AES PNW Section Meeting

Dante

Outline

- Dante is and Ethernet audio solution (IEEE 802.3)
  - What is Ethernet?
  - IP Address, Subnet Mask, how to get them…
  - Ethernet Networks, Protocols & OSI Layers
- Why is Dante special?
  - Audinate solutions for manufacturers & users
  - Deterministic, uncompressed, multichannel…
  - Master clocks, compatible sample rates…

Synchronizing Digital Signals (cont.)

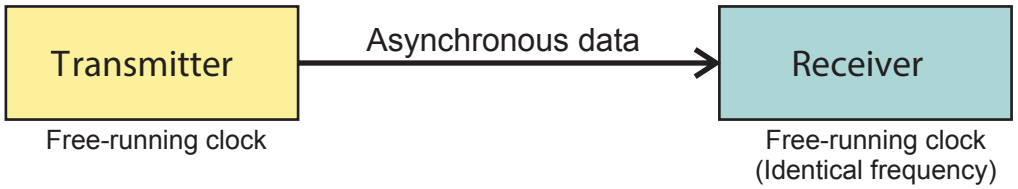
Asynchronous - A transmission process where the signal is transmitted without any fixed timing relationship between one word and the next.

Synchronous - A transmission process where the bit rate of the signal is fixed and synchronized to a master clock.

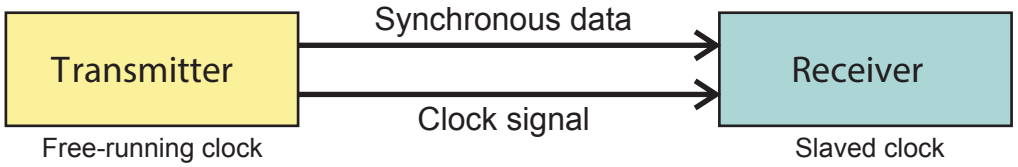
Isochronous ("iso" equal + "chronous" time) - A term meaning time sensitive; isochronous transmission is time sensitive transmission. For example, voice and video require isochronous transmission since audio/video synchronization is mandated.

from the Rane Pro Audio Reference

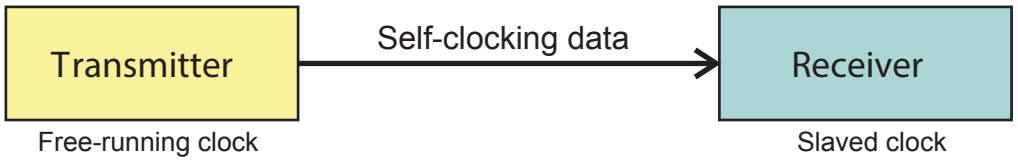
Asynchronous (eg. file transfers, email, control and monitoring)



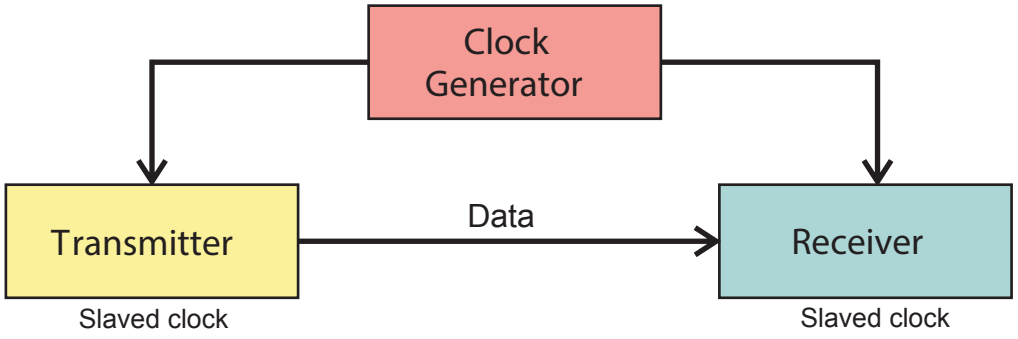
Synchronous (eg. MADI, AES3, S/PDIF, ADAT)



Synchronous (eg. AES3, S/PDIF)



Isochronous (eg. USB, Firewire, some AoE protocols)



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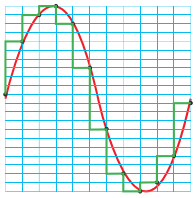
Packetizing Data

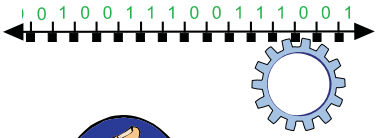
Ethernet is the
United Parcel Service
of Data Delivery

1. Standardized
2. Widely available
3. Strong infrastructure

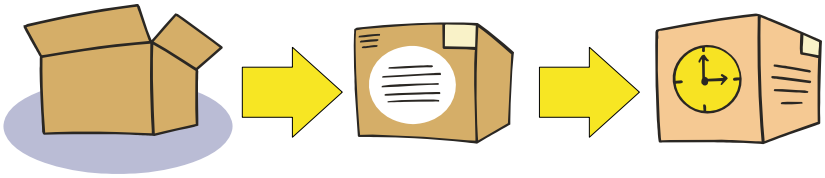


Conversion

"Hello!"



Go!



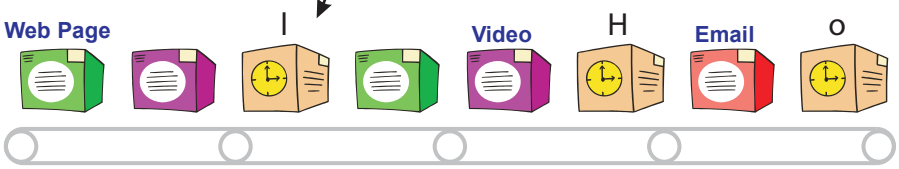
Packaging (packet or datagram)

Routing Info

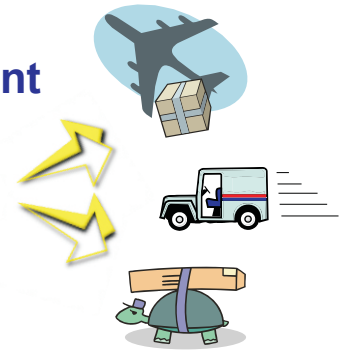
Prioritization

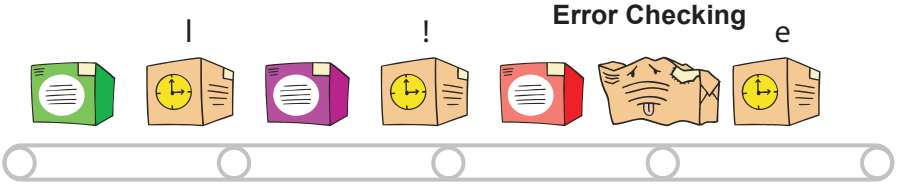
100Mb rate: 1 in 100
1Gb rate: 1 in 1000

Interspersion

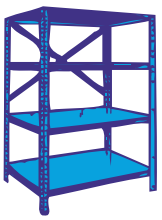


Shipment



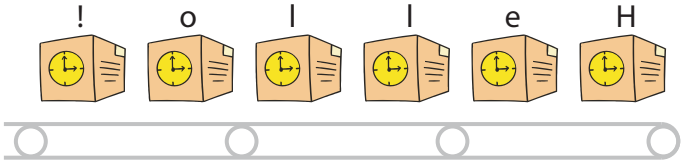


Buffer



Delivery

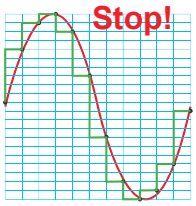
Sorting/Routing



Unpacking

Latency

Stop!



Conversion
"Hello!"

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Using Ethernet* as an Audio Transport

**CATx cables/connectors*

Bird's Eye View...

1. Audio data is packetized

   CobraNet, EtherSound, Dante, A-Net, etc.

2. It's no longer audio, it's data

   The touchy, feely audio stuff is gone!
   The issues are bit depth, sample rate, latency, routing and throughput.

