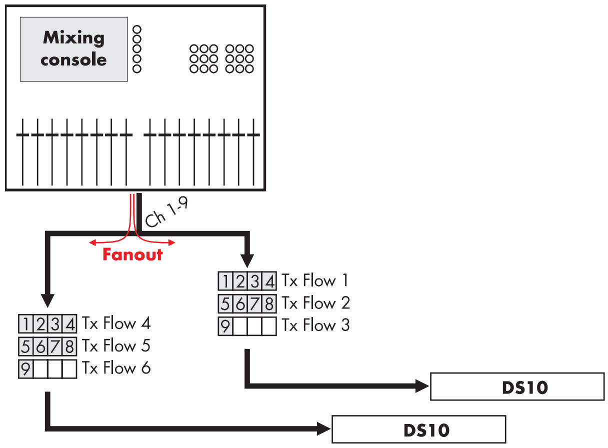
2.3 Methods of transport in Dante networks

2.3.1 Unicast and Multicast-flows

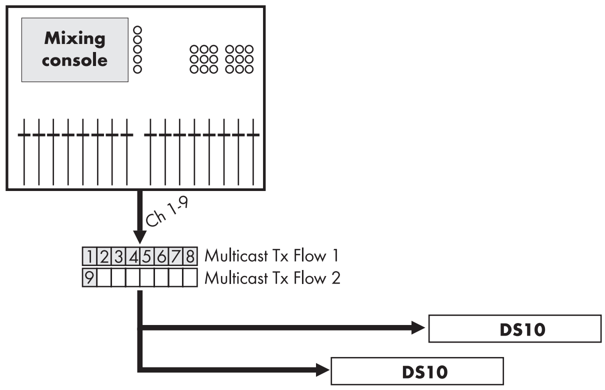
To use network bandwidth more efficiently, Dante combines audio channels to be transmitted into logical flows. These, in turn, can be transmitted as **unicast** or multicast flows.
By default, all flows are unicast. In this case, separate flows containing up to four audio channels are created for every receiver. The total number of flows is therefore determined by the total number of channel subscriptions per receiver.



If multiple receivers subscribe to the same audio channels, this results in the respective multiple of flows and network bandwidth consumed. Such a duplication of flows is referred to as "fanout configuration". Normally, this is not relevant from a bandwidth point of view, as up to 512 audio channels at 48 kHz can be transmitted bidirectionally over a Gigabit Ethernet link. It is much more likely that a transmitter at some point is no longer able to generate the required number of flows, as the maximum transmit and receive flow count typically is 32, which may become the limiting factor even if only a small number of channels needs to be transmitted to a large number of receivers.



In such cases, the use of **multicast** should be considered. Multicast flows have to be specifically generated in Dante Controller. In contrast to unicast flows, they contain up to eight audio channels and need to be generated only once regardless of the number of subscriptions to these channels. At the transmitter, there is no duplication of traffic or flows, rather switches handle multicast flows by outputting them through all ports, thus flooding the network.



However, due to this flood of data packets further regulatory measures are recommended when multicasts are used in order to prevent the overloading of network segments or devices.

2.3.2 IGMP Snooping

Meaningful use of Multicast requires all backbone switches to support measures that prevent the simple flooding of the network with data packets. This is why Dante implements IGMP Snooping (IGMP = Internet Group Management Protocol). Switches supporting this feature can handle the forwarding of Multicast data intelligently in such a way that they do not simply pass on multicast data to all ports but query the rest of the network to determine where it is needed. All of this is performed automatically if IGMP Snooping[5] is enabled and, depending on the make and model of the switch, if it is configured correctly.

