Networking Fundamentals for Audio Professionals

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Audinate

Topics we are going to cover today… (and when and why you should care)

- Bandwidth
- Standards
  - QoS
  - DHCP & Zeroconf
  - DNS
  - Multi-Cast vs. Unicast
  - IGMP Snooping
- Switch Selection
- Talking to the IT Department

COMMON STANDARDS

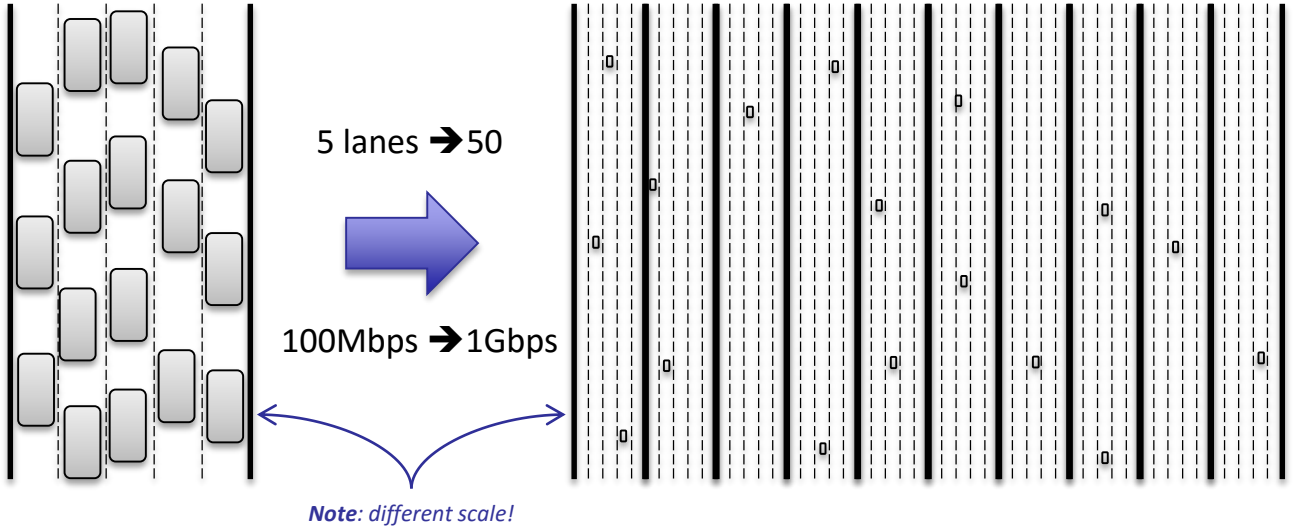
- QoS – Quality of Service
- DHCP – Dynamic Host Configuration Protocol
- Zero Configuration Networking (Zeroconf)
- DNS – Domain Name Service
- mDNS – Multicast DNS
- IP Multicast
  - IGMP

BANDWIDTH

- Networks & Traffic Analogies
- Networks are similar to roads with cars
  - Cars -> packets
  - Lanes -> bandwidth
- Busy networks -> traffic congestion
  - QoS can help..
  - But more bandwidth is very effective!

BANDWIDTH

- What does 100Mbps -> 1Gbps look like?
  - Cars on a 5 lane freeway -> 50 lane(!) freeway

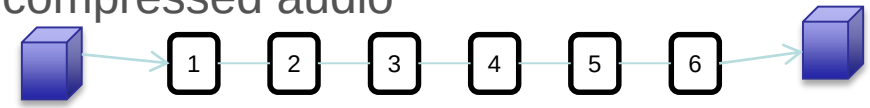


BANDWIDTH

- Bandwidth matters – more than you think!
- Everything gets better with increased bandwidth
  - Latency goes down
  - Number of channels goes up
  - Systems can scale larger
  - Quality can be improved
    - Uncompressed audio/video
    - Higher sample rates
- Historically, new applications are enabled by increasing bandwidth (e.g. 10Gbps & video)