3. The Ethernet world is standardized and rigid

   The rules don't bend as with analog audio.
   Audio people need to understand the rules.

4. It becomes audio again at the other end

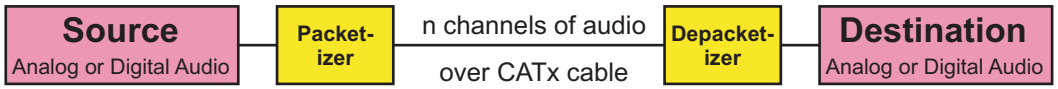
   Audio skills still required!

5. Implementation ranges from "plug-and-play" to complicated.

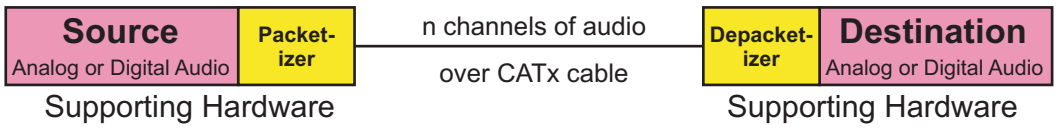
Plug-and-Play

- Simple implementation
- User is insulated from the network details
- Proprietary hardware (no Office Depot stuff!)
- e.g. Aviom A-Net

External



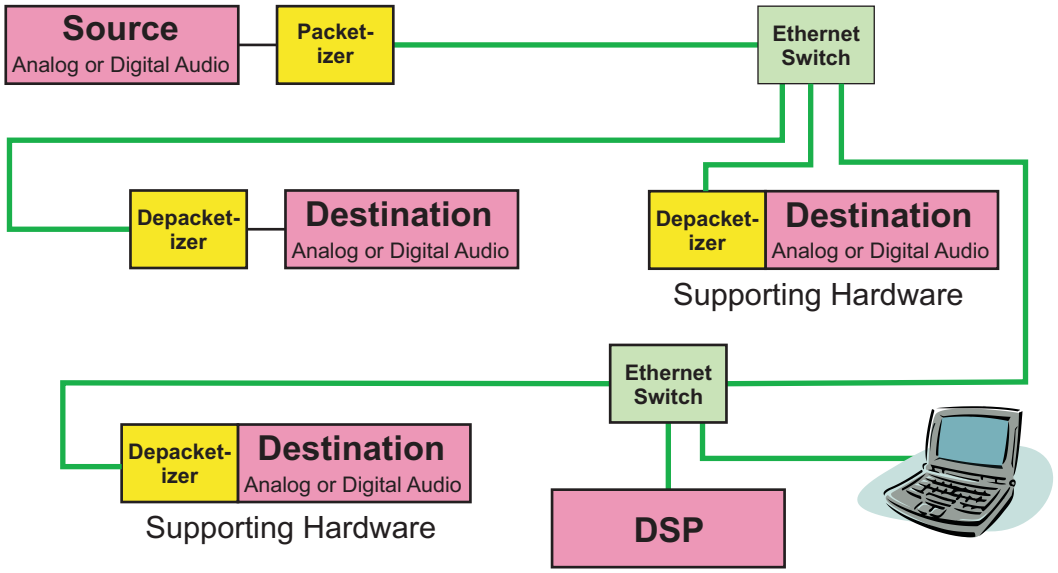
Internal



More Involved

- Potentially complicated implementation
- Greater need to understand Ethernet rules
- Can use any Ethernet-compliant hardware for distribution.
- Virtually unlimited expansion
- e.g. CobraNet, EtherSound

An Audio Network



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Who Are You (on the network)?

MAC Address (Layer 2)

Mandatory!

01:23:45:67:89:ab

arp -a at command prompt to see MAC addresses!

Media Access Control address

- or physical address
- unique identifier for Ethernet hardware
- typically assigned by manufacturer
- allows frames to be marked for specific hosts
- 48 bits in six groups of two HEX digits

IP Address (Layer 3)

- Each network has an Internet address.
- Each network must know the address of every other network that it communicates with.
- A unique network number is requested/provided by the Network Interface Card (NIC) and becomes part of the network's IP address
- A unique host address is added to the end of the IP address

1 Byte	1 Byte	1 Byte	1 Byte	
1st Octet	*2nd Octet*	*3rd Octet*	*4th Octet*	
11111111.	11111111.	11111111.	11111111	Binary
255	255	255	255	Decimal

The IP Address is unique for every host on the network

192.168.1.100

The Subnet Mask divides the IP address into Network ID and Host ID

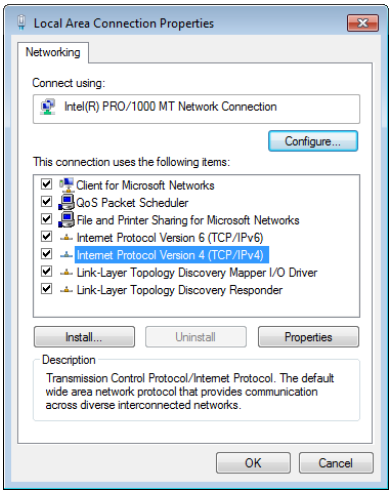
Network ID | Host/Node

255.255.255.0

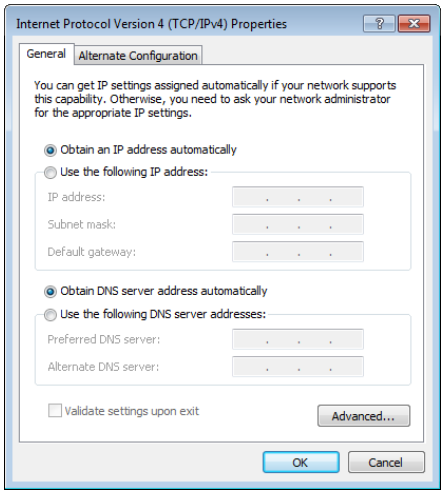
Identical | *Unique*

Obtaining an IP Address

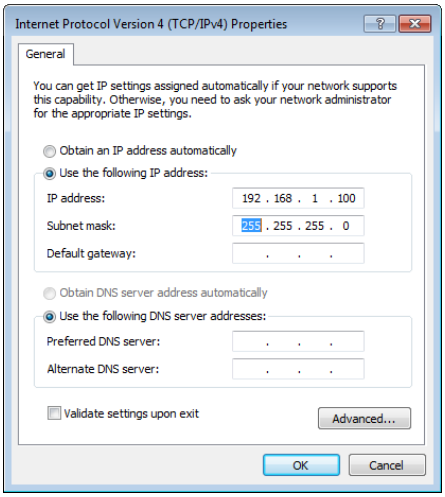
Open Network Connection Properties (Control Panel)



Method 1: DHCP (Dynamic)
A DHCP server issues the address

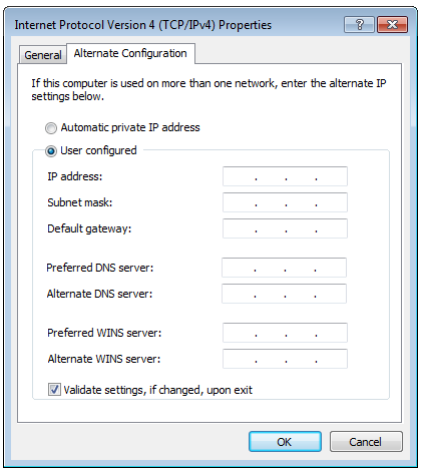


Method 2: Static (Manual)
A user specifies the address



Plug it in!...

If no DHCP Server is found:
- After 1-2 minutes a link local address is self-assigned (169.254.xxx.xxx)
- You can specify an alternate configuration under IP Properties



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What is Ethernet?