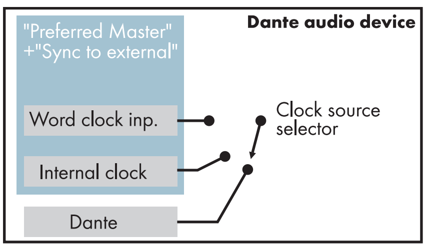
2.4 Clock distribution and recovery

To enable synchronous playout, every audio system requires a central clock source. In the case of Dante, every hardware device on the network can assume this role rather than requiring a separate device to perform this function. Clock distribution is facilitated via the network using the Precision Time Protocol according to IEEE1588[6]. The same mechanism automatically selects the most stable clock source. If the connection to this device is lost, a replacement is selected automatically without any interruption to the audio. The synchronicity of all playout devices is achieved with a deviation of less than 1 µs.[7]

In order for this to work, all devices have to be configured to clock off the network. Digital mixing consoles are a prime example – since they also feature an internal clock, they typically have to be expressly configured to clock off Dante.

The automatic clock source selection within a Dante network can be monitored and if necessary overridden in Dante Controller. In this case, the status “Preferred Master” is assigned to the desired device.

Clocking to sources outside of the Dante network is also possible. For clarity reasons, it should be noted that even the internal clock of a mixing console, to stay with the above example, is considered as “external” to Dante. In this case, the option “Sync to External” has to be checked in addition to “Preferred Master” for the desired device. Within the configuration of this device, the desired clock source can then be selected (e.g. the internal clock or an external word clock generator).

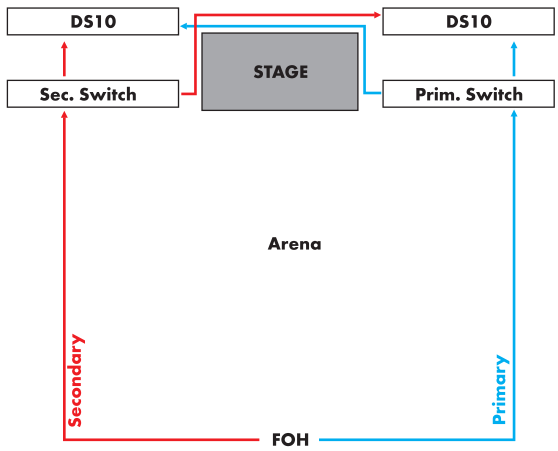


Experience shows that forced external clocking more often hinders the commissioning of a Dante network than improving anything. We therefore recommend only using an external clock source if this is technically imperative.

2.5 Redundancy

Dante supports redundant network links for applications that require enhanced resiliency against failures. Dante enabled devices set to redundant mode are connected via two separate network interfaces (Primary and Secondary) and two physically or logically separate networks. In redundant mode, a Dante enabled device constantly transmits on both networks. Receivers working in redundant mode analyse all incoming traffic and simply discard duplicate packets. In case of a failure in one network, the communication persists over the other. No connection must be made between Primary and Secondary networks, e.g. by connecting a primary and a secondary switch to each other.

In actual use, mechanical or electrical problems with network lines or connectors are by far the most frequent cause of failure. In light of this knowledge, it is prudent to run both network lines separately as much as physically possible, as the illustration shows, to avoid simultaneous damage to both lines by external influences.



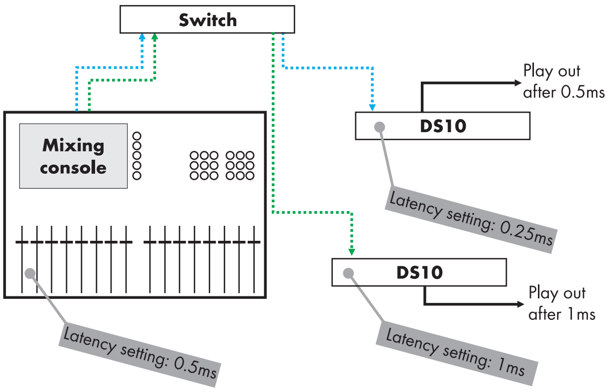
2.6 Latency

The transmission of data over a network requires a finite amount of time that is not necessarily constant. This throughput time or network latency depends on the latency of the transmitting device and to a large degree on the number and performance of network switches the signal has to pass on its route from transmitter to receiver. To ensure deterministic playout, the receiving device has to buffer incoming data long enough to compensate for the highest expected and occurring network latency. This time can be configured in all Dante enabled devices and the value should be chosen according to the topology of the network. If the latency settings of receiver and transmitter for a given audio route are not identical, the higher value in each case will be used for this route, as shown in the illustration below.

