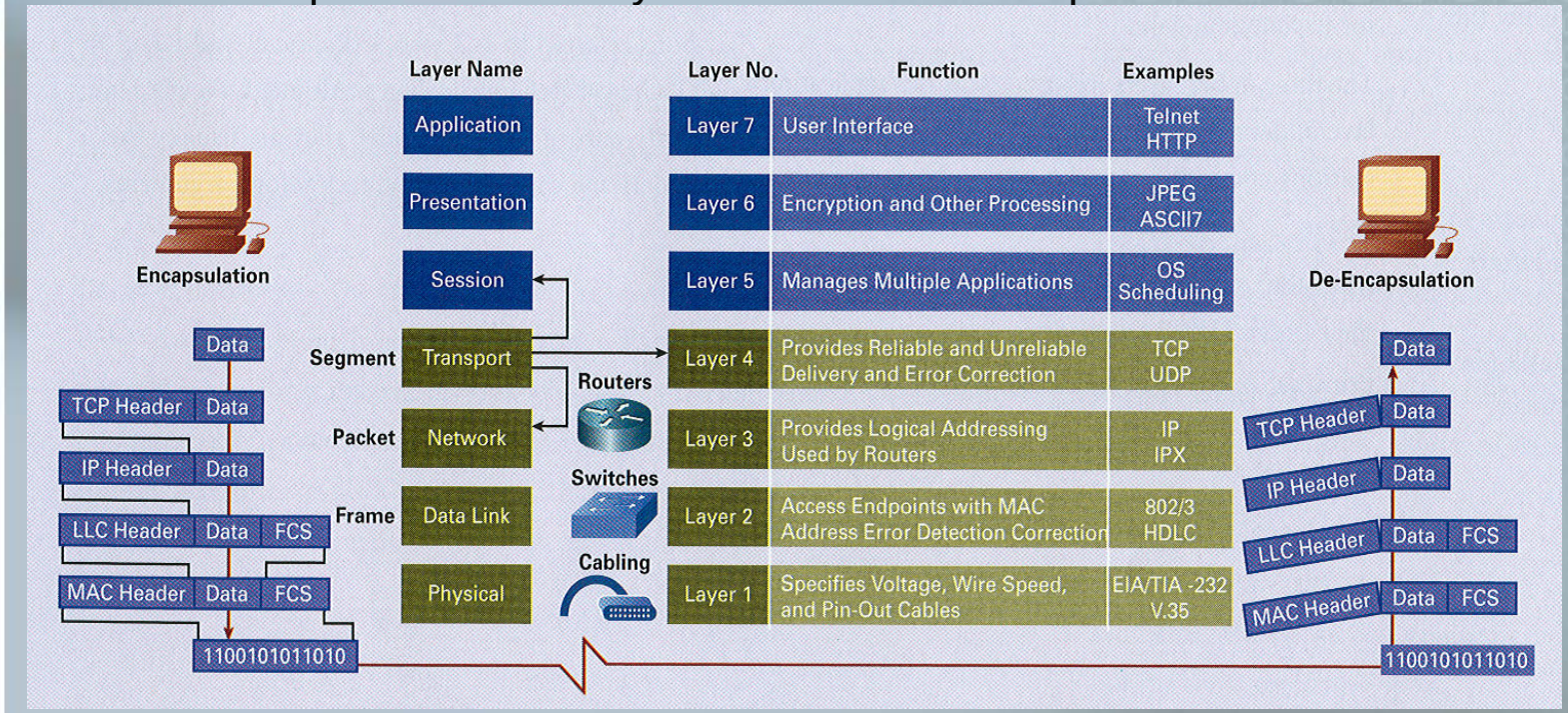
Presentation by: Geoffrey Sherman

Internet Backbone Technology Advances

Causing global need for the implementation of IPv6 to internet devices

OSI Layers

- This section will serve as a preface to the presentation just to get a few brief concepts out of the way and make them transparent.



The OSI (Open Systems Interconnection) was developed for several reasons. To increase interoperability between vendors. For the reduction of complex network operation to better understand components. Insurance of compatibility between layers due to relevant change. Provide methods or models for the interconnectivity of devices for the betterment of communication.