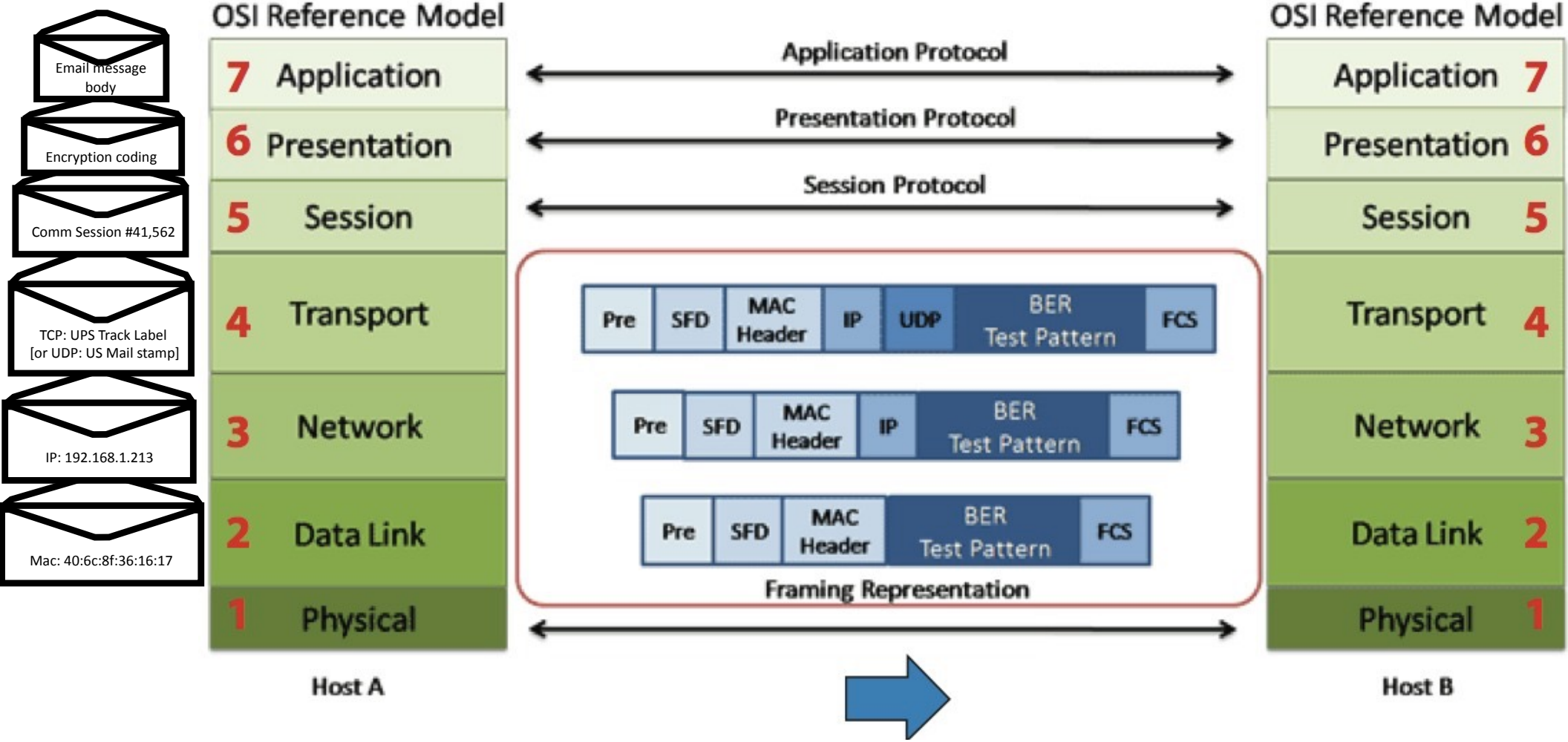
- **Ethernet is a combination of wired hardware devices and their set of protocols or rules**

What are OSI Layers?

- OSI - Open Systems Interconnection - conceptual model about communications. International Organization for Standardization (ISO)
- OSI Layers are a worldwide abstract framework used to explain how messages can be transferred between systems
- To help Ethernet developers obey the rules, and communicate between devices & developers, OSI Layers break the communications problems into pieces
- Each layer solves a subset of the communications rules
- Ethernet only applies to OSI Layers 1 & 2

OSI Reference Model

"We need a Layer 3 solution..."



Bugs Bunny Example

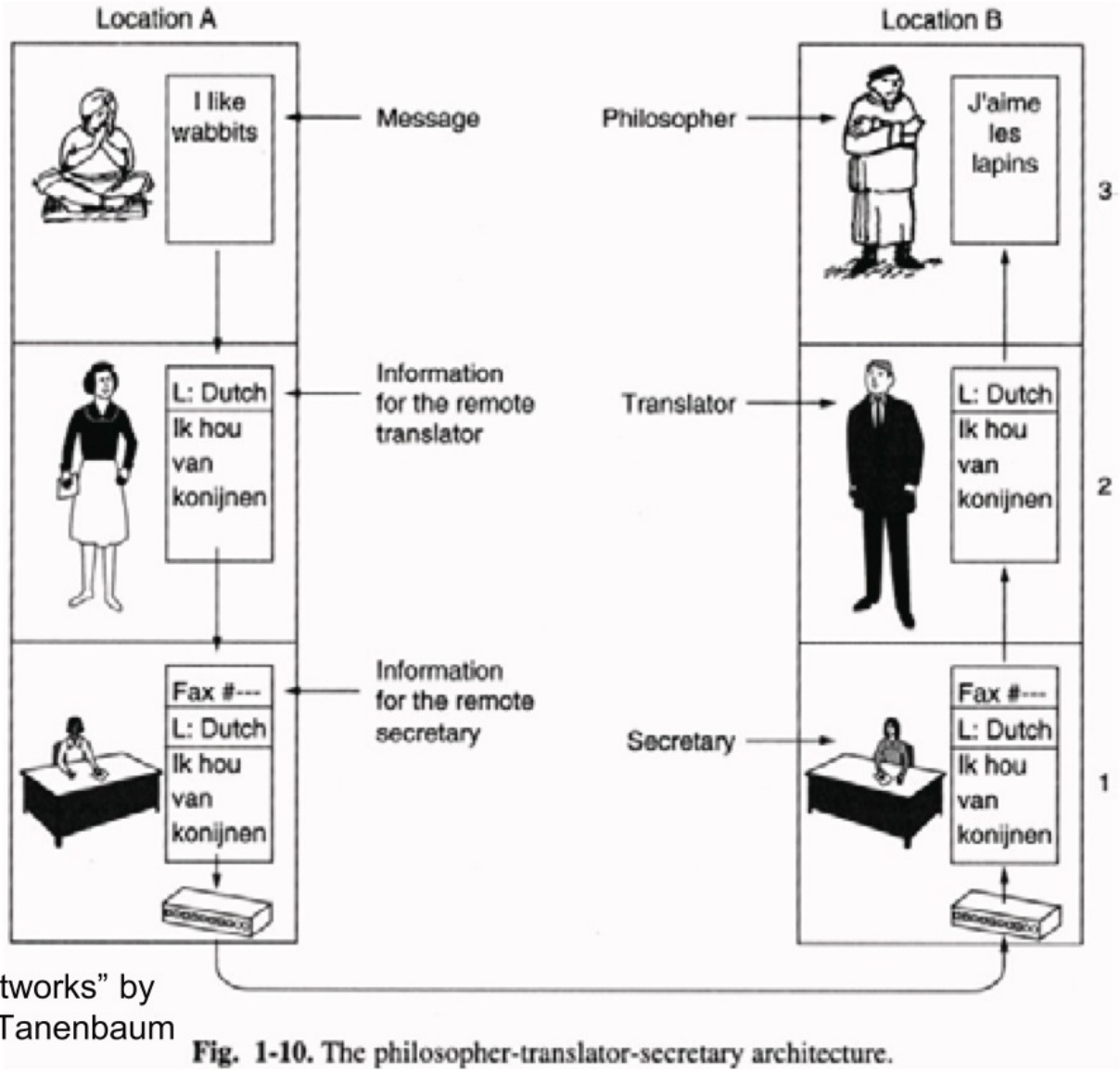


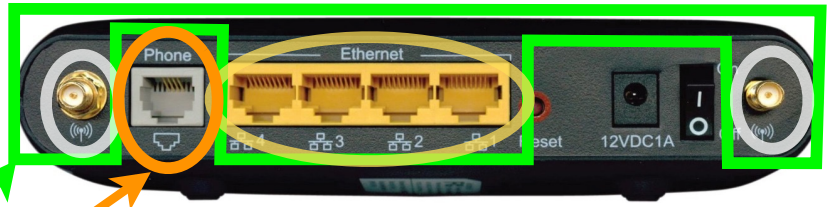
Fig. 1-10. The philosopher-translator-secretary architecture.