[5] https://en.wikipedia.org/wiki/IGMP_snooping

[6] https://en.wikipedia.org/wiki/Precision_Time_Protocol

[7] To put this in perspective, the duration of a single sample at 96 kHz is 10.42 µs.



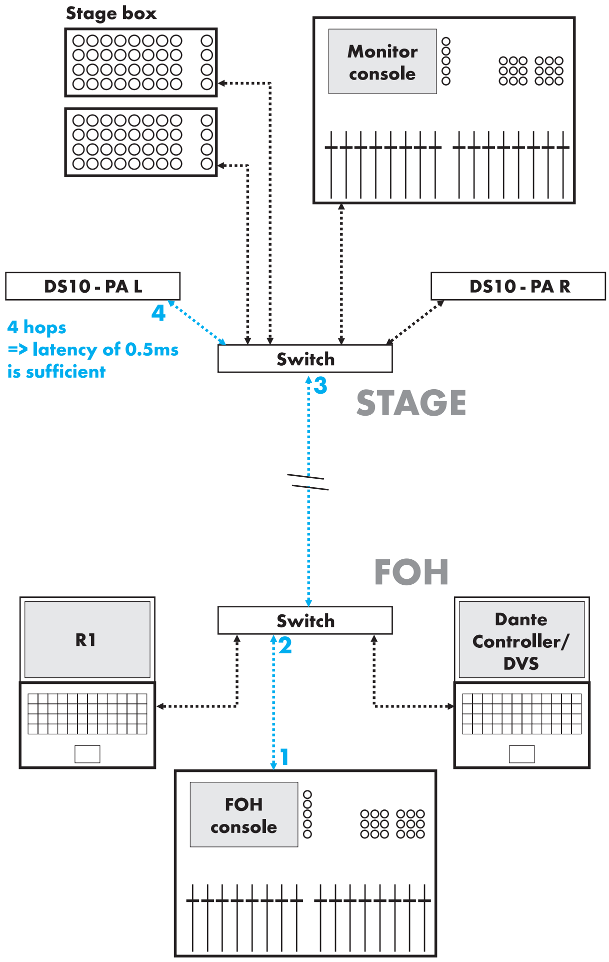
This parameter is vitally important with regard to simultaneous playout from different Dante enabled devices. Considering one DS10 per side driving a large PA system , both of them have to be set to the same latency value. Additionally, in case of a live event, this value should be as low as possible.

The number of switches or "hops" the signal has to pass on its way through the network can be used as a guideline to determine a suitable latency setting. Every Gigabit hop amounts to about 0.1 ms of additional latency. It is important to know that every Dante enabled hardware device typically also counts as an additional hop. As a consequence, the ideal network topology in terms of latency minimizes the number of hops for every conceivable route as much as possible.

Max, number of hops @1Gbps	**Recommended latency setting**
Up to 3	0.25 ms
Up to 5	0.5 ms
Up to 10	1 ms
11 or more	5 ms
Multicast	Mind. 1ms

The system in the following illustration shows a typical Dante based application consisting of a stage with several Dante enabled stage boxes, separate Dante enabled monitor and front of house consoles and the possibility to record and play back audio via Dante Virtual Soundcard. For simpler cable logistics, each side of the PA is driven by a separate DS10. In this way, the system provides sufficient AES/EBU outputs to not only drive the PA, but also a considerable number of monitor channels. In addition, every DS10 provides a number of additional network ports to integrate the system amplifiers using the R1 Remote control software.

