



Introduction to IT Networking for Facilities Managers



APPA Institute for
Facilities Management
Washington DC
September 10, 2018



Course Description

This session will introduce participants to the world of connectivity and possibilities of networking in facilities management and specifically in the energy and utilities arena. The basics of a university networking backbone will be explained as well as how different systems connect and use a campus network to facilitate systems and web access.



Facilitator

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Class Logistics

- Be sure to sign the sign-in sheet being passed around the room.
- Make yourself comfortable. If you need to leave for a short break quietly exit and return.
- APPA Institute is more than learning technical information about college and university facilities. It is also about building relationships and networks beyond your current organization.
- APPA wants to make this experience valuable to each and every one of you. We do this by gathering your feedback. Remember to fill out your course feedback forms.

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Learning Objectives

- Learn about the world of connectivity and possibilities of networking in facilities management
- Learn about networking in the energy and utilities arena
- Learn about the basics of a campus networking backbone
- Learn how different systems connect and use a campus network to facilitate systems and web access

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What would you like to know about data networks?

What questions about IT networks would you like answered by the end of this class?

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Historical Perspective

- The first wired networks, telegraph and telephone, required a circuit.
- Wired networks connected end-points by switching circuits. The earliest used a switchboard.
- Wireless networks broadcast to everyone. Getting to the right message required tuning to the correct frequency.



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Telephone Switchboard



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Mechanical Switch



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To switch or not to switch that is the question

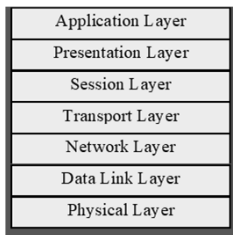
- Rather than switch the circuits, switch the data traveling along the circuits.
- Leonard Kleinrock at MIT published the first paper on packet switching theory in July 1961 and the first book on the subject in 1964.



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The Basics - Layers

Open Systems Interconnection



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Physical Layer

Wires, Cables and Media

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Wires and Cabling



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In Building Wiring

- Supports
 - LAN
 - Phone
 - Cable TV
 - Facilities Controls
- Structured Cabling System
 - Category 5
 - Category 6

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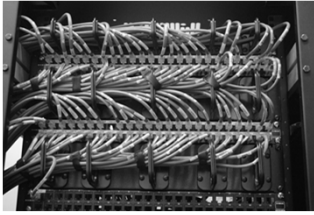
Structured Cabling



Category 6a cabling
installed on Ethernet
switch

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Structured Cabling



Category 6a
structured
cabling cross
connect

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Structured Cabling



Structured
cabling
pathways and
spaces

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BICSI

- Building Industry Consulting Services International
 - Promotes the economical and efficient design and implementation of telecommunications distribution systems in commercial and multi-family buildings
 - International non-profit professional association
 - Founded in 1974
 - Approximately 20,000 members in >85 countries!

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Physical Layer Elements

- Telecommunications Media
- Topology
- Transmission Rate
- Transmission Mode
- Channels and Multiplexing

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Telecommunications Media



- **Bounded Media:** signals are confined to the medium; they never leave it.
- **Unbounded Media:** signals are not confined to the medium; they are free to propagate through the atmosphere, the ocean, and outer space

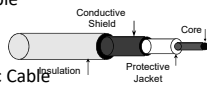
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Types of Bounded Media

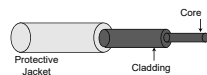
- Twisted Pair



- Coaxial Cable



- Fiber-Optic Cable



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Wireless Networking

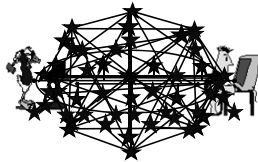


Wireless network access point. Note the access point is wired 😊

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Topology

- Point to Point
- Complete
- Star
- Bus
- Ring
- Tree
- Irregular

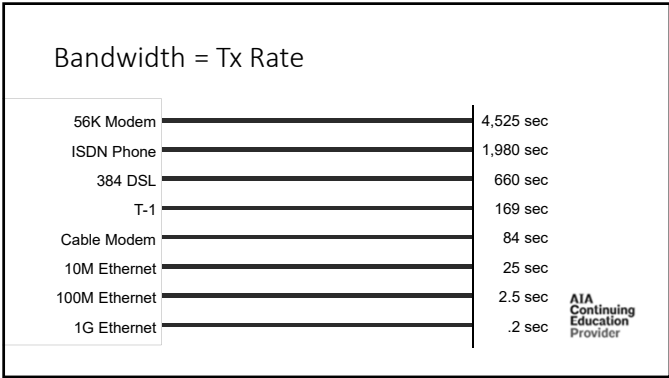


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Transmission Rate

- The capacity of a communication channel, measured as the difference between the highest and lowest frequencies carried by the channel. The greater the bandwidth, the greater the amount of information that can be simultaneously transmitted over the channel.