"the map is not the territory"

Cisco's interpretation of the OSI model and rules of conduct...

- Cisco is known throughout as the leading manufacturer of networking products. They have further advanced the connectivity of devices, speed of throughput, and reliability of service possibly more than any other company.
- There can often be possible loose interpretations of the conceptual ideas of the OSI model that may be close to correct but not completely accurate.
- To prevent this Cisco has developed 2 rules

  Rule# 1 – Cisco's interpretation is correct.

  Rule# 2 – If Cisco's interpretation is not correct, see rule number one.

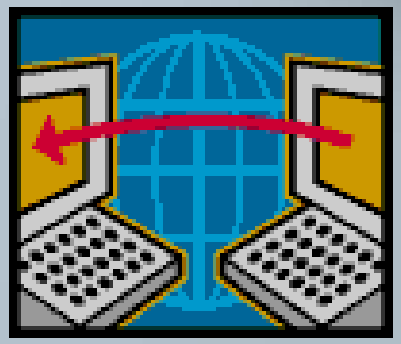
  -Ed Tittel Que Certification Publishing

A Push for Bandwidth

- Multimedia applications such as streaming video and E learning are causing bandwidth increases to drastically be needed.
- Email, is regarded still by far as the “killer app” of the internet.
- The internet is being used for VOIP voice over ip which is a method of converting voice to a digital signal and traversing it over the internet to another receiving party. By using VOIP charges that would be normally acquired by use of PSTN (public switched telephone network) are avoided
- QOS Quality of Service which is a collection of methods designed to ensure reliable, timely delivery of voice and other real-time packets across an IP network. Data is very different from voice and video, data can be broken up into smaller parts and checked for errors where voice has to be transported in an almost raw format utilizing UDP (User datagram protocol) which is a connectionless, unreliable protocol that does not ensure successful delivery of packets. This is useful in cases where retransmission doesn’t make sense for example voice conversations.
- Now massive amounts of file sharing as well as downloading take place. From downloading songs in a matter of seconds to sending a spreadsheet of data across the world. Increases in bandwidth make it possible.

In the beginning there were two. (ARPANET)

- In 1969 ARPANET became the first major backbone it was far from high speed but did set the standard for the time. It linked UCLA and SRI (Stanford Research Institute) together, shortly following was the university of Utah.
- In 1971 the first deployment of TIP's Terminal Interface Processor occurred allowing direct dial into ARPANET and greatly progressing its growth.
- ARPANET became the stepping stone for what would be called the internet. By 1977 there were 111 computers on ARPANET.
- In 1985 ARPANET gateways to external networks across North America, Europe, and Australia. ARPANET reached a global scope in size.
- By 1990 there were 92 million computers in the US.
- Also in 1990 Arpanet, after reaching 300,000 Hosts and 1,000 newsgroups officially is abandoned and the term the "Internet" is now used.