Front of house and the stage are both catered for by a separate network switch which creates a star topology for each to minimize the number of network hops. At the same time, a significant number of additional devices can be integrated in the network without the need for higher latency settings or any compromise to the reliability of the network. All devices can be reached from any point in the network with a maximum of four hops, which means that a latency setting of 0.5 ms is sufficient for all devices.



3. Network hardware selection

To realise a network topology as previously described that offers sufficient flexibility, reliability and low latency, additional network switches may be required. In case the port count is sufficient, this functionality can easily be provided by DS10s. Larger external switches are called for when more ports are needed, and special features such as IGMP Snooping are required or when distances of more than 100 m between switches necessitate the use of fibre-based interconnects. In every case, careful consideration and planning e.g. of the most suitable topology are preconditions for a meaningful choice.

3.1 Criteria for selection of Dante network switches

Suitable criteria for the selection of network switches for Dante audio systems can be deduced from the formal requirements of Dante and the intended use in the event industry. Great emphasis lies on establishing high overall network performance and uninterrupted data transmission.

3.1.1 Gigabit Ethernet

Gigabit Ethernet technology is required to make use of the full potential of Dante. While Fast Ethernet (100 Mbit) links are technically possible, they considerably reduce the achievable channel count and increase the minimum possible latency and therefore are not recommended.

3.1.2 Internal switching bandwidth

Switches in Dante networks must be capable of routing full-bandwidth bi-directional traffic of all ports simultaneously. This feature is known as "non-blocking". Accordingly, an 8port Gigabit switch must have an internal switching capacity of at least 16 Gbps.

3.1.3 Management features

Managed switches offer significant flexibility in configuring switch features based on the requirements of a specific application and are therefore recommended by Audinate. At the same time, the available options are often fairly complex and require expert knowledge of the specific switch. Also, terminology and feature implementation is not necessarily consistent from one manufacturer to another. In practical use, mis- or overconfiguration of switches much more often results in network problems than malfunctioning or unsuitable hardware. It is therefore recommended reducing the need for overly complex network configuration scenarios as much as possible and configuring switches in a way that allows them to be used as "black boxes" that will not require frequent reconfiguration.

3.1.4 Quality of Service (QoS)

IP networking was not invented with real-time-critical transmission of data in mind. Without any further measures, this means that interruptions may occur in Dante applications at times of high network load or with conflicting types of network traffic. To enable deterministic data transmission, a number of prioritisation or Quality of Service[1] (QoS) mechanisms are implemented. In Dante systems, the transmitter tags outgoing packets with DiffServ/DSCP[2] labels according to their priority. Network switches that are used in Dante networks should be able to interpret these labels and prioritize traffic in at least 4 "queues" (= 4 priority categories) with strict priority. This means that the switch will always forward packets with higher priority first.
In some managed switches, DSCP labels have to be manually mapped to priority levels. The proper mapping can be found in the table below.

Priority	Type of data	Diffserv/DSCP Label	Hex	Decimal
high	Time critical PTP data (synchronisation)	CS7	0x38	56
medium	Audio, PTP	EF	0x2E	46
low	Control	CS1	0x08	8
none	other daten	Best Effort		0

QoS can only work properly if the entire bandwidth available at the respective switch port or network segment is not exceeded. It is recommended having QoS enabled at all times.