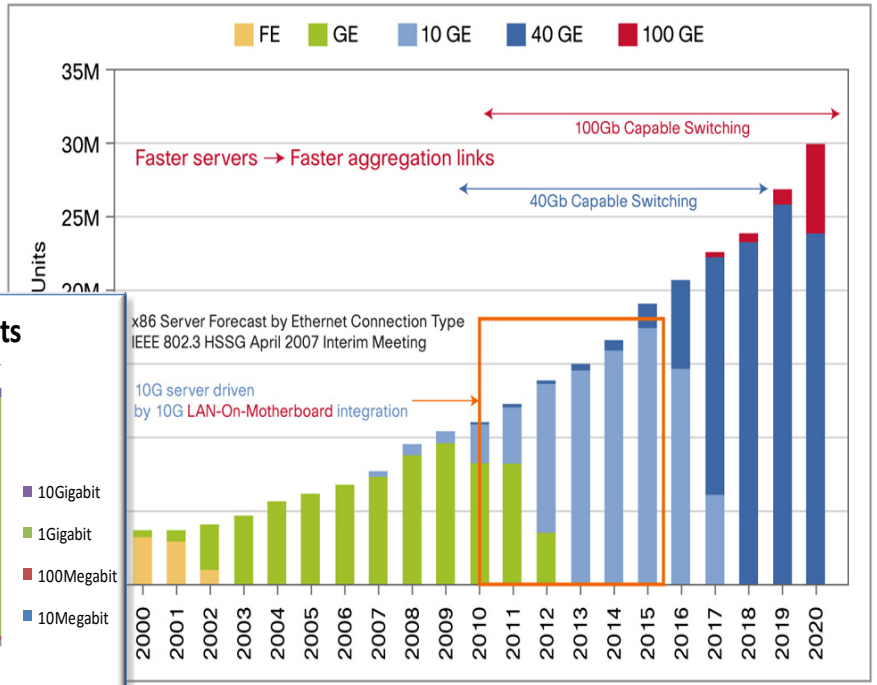
BANDWIDTH

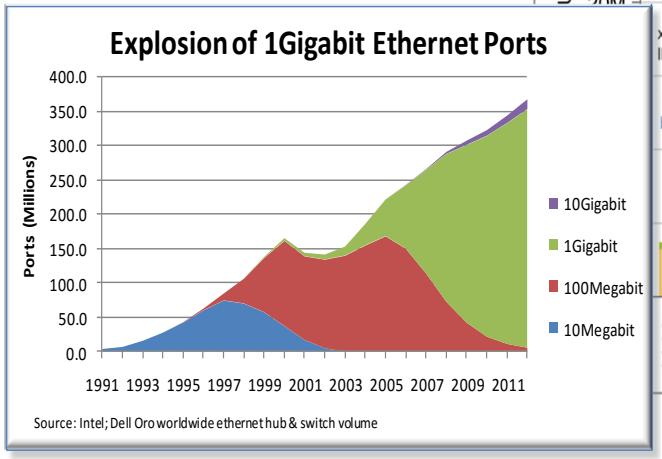
- Example calculations
  - 24bit 48kHz uncompressed audio
- Latency
  - 16 samples/channel, 8 ch/stream, 70% utilization
  - 7 network hops (6 switches)
  - 1.5ms latency (100Mbps) -> 500µs (1Gbps)
- Channel capacity
  - 16 samples/channel, 8 ch/stream, 66% utilization
  - 48 channels (100Mbps) -> 480 channels (1Gbps)



BANDWIDTH

- Adoption curves
  - 100Mbps
  - 1Gbps
  - 10Gbps
  - 40Gbps, 100Gbps, …
- Same shape

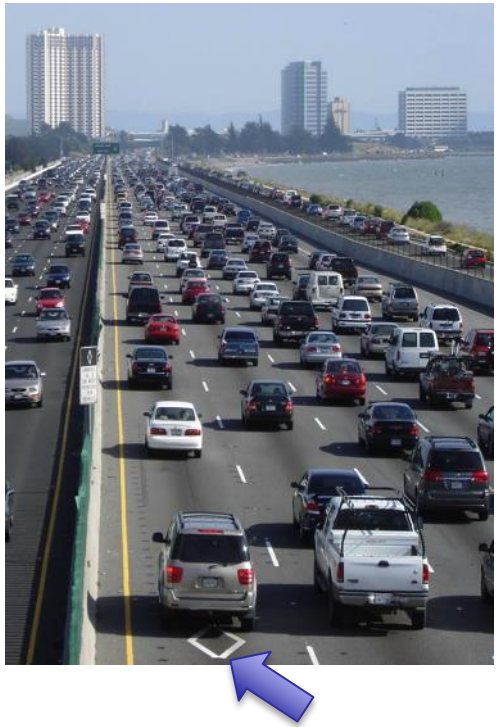




QOS

QUALITY OF SERVICE

- Remember the traffic analogy
  - Cars are like packets
- Intuitively, chose some cars on the road and give them better service
  - E.g. priority lane
- Things to note
  - Other cars get worse service
  - You cannot give all cars best service…



QOS

- What you do when you can’t add bandwidth..
- Two broad approaches
  - Prioritize certain classes of packets
    - Tag packets with a priority
    - Switches forward high priority first
  - Reserve network capacity
    - Devices signal requirements
    - Switches reserve resources
      - e.g. bandwidth/buffers

QOS
PRIORITIZATION

- Prioritization creates traffic classes
  - E.g. business class, economy class, different lines at the airport
- Use prioritization when some packets need preference over other packets
  - E.g. Clock sync traffic vs audio traffic
  - Improve performance when network is busy (e.g. >50% utilization)
- This is how DiffServ works
  - Differentiated Services Code Point (DSCP)
- Not useful if all your traffic is high priority…

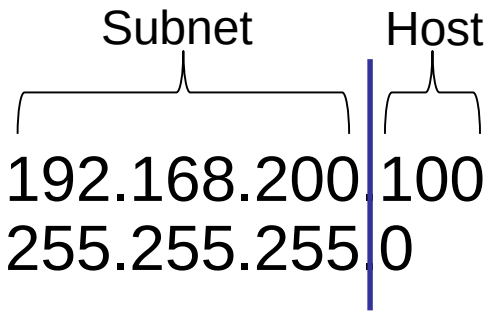
QOS
RESERVATION

- Reservation allocates resources in the network
  - Devices signal resource requirements
  - Switches reserve resources
    - Memory buffer space
    - Bandwidth on egress ports
- Works great in the phone system: busy signal, calls dropped

- Arguably not so useful for AV systems…
  - Resources must be provided for all conceivable use cases
    - Not doing so is a system design flaw
    - Adding bandwidth is cheap, esp. in the core
  - Therefore, reservations always succeed… Why have them?