"Computer Networks" by Andrew S. Tanenbaum

Virtual OSI Layers

Physical Devices

Layer 4 TCP / UDP...



By default, Gold & White networks typically on the same network or subnet.

Layer 3 IP Address

Layer 3 Network Routers

Deliver data between different networks or subnets:
Orange (DSL) & Green (Ethernet)

Layer 3 - IP tools are what the IT professionals use & know

Layer 2 MAC Address

Layer 2 Ethernet Switches

Deliver data between MAC Addresses

Layer 1 Physical: cable, fiber, WiFi...

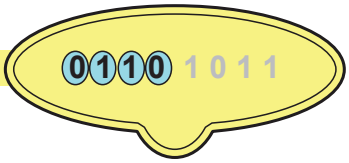
Ethernet Transport

Subnet Masks: Organizing the Network Neighborhood

Subnet mask. These words are not even a sentence yet they still strike fear in all but hardened network nerds. Subnet masks affect us audio folk when we dive into the IP address properties of computers to configure networks or debug Ethernet communications. While network problems are usually related to firewalls, antivirus, network device settings, service providers, and/or Microsoft's security "features," they can occasionally be caused by inappropriate subnet mask values. Thinking digitally about subnet masks can overcome this obstacle.

Subnet masks help nerds and network devices figure out which part of a device's IP address is the network part (or *street*) and which part is the host (or *house*) in the network neighborhood. Why distinguish between the network and the host? For the same reason you need to put the street and the house number on a letter. Packages need both the house and street to be delivered properly. For network packets to be delivered, devices need to be on the same network (street) and have a unique house number .

Value (in binary)	**0110 1011**
Mask	**1111 0000**
New value (when masked)	**0110 0000**



The word *subnet* is used since subnetworks of an *entire* network are really what we typically encounter. But what's a mask? Just as a party mask hides some of your face while exposing your eyes, a mask in IP and subnet contexts masks-off (blocks or hides) some bits of an IP address and allows other bits to be seen or used. Thinking digitally about a subnet mask's bits is aided by viewing them digitally, in binary, as if through a mask like the one shown. Ones in the mask are like "holes" that expose the network ID bits (street). Zeros in the mask hide the IP bits not used for the network ID, thus revealing the host ID (house). Said another way, the new value can see only the original values's bits that have not been blocked by 0's in the mask.

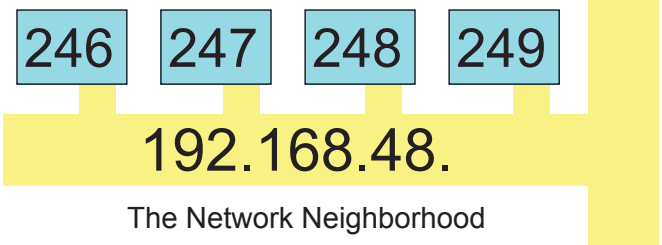
IP Address	192	168	48	247
Subnet Mask (binary)	1111 1111	1111 1111	1111 1111	0000 0000
Subnet Mask (dotted decimal)	255.	255.	255.	0

192.168.48.247

Network ID | Host ID

Where a subnet mask's binary bit is 1, the corresponding bit in the IP address is part of the network ID or street. Where the subnet mask value is 0, the corresponding IP address bits are the host ID or house. To make things easier for us non-nerds, subnet mask values are typically kept on clean boundaries of 8-bit octets. In the 255.255.255.0 example above, we're using the first 24 bits (3, 8-bit octets) for the network ("192.168.48" street) and the last 8 bits for the host (house, "247"). But any number of the 32 bits in a subnet mask can be used to make the distinction. Thus, where the subnet mask is 255.255.255.0 (1's in the first 24 bit positions), each device must have a *matching* network ID (e.g., 192.168.48) and each device requires a different and *unique* host ID (247 for one device, 248 for the next, etc).

Network administrators use subnet masks to help manage the number of devices they support on their network or street. Small companies need small streets for their small number of houses. Big companies need different size streets for their many houses. There's a difference in the installation, management, security and administration costs between different approaches: one street with lots of houses or lots of streets with few houses and many implementations in-between are all viable. But we'll leave the details to the network nerds. *sm*



The Network Neighborhood

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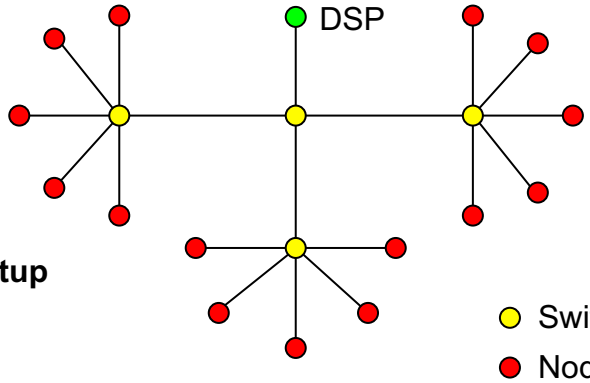
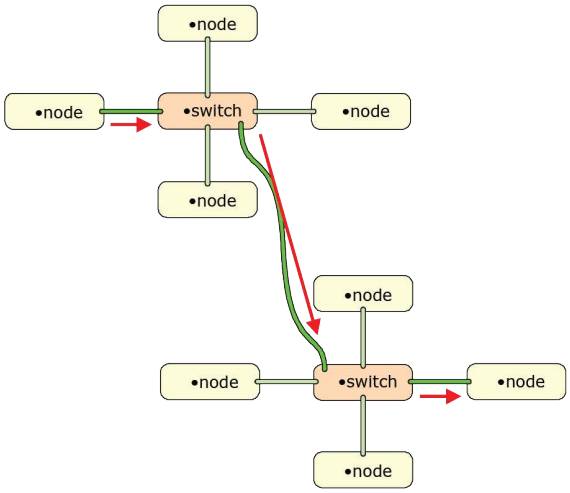
Ethernet Hardware