Internet Growth Trends

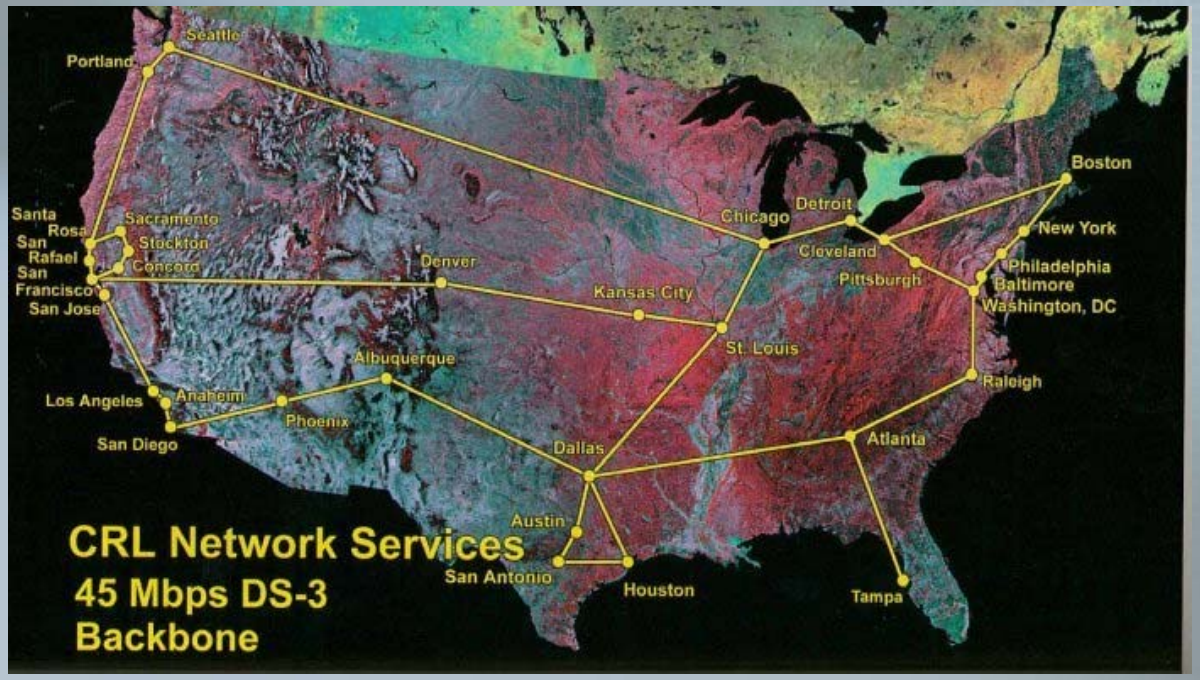
(Number of hosts versus year)

- 1977: 111 hosts on Internet
- 1981: 213 hosts
- 1983: 562 hosts
- 1984: 1,000 hosts
- 1986: 5,000 hosts
- 1987: 10,000 hosts
- 1989: 100,000 hosts
- 1992: 1,000,000 hosts
- 2001: 150 – 175 million hosts
- 2002: over 200 million hosts
- 2005 A brilliant presentation is written on internet backbone technology
- By 2010, about 80% of the planet will be on the Internet

Data according to

What is Internet Backbone Technology?

- Internet Backbones are high speed networks that carry internet traffic. For the most part the main nodes or connections to these backbones are connected by large companies such as AT&T, MCI, UUNET, Sprint, GTE, and Netcom.