3.1.5 EEE-(Energy Efficient Ethernet)

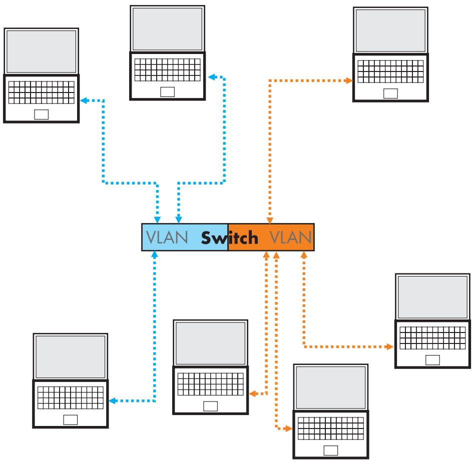
This extension of the Ethernet standard, sometimes also referred to as „Green Ethernet", is intended to reduce energy consumption in large networks by throttling or deactivating single network ports. However, this is contradictory to Dante performance requirements. Therefore only switches without EEE functionality or switches where this feature can be disabled should be used.

1 https://en.wikipedia.org/wiki/Quality_of_service

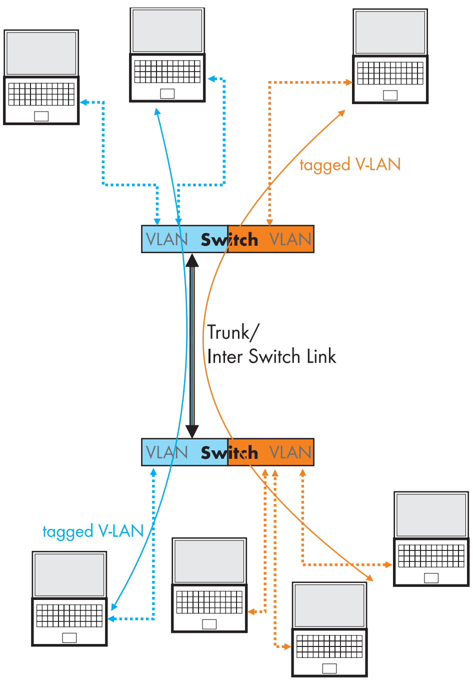
2 https://en.wikipedia.org/wiki/Differentiated_services

3.1.6 V-LANs

Many managed switches allow individual ports to be grouped into logically separate networks or VLANs[3] (Virtual Local Area Network). The switch then acts as several completely independent devices which means that traffic from ports assigned to one V-LAN is not forwarded to ports assigned to another. To the network, this is completely transparent if the switch is non-blocking.



Several V-LANs can also be transported between switches without requiring a separate physical link per V-LAN. In this case, so-called "tagged" V-LANs are used – the switch tags all packets according to their V-LAN associations. One or more switch ports are then configured as "trunk" or "inter switch link (ISL)" ports. These combine the traffic of all VLANs. The other switches have to be configured in the same way, which means that they must provide at least one trunk or ISL port to receive the combined traffic and an adequate number of appropriately tagged V-LANs to which they can assign the various packets.



[3] https://en.wikipedia.org/wiki/Virtual_LAN

Since different implementations exist with regard to V-LAN tagging and trunking, it is recommended only using one kind of backbone switch throughout the whole network. If a mixed infrastructure is deployed, it must be carefully configured and tested beforehand.

V-LANs are often used to create redundant Dante networks without the need for two physical networks. In this case, separate V-LANs are provided for the primary and secondary Dante connections and are trunked between switches. It is important to consider that in this case only the connections between the switches and the endpoints are truly redundant, as both networks share the same physical switch and interconnect between switches. A hardware failure in the switch or an interrupted trunk line will disrupt both networks. Also, since both networks now share the same Gigabit network link, the available bandwidth per network is at least halved, an important fact when high channel counts are used.
Another typical use of V-LANs is to logically separate Dante and third-party traffic (such as remote control networks). If QoS is configured correctly, this is largely unnecessary.

3.1.7 IGMP Snooping

As described before, IGMP Snooping is vital in handling Multicast traffic. It is recommended choosing switches that implement IMGP v3. With modern switches, this feature can be left activated permanently, making a reconfiguration in case of spontaneous Multicast traffic handling unnecessary.