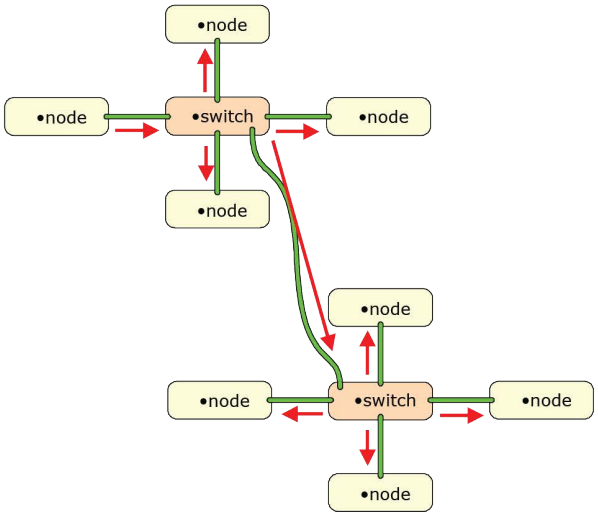


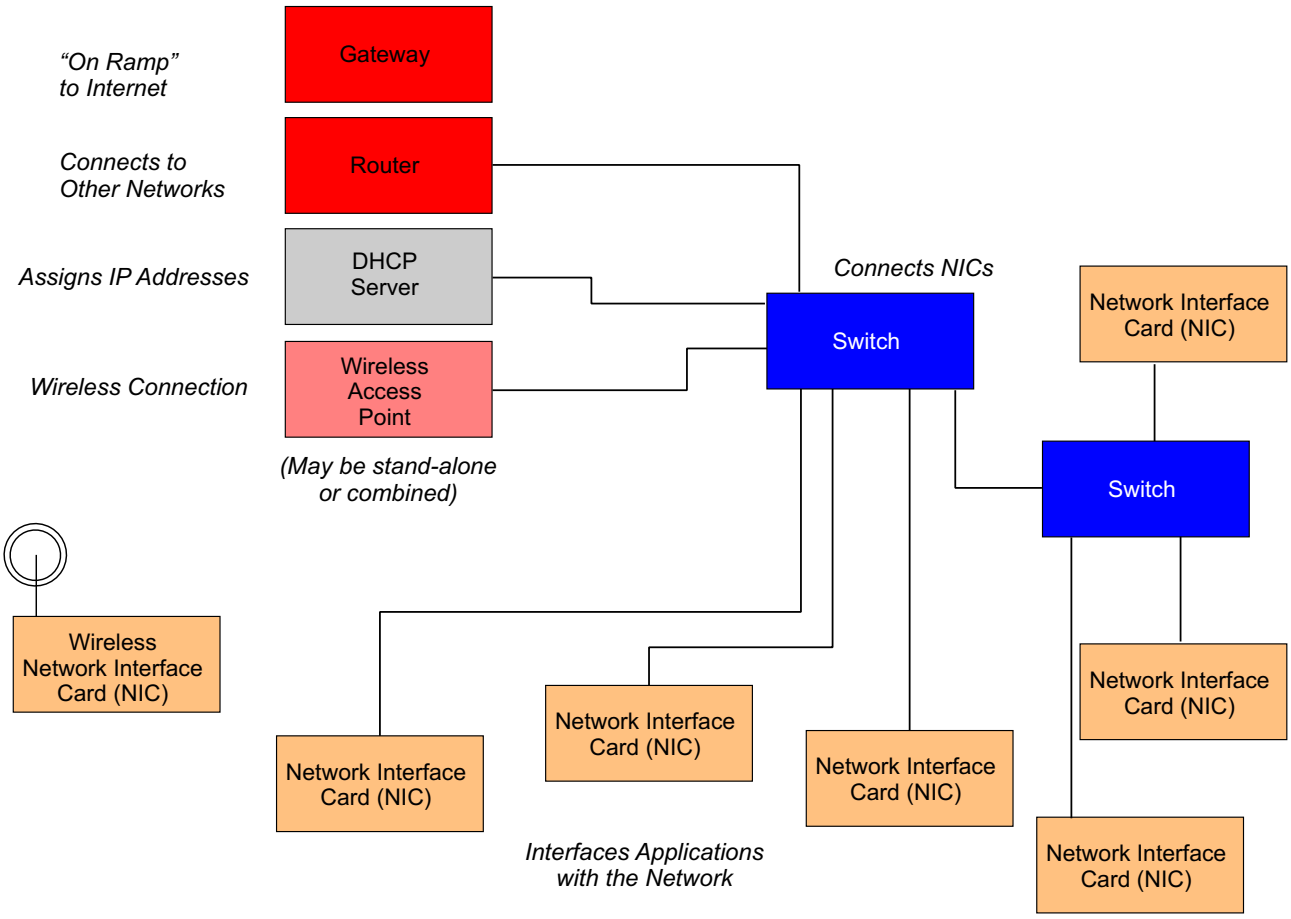
Classroom Setup

Unicast or Point-to-Point Packets



Multicast or Broadcast Packets





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Network Switches

Unmanaged - a glorified hub. Switch “does its own thing” without user intervention.

Pros:
Cheap
Ubiquitous
Adequate for simple networks

Cons:
No customization possible

Managed - a “smart, configurable” switch.

- Has own IP Address
- Setup by Telnet and/or Web interface
- VLANs possible (breaks ports out into virtual, indepdendent switches)
- Can monitor usage and provide statistics
- Can require admin interaction before connecting

Legacy Switches vs. Current Models...

An Ethernet **crossover cable** is a type of Ethernet cable used to connect computing devices together directly where they would normally be connected via a network switch, hub or router, such as directly connecting two personal computers via their network adapters.

Auto-MDIX (automatic medium-dependent interface crossover) is a computer networking technology that automatically detects the required cable connection type (straight-through or crossover) and configures the connection appropriately, thereby removing the need for crossover cables to interconnect switches or connecting PCs peer-to-peer.

Most new switches (and all gigabit switches) are Auto-MDIX!

Ethernet hub (aka repeater) - an obsolete multiport device that sends incoming packets out all other ports. It simply repeats all packets out all ports (except the port the packet rode in on). Such devices are no longer produced and hard to find.

Ethernet switch- a multiport device that keeps a record of packet traffic using a constantly-updated address table. The table lists which port has "seen" which source and destination MAC Address enter. This allows it, just like the US Postal Service, to log current and past source and destination addresses (To: and From: addresses) and only delivers packets to the port required to successfully deliver all packets. It does this blindingly fast - much faster than FedEx overnight and UPS Red.

Managed Ethernet switches provide advanced programming, protocol management, filtering and flexible configuration setups (e.g., VLANs) to manage data flow and security.

Ethernet bridge - Often interchangeable with the term Ethernet switch.

Ethernet router - a multiport device intended to connect two different network types or mediums together. Examples include "routing" between an Ethernet and a **DSL network**; or an Ethernet and a cable modem network; or a wired Ethernet and a wireless Ethernet network. Also, an Ethernet device intended to "route" between two layer (or "subnets") of the same physical Ethernet network. Routers can be used to filter or forward traffic to manage data flow and bandwidth.

Ethernet gateway - a device designated to be the doorway (IP Address) to the Internet.

Ethernet WAP (wireless access point) - a router between wired Ethernet and wireless Ethernet.

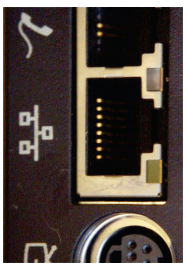
Power over Ethernet or **PoE** technology describes a system to safely transfer electrical power, along with data, to remote devices over standard category cable in an Ethernet network.

- Similar in concept to phantom power in audio systems
- Some switches can provide PoE (Endspan)
- Can be added externally (Midspan)
- 48VDC, up to 25W power (hardware-dependent)
- 100 W on the horizon

802.3af Standards A and B from the power sourcing equipment perspective

Pins at switch	T568A color	T568B color	10/100 mode B, DC on spares		10/100 mode A, mixed DC & data		1000 (1 gigabit) mode B, DC & bi-data		1000 (1 gigabit) mode A, DC & bi-data	
Pin 1	White/green stripe	White/orange stripe	Rx +		Rx +	DC +	TxRx A +		TxRx A +	DC +
Pin 2	Green solid	Orange solid	Rx –		Rx –	DC +	TxRx A –		TxRx A –	DC +
Pin 3	White/orange stripe	White/green stripe	Tx +		Tx +	DC –	TxRx B +		TxRx B +	DC –
Pin 4	Blue solid	Blue solid		DC +	Unused		TxRx C +	DC +	TxRx C +	
Pin 5	White/blue stripe	White/blue stripe		DC +	Unused		TxRx C –	DC +	TxRx C –	
Pin 6	Orange solid	Green solid	Tx –		Tx –	DC –	TxRx B –		TxRx B –	DC –
Pin 7	White/brown stripe	White/brown stripe		DC –	Unused		TxRx D +	DC –	TxRx D +	
Pin 8	Brown solid	Brown solid		DC –	Unused		TxRx D –	DC –	TxRx D –	

Troubleshooting Networks - Check this stuff first!



Physical Verification - Link light turns on when both ends plugged in and powered.

Data Verification - LAN light blinks when IP packets detected.