IP ADDRESSING

- IP addresses have 2 parts, defined by netmask
  - Network Prefix and Host Address
  - e.g. 192.168.200.100, Netmask 255.255.255.0
    - Network Prefix: 192.168.00.0
    - Host Portion: 0.0.0.100



IP ADDRESSING

- Addresses can be set static (manual) or dynamic
  - Static schemes require someone to design, manage, configure, and maintain
    - Error prone, time consuming

IP ADDRESSING

- DHCP (Dynamic Host Configuration Protocol)
  - Most devices will use DHCP if it is present on the network

- Often DHCP servers will also allow you to create a “reservation” for a particular address
  - Much better than manual configuration!

DHCP & ZEROCONF

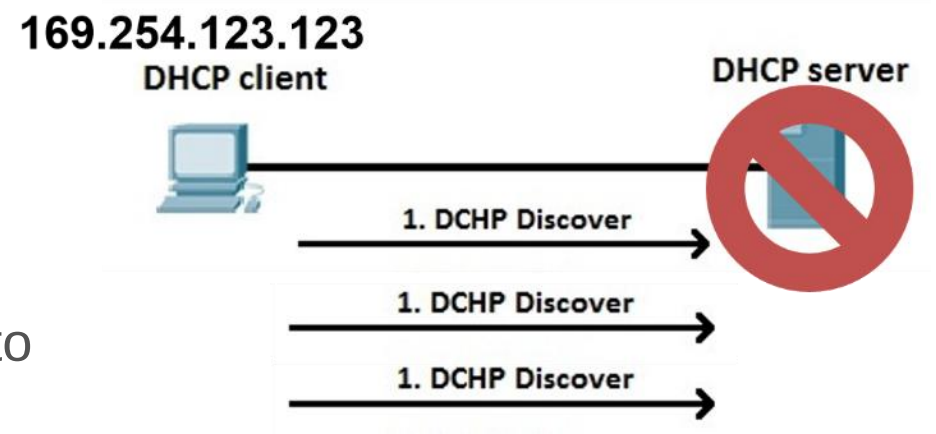
- What if there is no DHCP server?
- IPv4 Link Local is an automatic scheme for zeroconf networks
  - Supported by all major OS's
  - Standardized - RFC 3927

ZEROCONF NETWORKING

- A set of technologies that automatically creates a usable computer network based on the Internet Protocol Suite when computers or network peripherals are interconnected
  - Which makes it possible to take two computers, connect them with an Ethernet cable, and have them communicate usefully using IP

ZEROCONF: IP ADDRESSING

- Hosts use an algorithm to find an IP address in the range of: 169.254.X.Y
  - Ask if the address is already in use:
    - If the address is in use, the owner responds.
  - If no response, then it is free to start using the IP address.



ZEROCONF BENEFITS

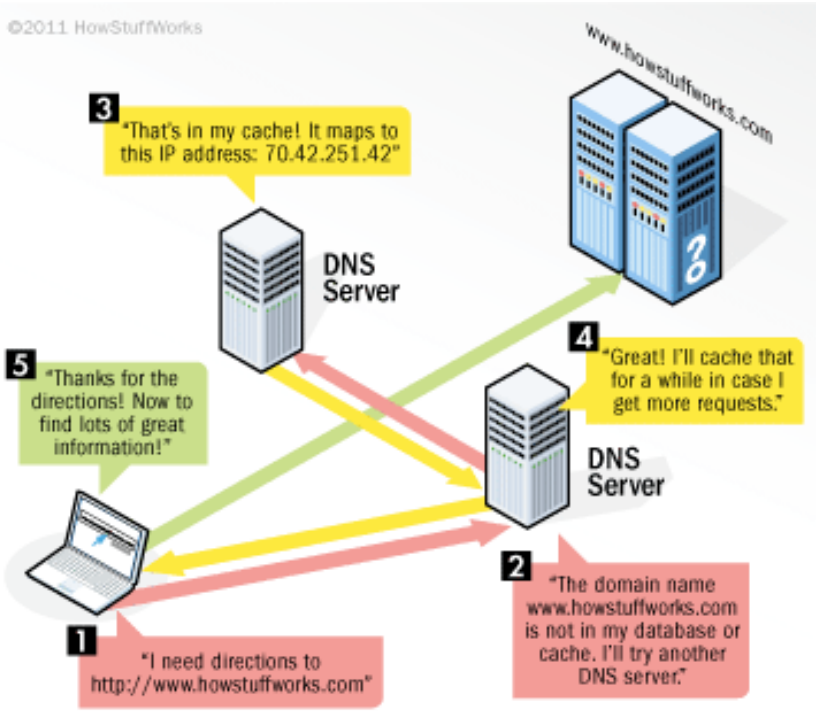
- Without zeroconf, a network administrator must set up services, such as DHCP and DNS, or configure each computer's network settings manually.