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Data Link Layer

The protocol layer that transfers data between adjacent network nodes

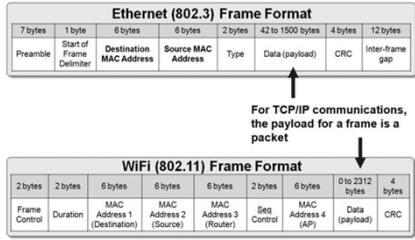
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Local Area Network (LAN)

- Data transferred in Frames
- Peer to Peer Networking
- Data Link Layer protocols IEEE 802.#
 - Ethernet 802.3
 - Token Ring 802.5
 - Token Bus 802.4
 - WiFi 802.11ac
- Transport level
 - Novell IPX/SPX
 - TCP/IP

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Data Link Frames



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Network Simulation

- You are only allowed to talk to people sitting next to you at your table or next to you at an adjacent table. You not allowed to shout out to the room to find out where the other person is located.
- Pass the envelop to the other named person.

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Discussion

- Did the message get from person A to person B?
- What challenges were encountered?
- Did the message take the most efficient path?
- What decisions had to be made to send the message from point A to point B?
- What could have made this easier?

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Network and Transport Layers

This is where the core of Internet is defined.

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Addresses

- Telephone

011 + 44 + 28 + 9043-4310

area code country code area code local number

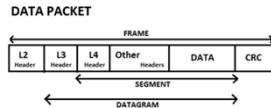
- IP Addresses

An IPv4 address (dotted-decimal notation)

172 . 16 . 254 . 1
↓ ↓ ↓ ↓
10101100 . 00010000 . 11111110 . 00000001
One byte = Eight bits
Thirty-two bits (4 * 8), or 4 bytes

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Data Packet



Packet at Layer 4 is called SEGMENT
Packet at Layer 3 is called DATAGRAM
Packet at Layer 2 is called FRAME

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Router Protocols

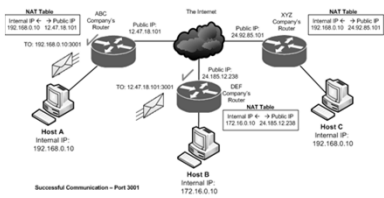
Border Gateway Protocol (BGP) is a standardized exterior gateway protocol designed to exchange routing and reachability information among autonomous systems (AS) on the Internet.^[1]

Interior Gateway Protocol (IGP) is a type of protocol used for exchanging routing information between gateways (commonly routers) *within* an autonomous system (for example, a system of corporate local area networks).



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Network Example



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Session and Presentation Layers

This layer makes the Internet easier to use.

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Common Protocols

- DNS – Dynamic Naming System
- DHCP – Dynamic Host Configuration Protocol
- BGP – Border Gateway Protocol
- HTTP – Hypertext Transfer Protocol
- URL – Universal Resource Locator
- NAT – Network Address Translator

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DNS – Dynamic Naming System

- But what if you don't know the IP address of the computer you want to connect to?
- What if the you need to access a web server referred to as www.anothercomputer.com?
- How does your web browser know where on the Internet this computer lives?

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DHCP – Dynamic Host Configuration Protocol

Dynamic Host Configuration Protocol (DHCP) is a client/server protocol that automatically provides an Internet Protocol (IP) host with its IP address and other related configuration information such as the subnet mask and default gateway. DHCP allows hosts to obtain required TCP/IP configuration information from a DHCP server.

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Network Engineer

- Design the Network
- Router Configuration
- DHCP Configuration
- DNS Configuration
- Assign messages for Hosts to send

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Routers

1. Each table assigns a person to be the gateway router for the table.
2. The gateway router person can speak to routers at adjacent tables. The gateway router provides links between the local table and adjacent tables.
3. The routers only understands and passes messages based on the numerical network addresses. They don't speak names.
4. A router can place or take messages from links to other routers.
5. A router can keep track of paths to other tables.
6. A router can choose which peer router to transfer messages to and from.