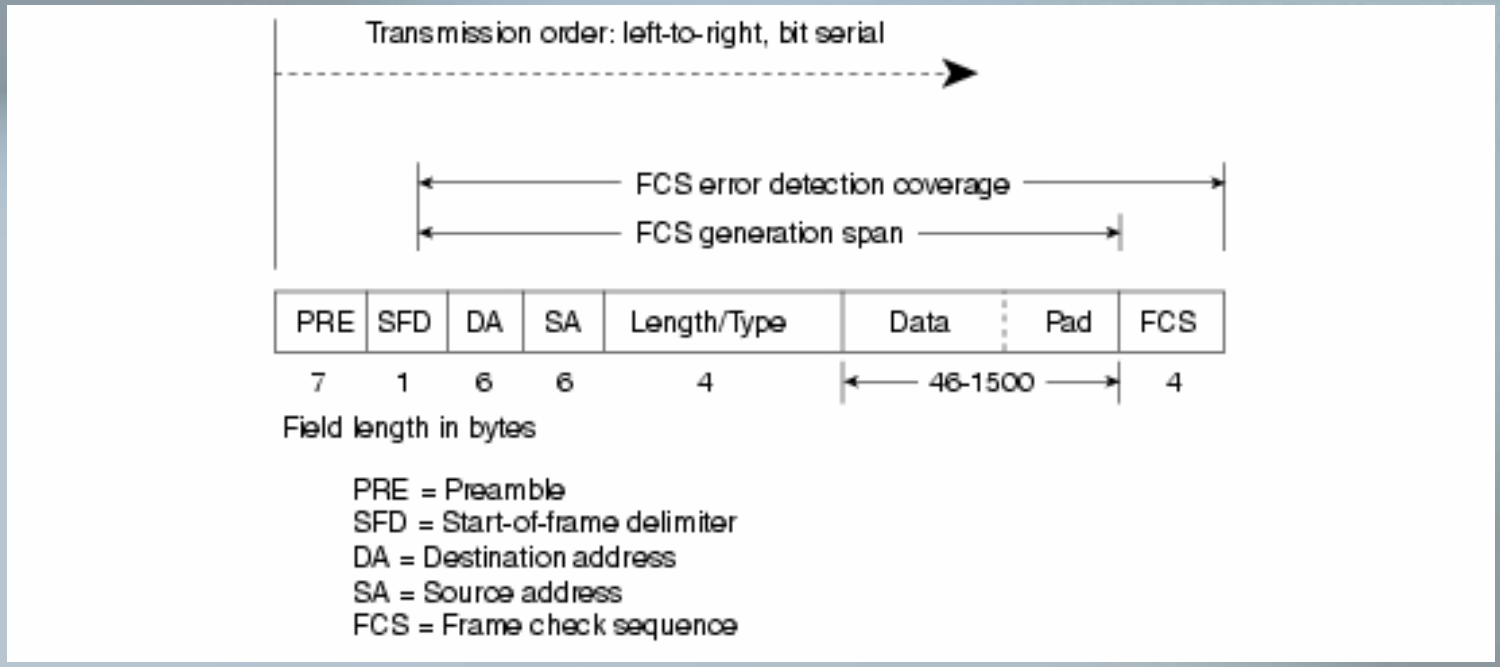
US DS3 Backbone

Ethernet the beginning of a standard

- Robert Metcalfe developed Ethernet at the Xerox Palo Alto Research Center (PARC) in 1972. 10 Years later the Institute of Electrical and Electronic Engineers IEEE adopted this standard based on the IP technology Metcalfe proposed.
- At this time IBM was working on its own technology called Token Ring since all devices on an Ethernet network occupied the same cable or hub. Many large corporations choose Token Ring due to their relationship with IBM.
- The problem with Ethernet was due to the sharing issues of cabling and that only one PC can talk at a time. Solutions were presented and the birth of CSMA/CD was brought forth. Carrier sense multiple access collision detect, allowed for computers to all wait their turn for transmitting of data.
- Ethernet began at a speed of 3Mbps and now operates from 10Mbps to 10Gbps and is only growing as time prevails.

Ethernet Framing

- The IEEE 802.3 standard defines a basic data frame format that is required for all MAC implementations, plus several additional optional formats that are used to extend the protocol's basic capability. The basic data frame format contains seven fields



Ethernet Cable Standards

Table 11-3 *UTP Cable Categories/Characterisics*

UTP Category	Max Speed Rating	Description
1	—	Used for telephones but not for data.
2	4 Mbps	Originally intended to support Token Ring over UTP.
3	10 Mbps	Can be used for telephones as well. Popular option for Ethernet in years past, if CAT3 cabling for phones was already in place.
4	16 Mbps	Intended for the fast Token Ring speed option.
5	1 Gbps	Very popular for cabling to the desktop.
5e	1 Gbps	Lower emissions, more expensive than CAT5, but better for Gigabit Ethernet.
6	1 Gbps+	Intended as a replacement for CAT5e, with capabilities to support multigigabit speeds when standards are created.

Ethernet is a limited standard long range transport options

Various ranges of cabling note the speed and range of fiber

11-4 *Summary of Ethernet Cabling Types*

	Maximum Length, Single Segment	Maximum Speed for Ethernet	Relative Cost	Advantages	Disadvantages
UTP	100 m	1 Gbps	Low	Easy to install, commonly available, popular	Susceptible to interference, limited distance
STP	100 m	100 Mbps	Medium	Low emissions, less susceptible to interference	Difficult to work with, limited distance
Coaxial	500 m (thicknet) 185 m (thinnet)	100 Mbps	Medium	Least susceptible to interference of all copper media	Difficult to work with (thicknet), single cable problem fails whole network
Fiber	10 km+ (SM) 2 km+ (MM)	100 Gbps (SM) 10 Gbps (MM)	High	More secure, long distances, not susceptible to EMI, highest speeds	Difficult to terminate when attaching connectors