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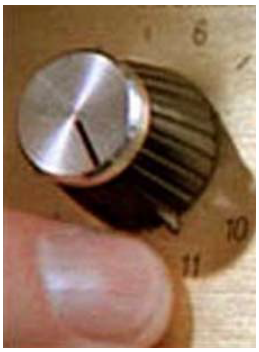
Audinate Dante™

Device discovery *User editable names* *One-click routing*



Dante Top "11" Basics:

1. >150 manufacturers licensed
2. Dante Controller software for (almost) all system config and troubleshooting
3. Dante Virtual Soundcard (DVS) integrates PC audio I/O. DVS is up to 64 x 64 channels.
4. Based on IT standards, not just Ethernet
5. Deployable on existing networks
6. Large number of available products
7. Centralized interface design and development (Audinate)
8. Dante devices are configured using simple names.
9. Dante devices auto-discover.
10. Doesn't require proprietary switches.
11. Allows both audio and control via one port.

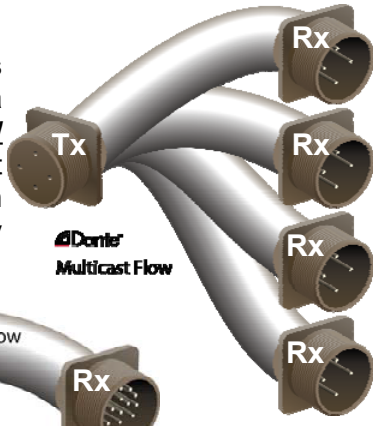
Subscriptions in Dante Controller:

- Dante transmit devices advertise audio channels on the network
- A receiver can subscribe to a transmit channel:
  - A Flow is from one Dante transmitter to one or more Dante receivers
  - Check grid cross points to subscribe & establish a Flow/subscription
  - Max number of Flows & audio channels supported varies per Dante device
  - More audio channels are added to Flows when needed
  - A system reboot reallocates Flows to improve network bandwidth, or adjust manually

4 audio Channels

Unicast Flow

Create multicast Flows manually - but data goes *everywhere!* Manage multicast network bandwidth using IGMP in every switch.



Flow audio channels adjusted automatically by Dante Controller, or manually by user

Dante Controller Subscription status indicators:

- Subscription in process
- Connection fully established & functional
- Warning – subscription unresolved. Is the transmitter powered off or unplugged?
- Error – requested bandwidth unavailable or sample rates not matched
- Pending – still setting up subscription. Typically when subscribing many channels

Dante Controller, under the hood:

- Uses UDP Ports 8700 thru 8705 & 8800
- Discovery basics: DHCP, static or Link Local

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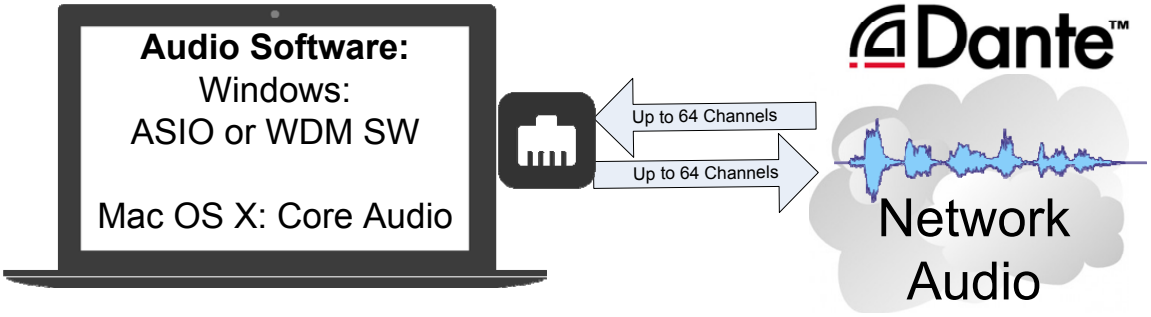
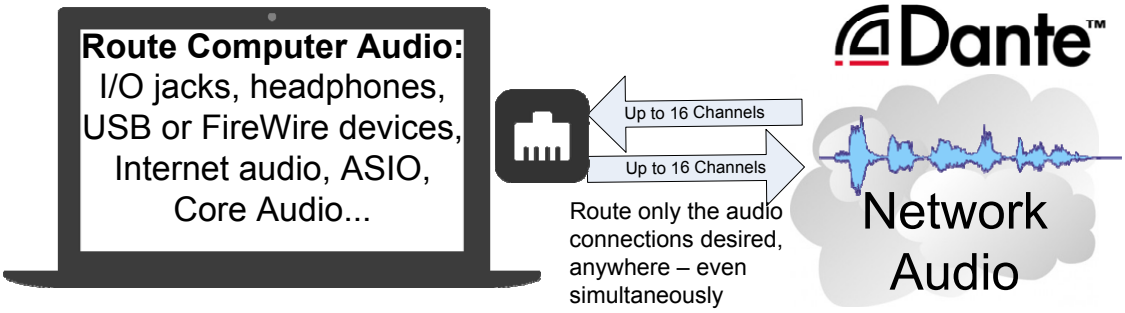
Dante Virtual Soundcard (DVS)

Audinate software - turns your computer's Ethernet port into a Dante network device.



Dante Via™

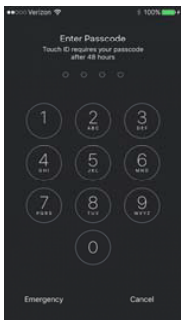
Dante DVS & Via cannot run on the same computer *at the same time*



Dante™ Device Lock/Unlock

Enter a 4 digit PIN (Personal Identification Number) to lock Dante devices. The device's subscriptions & settings become read-only.

The manufacturer must offer Dante firmware v 3.10 or higher to support Device Lock.
Works with the latest both DVS & Via versions.



Resetting the PIN

Isolate the locked device and the Dante Controller PC as the only two devices on a network. Repower the Dante device. Wait 2 minutes. Click Reset PIN in Dante Controller.

= Lock not supported in this device

Caution: earlier versions of Dante Controller do not support Device Lock, therefore changing Locked device settings fails without warning in earlier versions.

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Basically, what you need to know is that Dante is all IP-based, and makes use of common IT standards. Each Dante device behaves much like any other network device you would already find on your network.

In order to make integration into an existing network easy, here are some of the things that Dante does:

- Dante uses DHCP for addressing when available, and will auto-assign an IP address if it is not, exactly like a PC or Mac.
  - Dante devices will continue to 'look' for DHCP even after auto-assigning an IP address.
  - Some (but not all) Dante devices allow the setting of static IP addresses.
- Dante implements IGMPv3/v2 to assist with multicast management.
  - Support for IGMP is not required in a network; it is in Dante to make integration into mixed-use networks simpler.
- Dante can make use of DiffServ QoS in the network. Dante will tag packets, and its tags can be integrated into an existing IT network QoS scheme:

Priority	Usage	DSCP Label	Hex	Decimal	Binary
High	Time critical PTP events	CS7	0x38	56	111000
Medium	Audio, PTP	EF	0x2E	46	101110
Low	(reserved)	CS1	0x08	8	001000
None	Other traffic	BestEffort	0x00	0	000000

  - QoS is only required for 100Mbps or mixed 1Gbps/100Mbps networks. It can be helpful on mixed-use networks. It is not required for dedicated, all gigabit, Dante-only networks. When used, it must be configured with strict priority.
  - Note that the QoS could be re-marked, provided that the PTP packets still receive high priority.