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DHCP

1. Choose someone at each table to be the dynamic host configuration protocol server (DHCP).
2. The DHCP gets key network information such as ASN, address range, DNS, and gateway router from the network engineer.
3. The DHCP assigns an address to each person at the table when they request it.
4. The DHCP tells each person who is the router.
5. The DHCP tell each person who is the DNS.
6. Each table is a local area network and can broadcast messages to everyone around the table.

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DNS

1. Choose someone to be the DNS at each table.
2. The DNS will be furnished with the addresses of the other DNS.
3. The DNS communicate with the other DNS in the room to exchange Host name information and build their local DNS table.
4. The DNS receives address resolution requests from Hosts around the table.
5. The DNS converts the Host name into a valid network address and sends it back to the Host.

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Hosts

1. Each participant that is not assigned another role is considered a Hosts.
2. Hosts get their network configuration information from the DHCP.
3. Host get other Hosts addresses from the DNS.
4. Hosts send messages to other Hosts using the network protocols and network services provided by the Routers, DHCP, and DNS.

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Try the Network Simulation Again?

- Using what you just learned about network protocols, design a classroom message passing network to route messages in the classroom.
- The no shout out across the room rule applies.
- People at a table can talk/pass messages to everyone around their table.
- What new rules or protocols would you add to the classroom network to make it easy to pass messages?

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Discussion

- Did the second simulation work better than the first?
- Did the message get from person A to person B?
- What challenges were encountered?
- Did the message take the most efficient path?
- What decisions had to be made to send the message from point A to point B?
- Did the DNS make it easier to send messages using Hosts names?
- Are there any other questions or comments about how the network worked or didn't work?

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Network Security

- Phishing
- Hacking
- Firewalls
- DMZs
- Intrusion Detection

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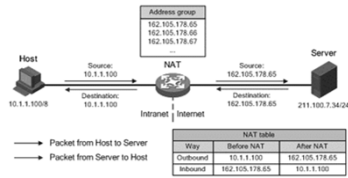
Firewalls

- Used to separate a private network from the public internet.
- Blocks certain types of network traffic
- Could be used to expand IP address space
- Performs network address translation
- Inspects messages for malicious code

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NAT – Network Address Translator

Network Address Translation (NAT) is a way to map an entire network (or networks) to a single IP address. NAT is necessary when the number of IP addresses assigned to you by your Internet Service Provider is less than the total number of computers that you wish to provide Internet access for.



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VPN – Virtual Private Network

- A network security technology that encapsulates network traffic in an encrypted payload to keep communications private between network end points.

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Application Layer

The part that the end-user interacts with the most.

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HTTP – Hypertext Transfer Protocol

The **Hypertext Transfer Protocol (HTTP)** is an application protocol for distributed, collaborative, hypermedia information systems.^[1] HTTP is the foundation of data communication for the World Wide Web.

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URL – Uniform Resource Locator

- A **Uniform Resource Locator (URL)**, commonly informally termed a **web address**

```
scheme://[user:password@]host[:port][/]path[?query][#fragment]
```

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VoIP Telephone



New voice over
IP telephone

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VoIP (voice over IP)

- Software PBX
- Uses existing data network
- Issues
 - Quality of Service
 - Security of Physical Network
 - Power over Ethernet

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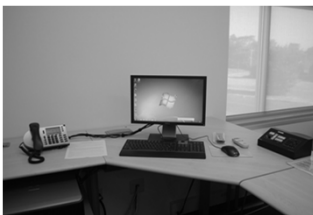
Software PBX



Software PBX to support a voice over IP phone system. Note the 25 pair (grey) legacy telephone cable interfacing to SoftPBX

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Emergency Notification



Classroom multi-media workstations make good points of emergency communications. Telephones can be used for voice annunciation and computers for text alerts.

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Closing Remarks

- Networks can be complex to understand, we can simplify them by breaking them down into layers
- Voice, video, and data are all now represented as bits on converged single infrastructure networks
- New technologies are entering the facilities workspace everyday
- Technologies are enabling institutions to manage resources and cut costs

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Closing Remarks

- Multi-Purpose Data Distribution Systems have replaced legacy telecommunications networks as the critical communications infrastructure for higher education institutions.
- Data Distribution Networks are complex systems that are best understood by breaking them up into layers.
- Voice, video, telemetry and data are all represented as bits on converged shared network infrastructure.

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This concludes The American
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