3.1.8 Fibre option

Typical applications in the event industry often require distances of 100 m or more to be bridged between backbone switches. As this exceeds the 100 m max length specification of copper links – all the more so, if passive patch panels are used between switches - fibre links are strongly recommended in such cases. Depending on the chosen option, these allow significantly longer distances between devices (up to 500 m with multimode fibre, up to 10 km with monomode fibre).
It is recommended investing in equipment that can be easily upgraded to fibre ports in order to keep the system future proof.

3.1.9 Road compatible hradware

For mobile deployment in the event industry, a few constructional details are helpful:

– Metal chassis
– Rackmountability
– EherCon connectors (much more reliable electrical connection and approximately tenfold number of connection cycles compared to RJ45)
– Built-in power supply with overvoltage protection or dual-redundant power supplies

3.1.10 RSTP (Ring and mesh topologies)

RSTP[4] (Rapid Spanning Tree Protocol) allows the creation of ring and mesh topologies for enhanced resilience against interrupted backbone links. In order for this to work, RSTP must be supported by all switches that are part of the loop or mesh. Should a network link fail, the switches can automatically reroute traffic through a redundant link. Depending on the model of the switch, this procedure may still cause an interruption of several seconds. Also, depending on the make and model of the switch, configuring RSTP may be non-trivial and should be thoroughly understood.

3.2 Recommended switches for Dante systems

The following recommendations are limited to only a few devices and are not exhaustive. The recommended models have been chosen based on application relevant features, ease-of-use and market presence. All device series either feature a chassis-mounted road-worthy fibre connector or can be upgraded accordingly using an additional break-out panel.

3.2.1 Luminex Gigacore series

These switches have been specifically developed for the event industry and are ideally configured for Dante systems out of the box or after a factory reset. Additionally, they support arbitrary mesh or ring topologies without any further configuration and feature a very short rerouting time when swapping links (no or nearly no audible artefacts while opening or closing a network ring).

3.2.2 Yamaha SWP1 series

These switches have also been specifically designed for Dante systems and are very easy to configure. Various presets are recallable by simple dip switches on the front panel without any software configuration.

Both previously mentioned product series not only stand out because of their technical features, but also due to their meaningful preconfigurations and very easy adaptability to different application scenarios.

3.2.3 Cisco SG300 series

This range of switches offers a very comprehensive feature set and excellent performance and is in fairly widespread use in the event industry. However, these devices were not primarily designed for this application and their configurations for Dante systems are not trivial. Due to the vast amount of configurable parameters, expert knowledge or a detailed configuration guide are required for custom configuration. As misconfigured switches are often the cause of networking problems, a basic configuration file for the SG300-20 model is available for download on the d&b website and will enact a stable configuration for Dante systems. You can find it on the product page of the DS10 Network Audio Bridge. For specialty configurations, please consult the respective manuals.

[4] https://en.wikipedia.org/wiki/Spanning_Tree_Protocol#Rapid_Spanning_Tree_Protocol

QoS	Enabled, DSCP/DiffServ Mapping entsprechend Audinate Vorgaben
IGMP Snooping	Enabled
EEE	Disabled

Cisco SG300 Series Dante configuration

4. Troubleshooting

One or several devices are not shown in Dante Controller.

Possible cause(s):

- Defective network cable – the cable is plugged in, but the status/activity LEDs of the respective socket do not light up.
- The network cable has not been plugged into the respective device (or the control computer) or the wrong cable has been plugged in.
- You have selected the wrong network interface within Dante Controller. Please check your selection using the appropriate dialog.

- A firewall or antivirus software that is active on your computer is blocking Dante relevant traffic. Deactivate the software or open the ports used by Dante Controller and Monitoring Service: UDP 8700 9705, 8800.

No signal routing possible in Dante Controller.