DNS

- DNS (Domain Name Service)
  - Most devices will use DNS if it is present on the network

- What makes the Internet work
  - Maps names to numbers
  - E.g: www.google.com -> 216.58.216.132

DNS



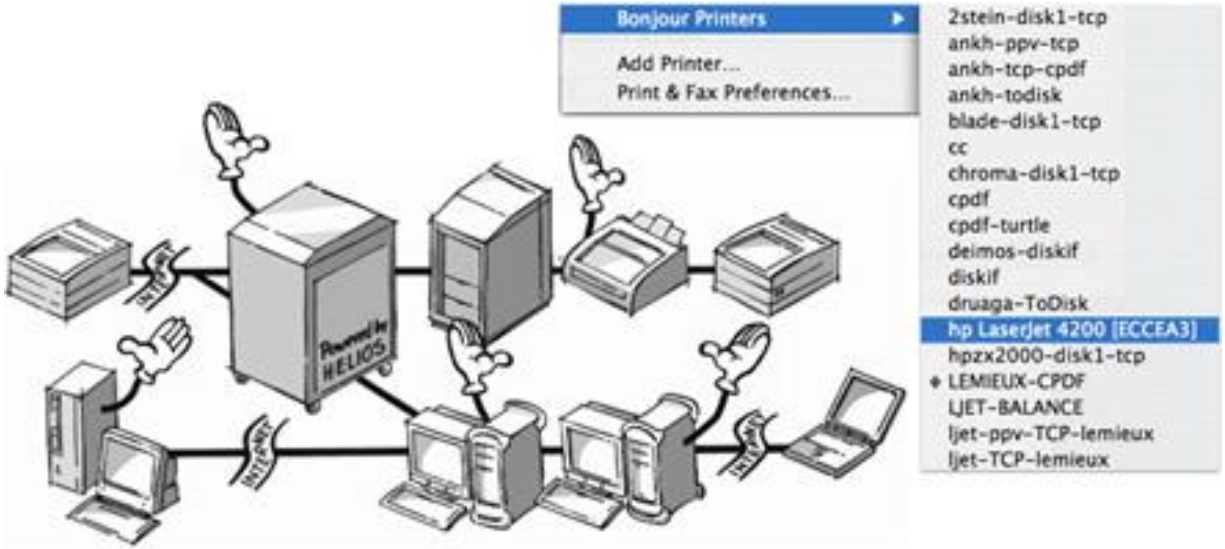
ZEROCONF: “DNS”

- What if there is no DNS server?

- mDNS and DNS-SD are combined to provide discovery
  - Supported by all major OS’s
  - Sometimes known as “Bonjour”,
  - Low traffic multicast protocol

ZEROCONF: “DNS”

- Devices can be reached by their device name (.local)



MULTICAST

- Unicast
  - Useful for point-to-point signals

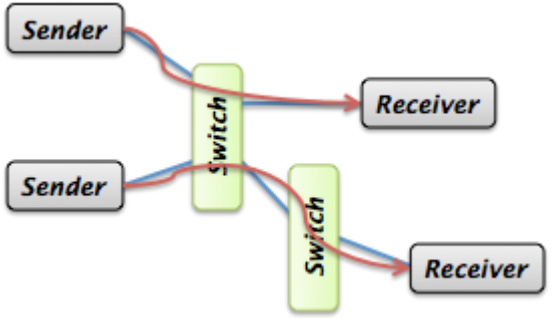
- Multicast
  - Useful for one-to-many signals

UNICAST

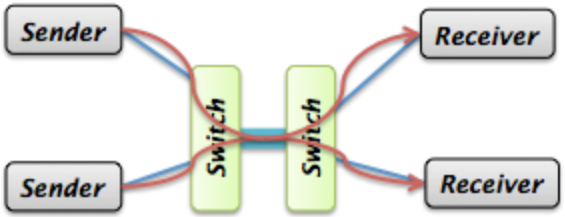
- Point-to-point efficiency
  - Channels are transmitted once for each receiver

UNICAST

- Packets stay on a narrow path between the sender and the receiver



- Packets only interfere with each other when paths cross
  - Make cross points / trunks gigabit (or faster!)



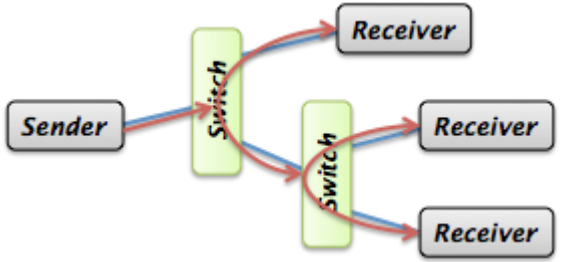
MULTICAST

- One-to-many efficiency
  - Channels are transmitted once to all receivers

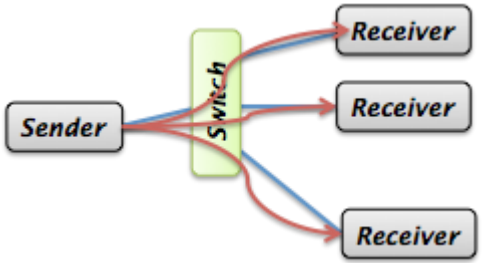
- Data is sent to a multicast group
  - An IP Address in the multicast range
    - E.g.: 224.0.0.251
  - Joining a multicast group
    - The receiver is listening to a particular IP Address

MULTICAST

- Packets flood throughout the network, duplicated by switches
- Assume that multicast channels will use bandwidth on all network links