So that you know what to expect, here is the kind of network traffic you will be seeing on your network with Dante devices:

- Dante uses UDP for audio distribution, both unicast and multicast.
  - Bandwidth usage is about 6 Mbps per *typical* unicast audio flow (containing 4 channels and 16 audio samples per channel). Flows are pre-allocated a capacity of 4 channels. The samples-per-channel can vary between 4 and 64, depending on the latency setting of the device. For multicast flows, channels-per-flow can be varied from 1 to 8 channels per flow.
  - Multicast audio is always on UDP port 4321. Unicast audio ports come from a range: 14336 - 14600.
  - Audio traffic should not take up more than 70% of the bandwidth of any network link.
- mDNS and DNS-SD for discovery and enumeration of other Dante devices (including Dante Controller and Dante Virtual Soundcard).
  - This traffic is on 224.0.0.251:5353.
- Precision Time Protocol (PTP) for time synchronization.
  - This is generally a few small packets, a few times per second. This traffic is on 224.0.1.129 - 224.0.1.132 ports 319/320.
- Dante-specific monitoring traffic on multicast addresses 224.0.0.230 - 224.0.0.232:8700-8706.

Can I use EEE (Energy Efficient Ethernet or 'Green Ethernet') in my Dante network?

Short answer: No.

EEE (Energy Efficient Ethernet) is a technology that reduces switch power consumption during periods of low network traffic. It is also sometimes known as Green Ethernet and IEEE802.3az. Although power management should be negotiated automatically in switches that support EEE, it is a relatively new technology, and some switches do not perform the negotiation properly. This may cause EEE to be enabled in Dante networks when it is not appropriate, resulting in poor synchronization performance and occasional dropouts.

Therefore, we strongly recommend that:

1. If you use managed switches, ensure that they allow EEE to be disabled. Make sure that EEE is disabled on all ports used for real-time Dante traffic.
2. If you use unmanaged switches, do not use Ethernet switches that support the EEE function, because you cannot disable EEE operation in these switches.

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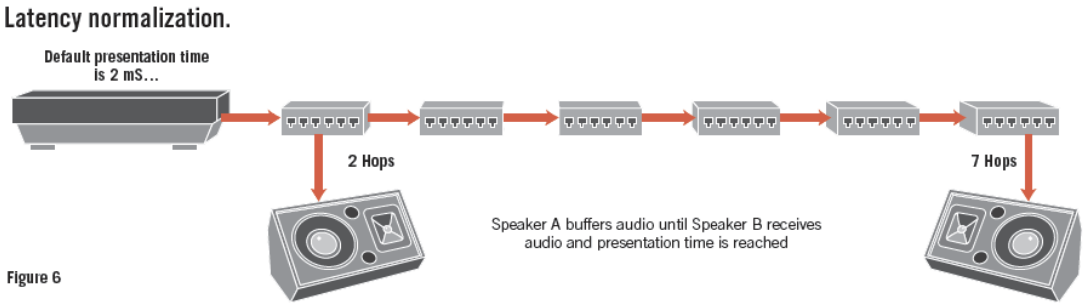
Ethernet AVB *aka Time Sensitive Networking (TSN)*

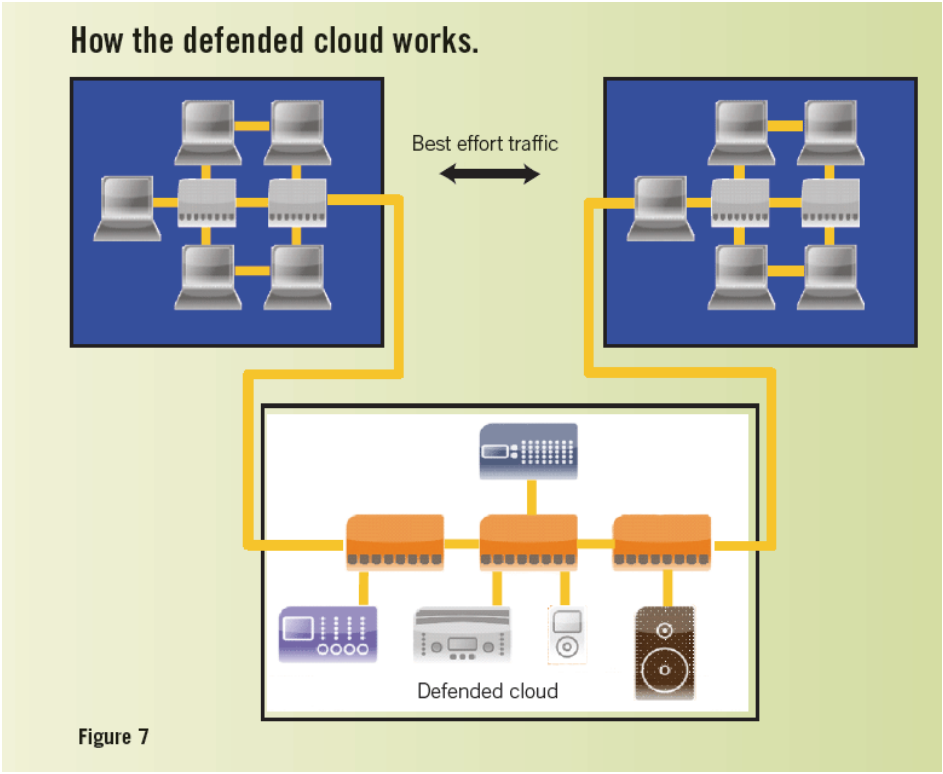
Protocols used in AVB to evolve Ethernet to be much more AV friendly:

IEEE 802.1AS: Timing and Synchronization for Time-Sensitive Applications (gPTP),
IEEE 802.1Qat: Stream Reservation Protocol (SRP),
IEEE 802.1Qav: Forwarding and Queuing for Time-Sensitive Streams (FQTSS), and
IEEE 802.1BA: Audio Video Bridging Systems

IEEE 1722 - Layer 2 Transport Protocol for Time Sensitive Applications in a Bridged Local Area Network.
1722 is also being developed to tackle Discovery, Enumeration, Connection management and Control (DECC)
IEEE 1733 - Layer 3 Transport Protocol for Time Sensitive Applications in Local Area Networks



Example AVB solution: 7 switch hops, less than 2 ms latency auto alignment.Multiple, independently aligned audio streams are supported.



The Defended cloud (white area) establishes time synchronized, low latency audio streams and can reserve up to 75% of the link BW (75 Mb on 100Base-T). The remaining bandwidth for PC traffic (blue) is “best effort.”

graphics from embedded.com

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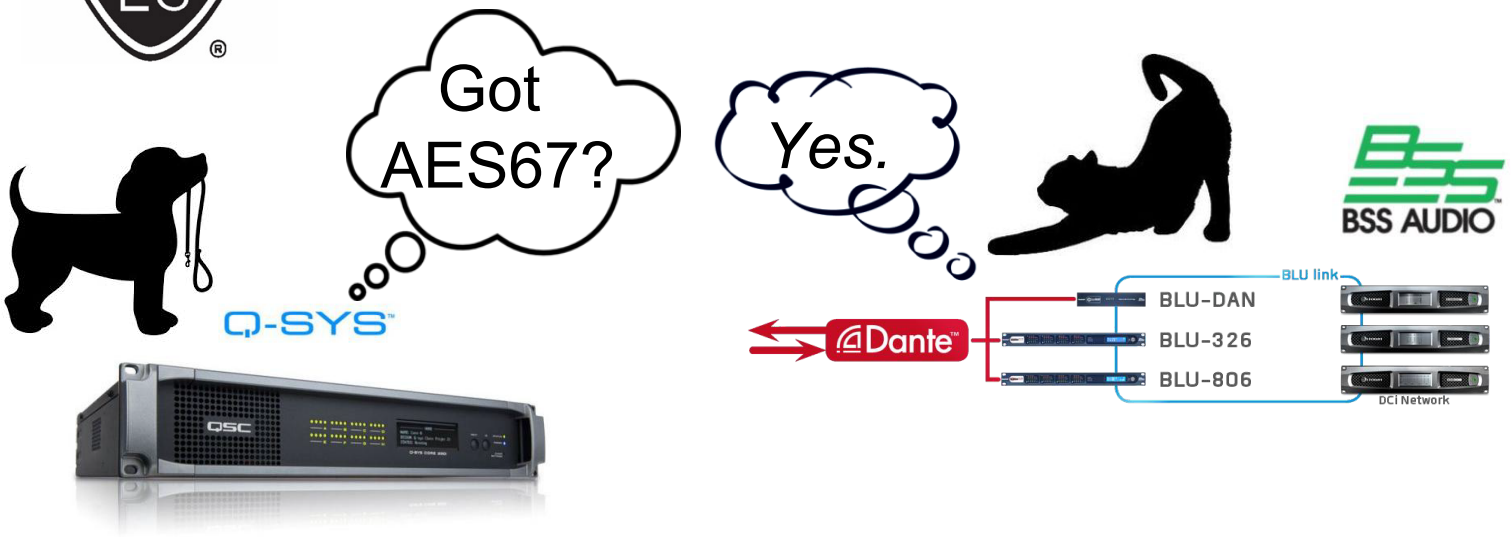
AES67