Possible cause(s):

- At least one of the affected devices uses network settings that are not compatible with your instance of Dante Controller or with the other devices. All Dante devices and Dante Controller must have compatible network settings for this to work. If this is not the case, the respective device will still be shown in Dante Controller, but no audio routing is possible. Check and adjust the network settings of the affected devices in Dante Controller's Device View as necessary. It may also be the network settings of the control computer that do not match and have to be changed.
- The affected devices are configured for different sampling rates. Though these can coexist within the same network, audio routing is only possible between devices with matching sampling rate.

  Check the sampling rates of all devices in Dante Controller's Device View and adjust them to match.

No or interrupted or distorted audio output.

Possible cause(s):

- The actual throughput delay for this audio route is partially or continuously higher than the latency settings in both, transmitter and receiver. For this reason, the receiver is not playing out audio or intermittently muting its output.
  Check the latency histogram of the receiver on the respective Device View tab. Red entries indicate dropped packets or audio interruptions. In these cases, the latency of the receiver has been set too low. Additionally, a wide distribution of values in the histogram typically also points to network problems due to misconfiguration.
- Due to misconfiguration of the network the clocking data cannot be transmitted reliably. The receiver is thus dropping individual packets and/or muting its output. This condition will be indicated on the Clock Status tab in Dante Controller.
- The receiver has been internally configured to use an external clock source (this is already the case when a Dante enabled mixing console's clock source is set to "Internal" instead of "Dante"), without being configured in Dante Controller to be the clock source for the whole network. The receiver is therefore not in sync with the rest of the network and will not play out audio. This is usually also indicated on the Clock Status tab in Dante Controller.
- You are using switches where the EEE (Energy Efficient Ethernet) function according to IEEE802.3az is active. This feature may also be called Green Ethernet. Deactivate the function or use a switch without EEE.
- The network is saturated because not all switches are non-blocking.

Dante Controller shows several devices as Clock Masters for the Primary and/or Secondary networks.

Possible cause(s):

- Every Dante network can only have one clock master at a time. Due to a misconfigured firewall, port filter, faulty network cabling or VLAN settings the network is accidentally split into several segments which cannot communicate properly with each other. Check your switch and network configurations.

Dante Controller shows different devices as Clock Masters for the Primary and Secondary networks.

Possible cause:

- The device which serves as the clock master in the primary network is not connected to the secondary network. In this case, another Dante device which is connected to both networks bridges the clock data from the primary to the secondary network, and is thus shown as the clock master in that network.
  If the device serving as clock master is connected to both networks, it should also be indicated as such in both networks. If that is not the case, this points to network problems.

Some parameters of a device are greyed out in Dante Controller and cannot be modified.

Possible cause(s):

- The respective features are not available on that device.
- Operating the respective features via Dante Controller is not possible with the device. Consult the respective user manual for further information.
- The device network settings are not correctly made. Check and adjust the network settings of the affected devices in Dante Controller's Device View as necessary. It may also be the network settings of the control computer that do not match and have to be changed.

5. Best Practices

5.1 Commissioning of Dante networks

When planning larger networks, draw a plan of the topology first.

Mapping out the network first will give you a much better idea of how many and where switch ports are needed and what the cable runs will have to be.

Make use of Dante's automatic configuration mechanisms, configure manually only when absolutely necessary.

Network configuration and clocking work automatically and reliably in Dante networks. Manual configuration of these settings is usually not necessary for proper operation.

Before using redundant networks, check both individually.

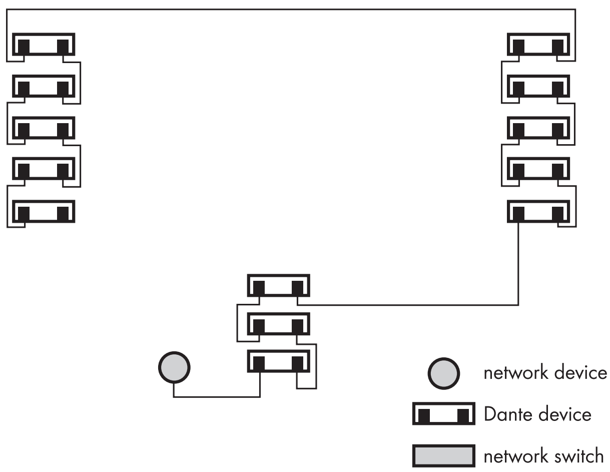
Connect only the primary interfaces first and check the network. Repeat the procedure with the secondary connections only. Connect both networks if they have worked individually.