- Compare to multi-Unicast



MULTICAST

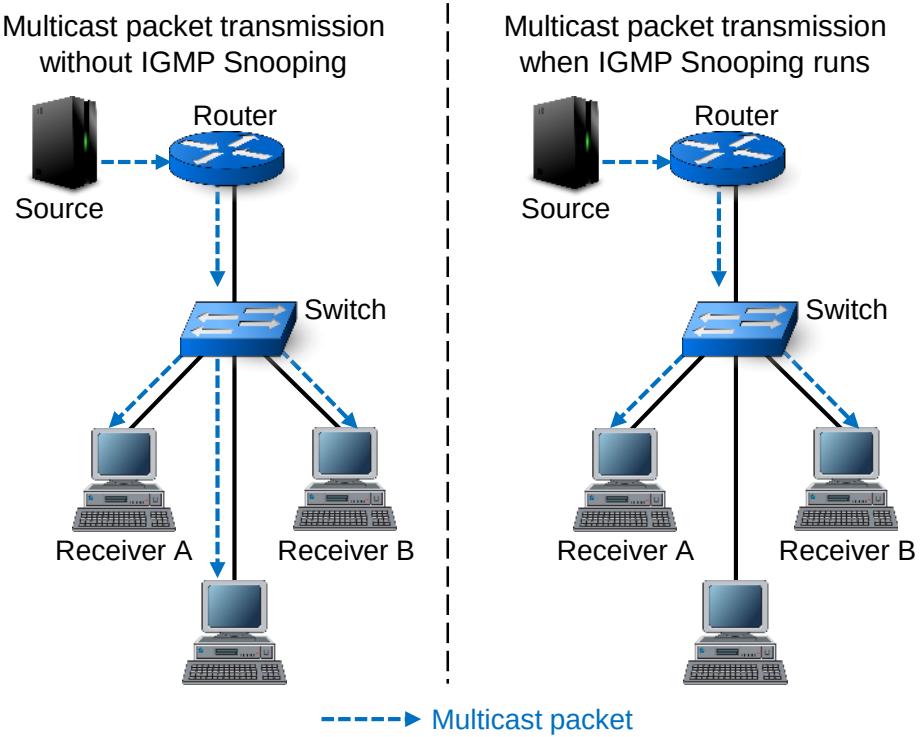
- The efficiency is for the sender of a signal with many receivers
  - At the cost of network flooding
- Unicast is efficient in the network (no flooding)
  - With a high transmission cost on the sender (the multi-unicast case)

IGMP

- Internet Group Management Protocol
  - Manages membership of multicast groups
    - In addition to receiver listening to the IP Address
      - Sends messages like “Join” and “Leave”
  - Used between IP hosts and multicast router

IGMP SNOOPING

- Allows a layer 2 (Ethernet) switch to listen in on IGMP protocol messages
- Switch can then route multicast traffic instead of broadcasting it to every port



IGMP SNOOPING

- Standard IP protocol behavior
  - Simply allows switches to control where IP multicast goes
    - With it, IP multicast is “one-to-many”
    - Without it, IP multicast is “broadcast” everywhere

SWITCHES

- Managed switches matter
- Switch GUI used to locate problems
  - See inside the network
- QoS (Quality of Service)
  - A Dante only network? Not required.
  - Enable it when using Dante along with other network traffic
  - Required if using Dante on a 100Mb network (32 channels, max.)
- IGMP Snooping
  - Use only if generating high volumes of multicast traffic in a Dante network with 100Mb nodes.
- Zero Configuration Networking (Zeroconf)
  - Easiest way to network

THE IT DEPARTMENT

- Data networks have been in use in educational and corporate environments for two decades
  - Standards for the Internet date back to 80’s
- The IT industry is mature
  - High-availability networks are the norm rather than the exception
- The standard for operation is the SLA
  - Service Level Agreement
  - Defines what is provided

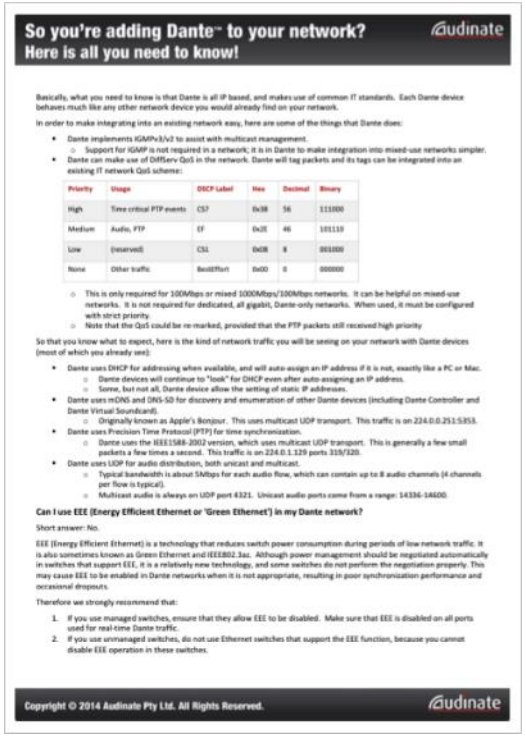
THE IT DEPARTMENT

- What to ask for?
  - Port counts
  - Bandwidth requirements
  - Isolated or Converged network
    - Are you using the IT departments DHCP/DNS or other infrastructure?

- Do you ask for a pool of IP addresses?
  - You are either a part of the existing scheme (a converged network)
  - Or, you are isolated, and there is no point

THE IT DEPARTMENT

- Things you must tell them about…
- Always:
  - IP Multicast!
    - IGMP support
- On a converged network:
  - DSCP Marks (QoS) including the expected priority
    - These can be “merged” with the existing IT QoS policy



So you're adding Dante™ to your network?
Here is all you need to know!