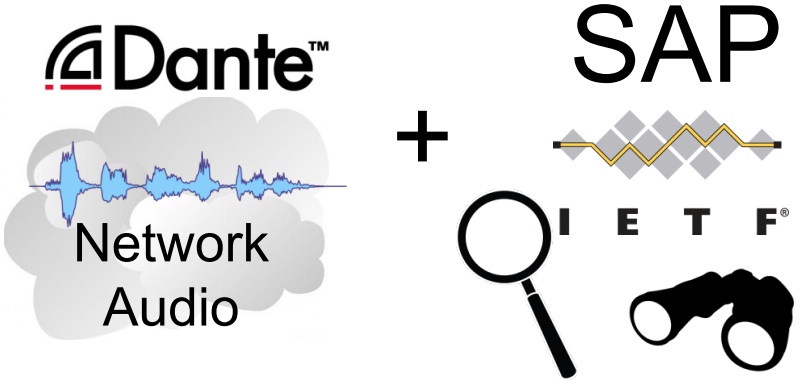
An Audio Engineering Society standard for audio-over-IP interoperability of, for example: Dante with QSC's Q-LAN, or broadcasting's Livewire with RAVENNA, or all of these.



Ghostbusters - Courtesy Columbia Pictures

...However

AES67 covers only audio packet exchanges (not discovering devices, for example). Four *options* are listed in the AES67 appendix for Discovery. One is, the Internet Engineering Task Force's (IETF) SAP (Session Announcement Protocol) method (RFC2974) which Dante uses.



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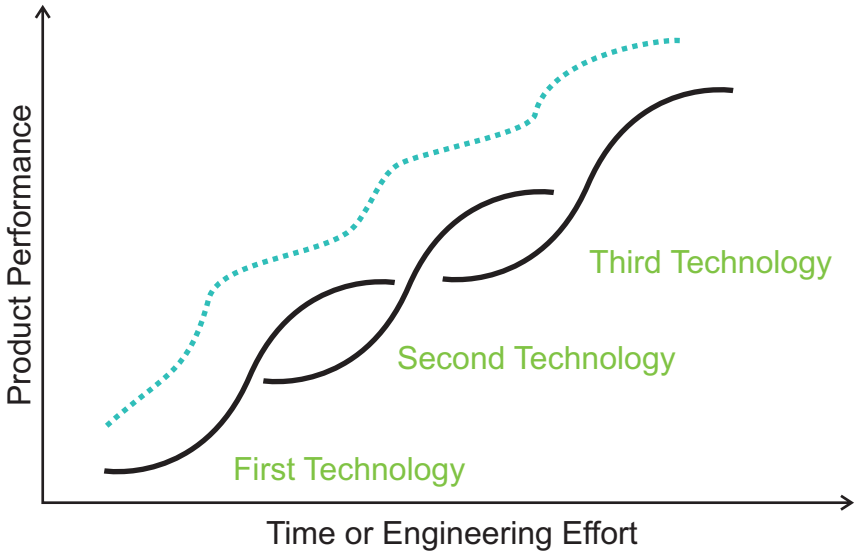
Why Digital Audio?

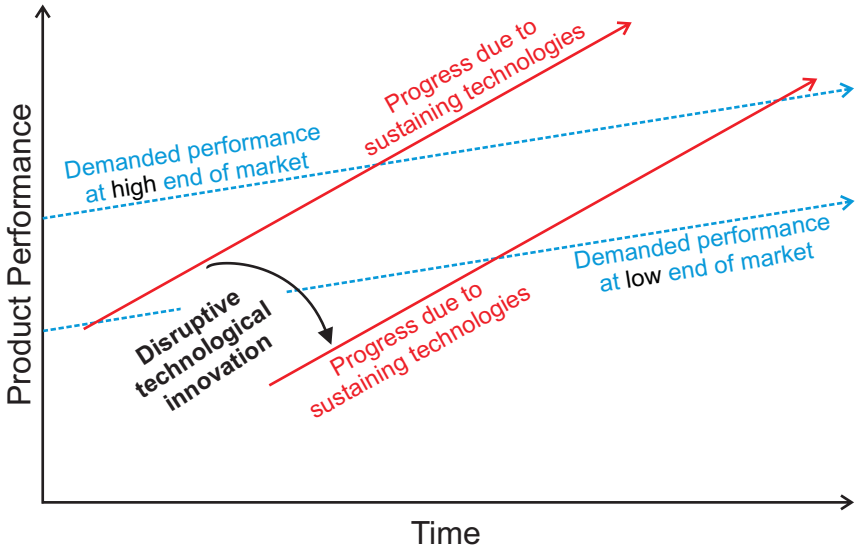


What is Analog Audio?

- Analog audio and acoustics are continuous mathematics disciplines, both in time and amplitude

- Audio typically presented as voltage, frequency, current, charge, mechanical grooves

- Human auditory senses are (apparently) analog



What is Digital Audio?

- Represents audio information in numerical form

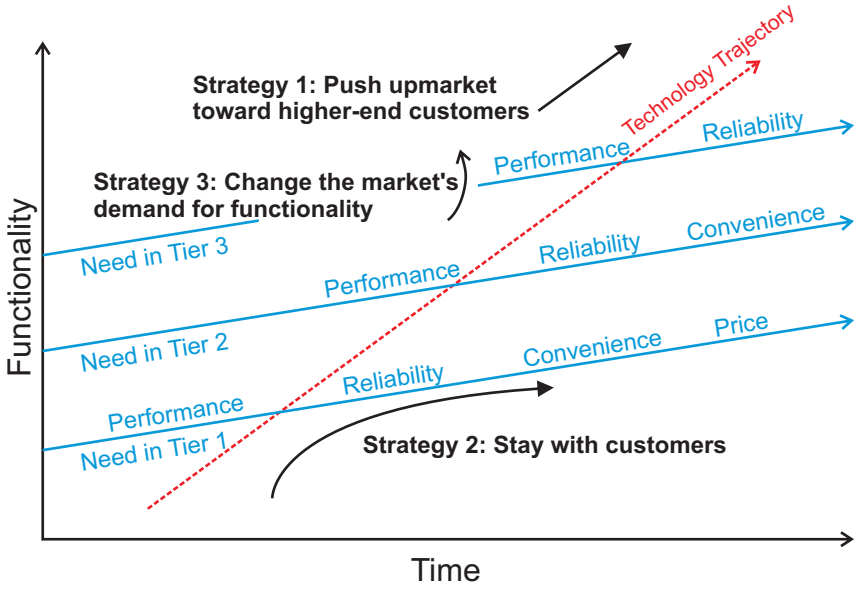
- Many schemes exist to encode audio into numbers

- Everything digital uses **discrete** math

Why Digital Audio?

- Efficient information management (code, process, store, transform, distribute, transport, duplicate, etc.)

- Implementations: less expensive, less power, less variation, increased reliability, noise immunity



Audio Expertise Still Needed

- Computer, construction and network folks may not want to become audio folks

- Audio folks may not want to become computer, construction or network folks

- Digital technology does not eliminate the need for audio/acoustic skills!

Technology Shift from Christensen's "The Innovator's Dilemma"

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