The "Clock Status" and "Network Status" tabs in Dante Controller will give you further detailed information about the status of network links and clock distribution/stability of the network.

5.2 Topologies

Different topologies can be realized within IP networks. This section outlines several basic variants with regard to their use in Dante networks.

5.2.1 Daisy-Chain



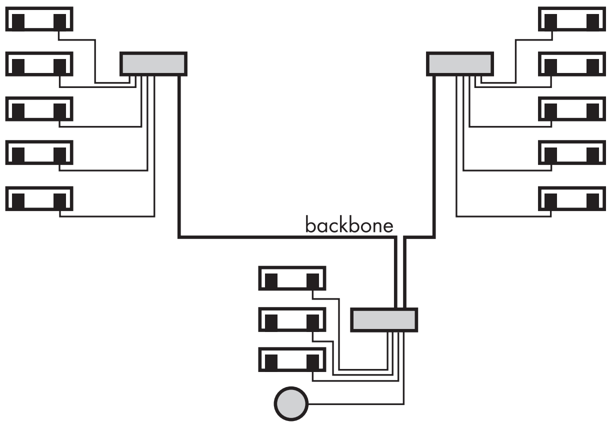
Pros:

- Easy to set up.
- Shortest physical cable runs.
- Easy to extend.
- External network switches are mostly not required.

Cons:

- High hop count = high throughput latency.
- Only works for non-redundant networks.
- High risk of failure (a single severed cable or unpowered device jeopardizes the whole network).
- Unnecessarily high network load.

5.2.2 Star topology



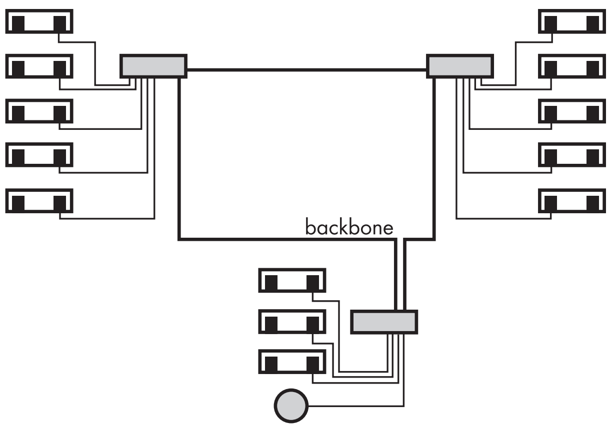
Pros:

- Deterministic hop count (minimized network latency).
- Dual redundant networks can easily be realized by simply doubling up the infrastructure.
- Easy to extend (if sufficient switch ports are available).
- Good resiliency against failures.

Cons:

- Potentially longer cable runs (depends on physical placement of devices).
- Requires advance planning.

5.2.3 Ring/mesh topology



Pros:

- Higher resiliency against cable failure.
- Dual redundant networks can easily be realized by simply doubling up the infrastructure.
- Easy to extend (if sufficient switch ports are available).

Cons:

- Requires correct configuration of RSTP in all backbone switches.
- Depending on the make and model of the backbone switches, an interruption of one backbone link may still produce a noticeable interruption of the network while traffic is rerouted.

D5317.EN. 01, 04/2016

d&b audiotechnik GmbH, Eugen-Adolff-Strasse 134, D-71522 Backnang, Germany, Phone +49-7191-9669-0, Fax +49-7191-95 00 00