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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 integrating into an existing network easy, here are some of the things that Dante does:

- 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

  - This is only required for 100Mbps or mixed 1000Mbps/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 received 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 (most of which you already see):

- 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 device allow the setting of static IP addresses.
- Dante uses mDNS and DNS-SD for discovery and enumeration of other Dante devices (including Dante Controller and Dante Virtual Soundcard).
  - Originally known as Apple's Bonjour. This uses multicast UDP transport. This traffic is on 224.0.0.251:5353.
- Dante uses Precision Time Protocol (PTP) for time synchronization.
  - Dante uses the IEEE1588-2002 version, which uses multicast UDP transport. This is generally a few small packets a few times a second. This traffic is on 224.0.1.129 ports 319/320.
- Dante uses UDP for audio distribution, both unicast and multicast.
  - Typical bandwidth is about 5Mbps for each audio flow, which can contain up to 8 audio channels (4 channels per flow is typical).
  - Multicast audio is always on UDP port 4321. Unicast audio ports come from a range: 14336-14600.

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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QUESTIONS?

Back-Up

ABOUT

- Chris Ware
  - SVP Engineering at Audinate
- Audinate – Dante™
  - Sydney – Corporate HQ
  - Brighton, UK – European Office
  - Portland, OR – US Corporate Office
  - Wanchai, HK – Asia Pacific Office

UNDERSTANDING

- Understanding the terminology

jar·gon[1]
/ˈjärgən/

noun

special words or expressions that are used by a particular profession or group and are difficult for others to understand.
"legal jargon"
synonyms: specialized language, slang, cant, idiom, argot, patter; More

UNDERSTANDING

- Nostalgia time
  - Look back over 10 years
    - What did we think would happen?
    - What actually happened?
  - Get some benefit from hindsight …
- Identify / Understand
  - Networking standards
  - Key non-standards trends
- Make informed design choices

BACK IN 2004…

- Networks were largely 100Mbps
  - With some 1Gbps ($$)
  - Switches had replaced hubs
- The state of the art was
  - CobraNet, Ethersound
  - Multi-channel TDM cable solutions (e.g. MADI)
- Ethernet switch features
  - QoS, IGMP not common, but was available
  - Spanning tree was fairly common

INFRASTRUCTURE CREATES INERTIA

- *Requiring* changes to Ethernet switches
  - E.g. Clock sync support, QoS
  - Makes *deployment* a lot harder
- If *every* Ethernet switch must change
  - Limited to small systems, green field, forklift upgrades
- AVB is an example
  - Cannot deploy on existing switches
- Harsh reality: wholesale changes takes a long time
  - E.g. IPv6 deployment

INFRASTRUCTURE CREATES INERTIA

- Does AV need “special networking gear”?
  - Short answer: No
- How can you be so sure?
  - Dante, AES67, RTP, …
  - All work on typical IT network gear
  - No special switches, cables, …
  - (Good implementations are needed, It isn’t trivial to get right)
- But, we don’t need to change the universe
  - Good news: we get to leverage cheap IT gear

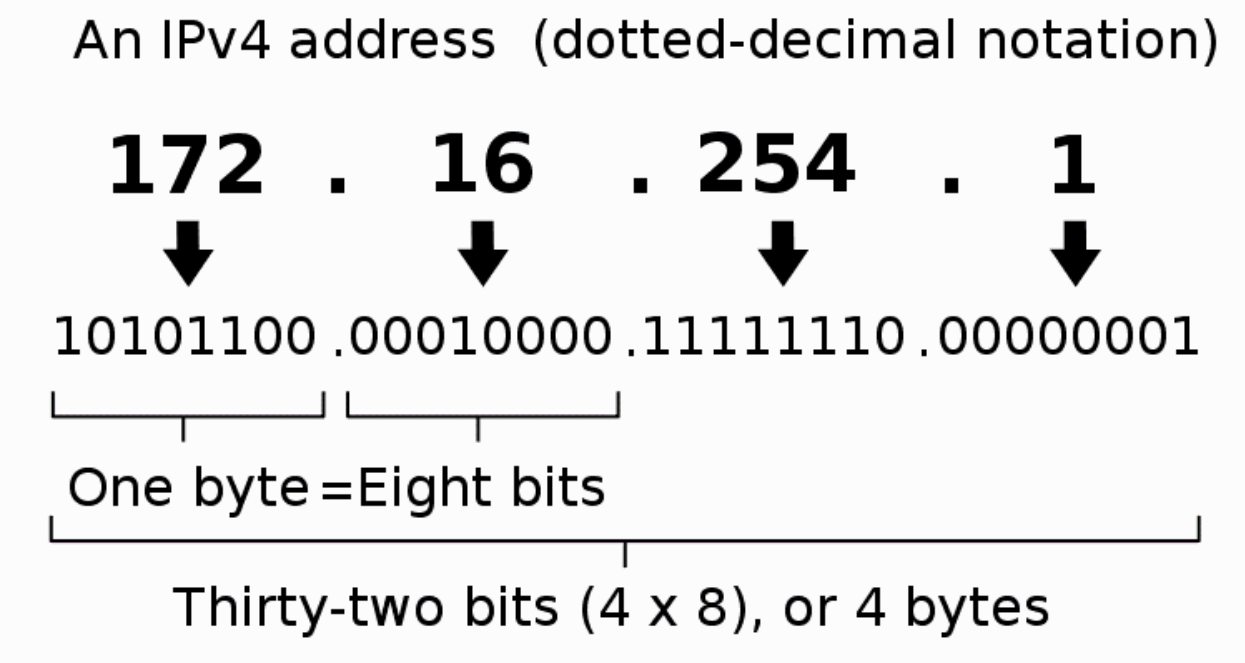
INFRASTRUCTURE CREATES INERTIA

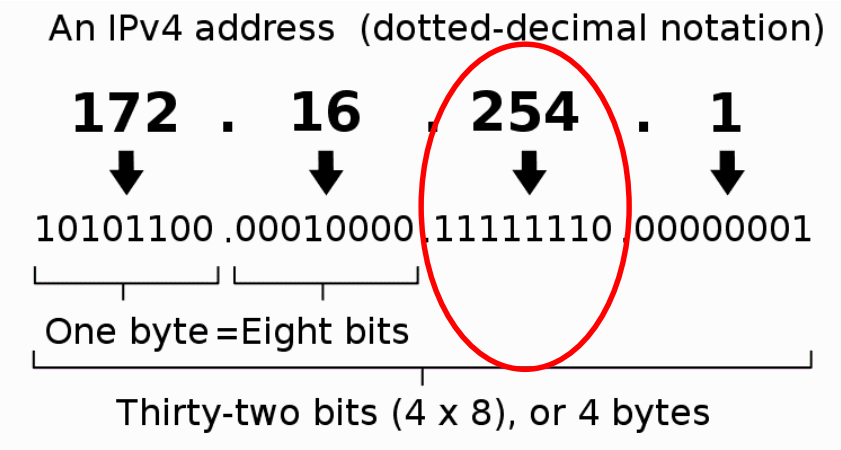
- AV Networking should be “low friction”
- Ease of use
  - Auto-configuration (IP)
  - Simple discovery, labels
- Minimize learning
  - “Fit” with typical practice
  - Use the most common protocols (c.f. CobraNet)
    - E.g. IP, UDP, DHCP, DNS, Diffserv..
  - Use the same tools
  - Integrate with network infrastructure

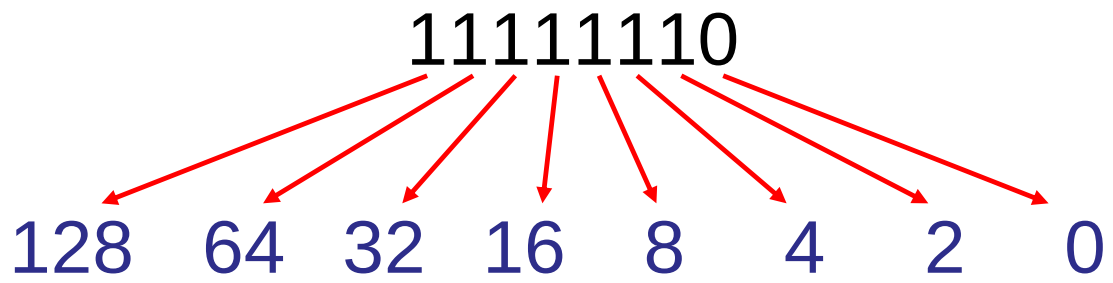
IP ADDRESSING

- IP uses IP addresses to define source/target.
- 32 bit numbers represented as 4 8 bit numbers separated by periods.
  - 192.168.001.010
- For example:
  - When visiting www.audinate.com in your browser, the computer must first translate it to an IP address.
  - Then the browser can make a connection to the web server on the target machine identified by the IP address.
- Think of this as the "phone number" of a device.

IP ADDRESSING

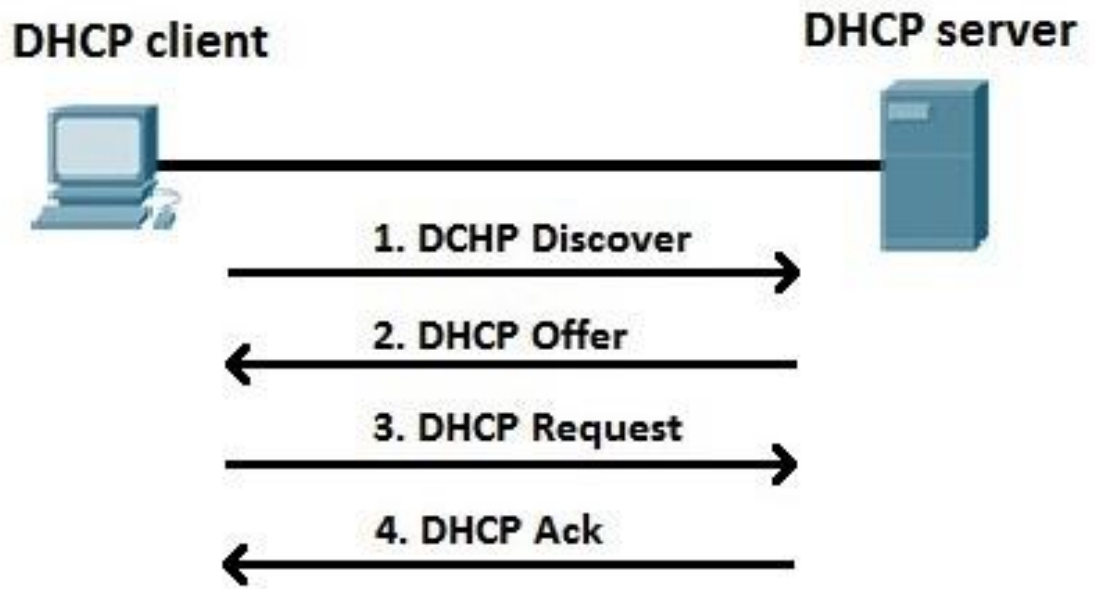






128 + 64 + 32 + 16 + 8 + 4 + 2 + 0 = **254**

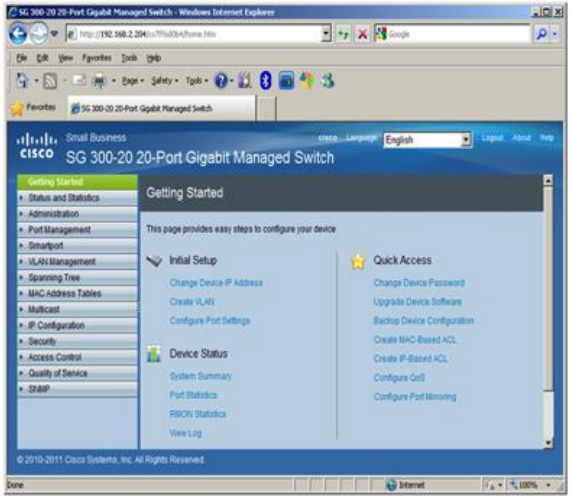
DHCP



SWITCHES

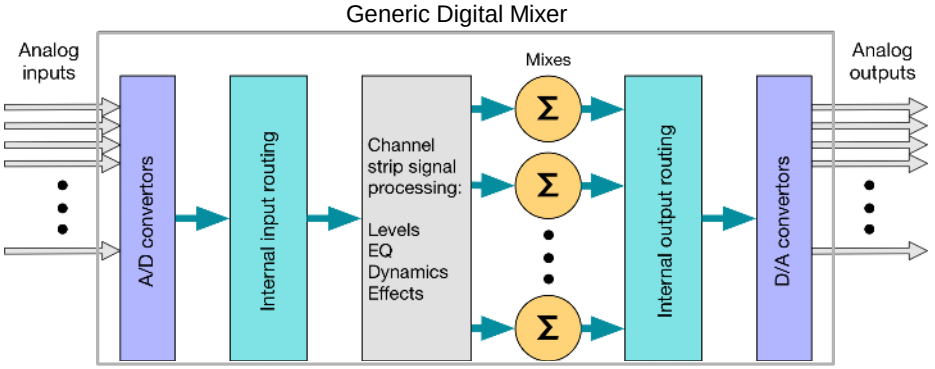
- Ethernet: store and forward
  - Packet is received (input)
  - Stored in memory / queued
  - Transmitted (output)
- Errors occur on a link-by-link basis
  - Detected on reception (e.g. CRC)
  - Drops on output (e.g. Congestion)

- Managed switches matter
- Switch GUI used to locate problems
  - See inside the network



AUDIO OVER IP

- Most available Audio over IP devices are just networked versions of the same devices that AV people are already familiar with
  - Not fundamentally new in operation and features



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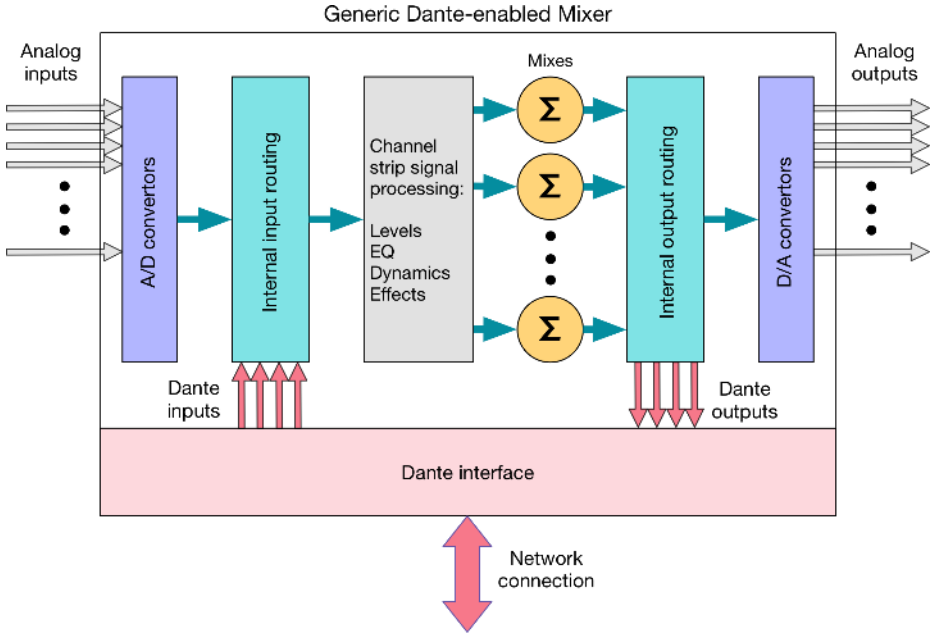

AUDIO OVER IP

- Troubleshooting an Audio over IP network is very similar to troubleshooting an IT data network

- Always troubleshoot from the bottom of the OSI model up
  - Layer 1 – Physical – Is it plugged in (to the right port)?
  - Layer 2 – Datalink – Are the lights flashing, are the packet counters counting?
  - Layer 3 – Network – IP Address conflicts? Same network subnet?

SUMMARY

- Best Practices – Understanding key networking concepts
  - Required for design or setup of audio over IP networks
- Managed Switches Matter
  - Allow you to disable Energy Efficient Ethernet
  - Advanced network configuration capabilities for future expansion
  - Network diagnostic tools for commissioning and troubleshooting
- Other information:
  - How to best work with the IT department – The SLA