Methods of Transport and Hardware

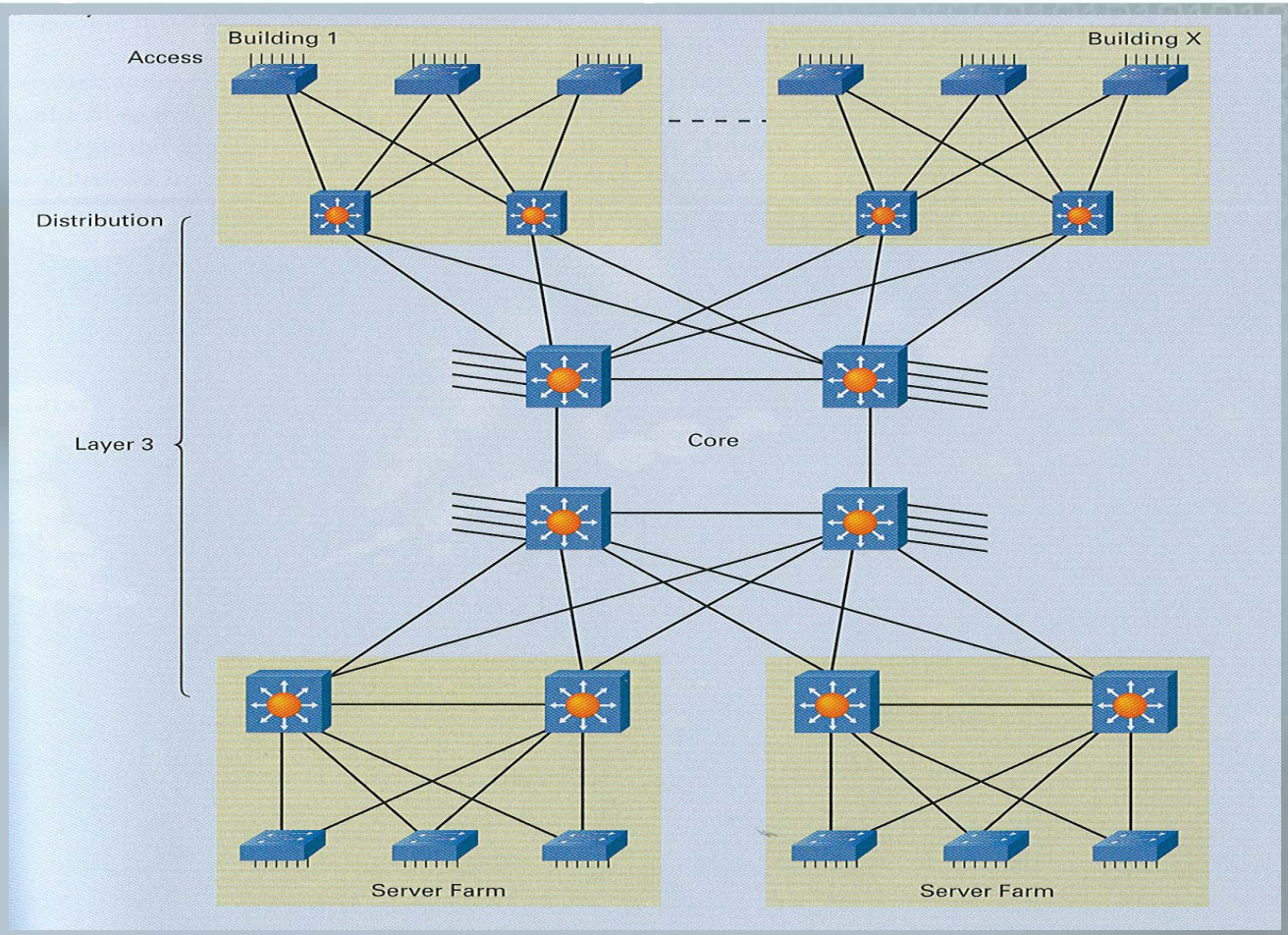
- Most of the major backbone providers will provide bandwidth and link to the smaller providers and so forth.
- Often companies will be linked to more then one backbone provider for redundancy and bandwidth requirements.
- Fiber Optics are utilized to transfer billions of gigabytes of data across the world.
- There are many standards of lines to carry high speed bandwidth T1 line which uses a signaling type of ds1 carries 1.544 Mbps a T3 line which uses the DS3 signal type carries 44.736 megabits
- There are also additional optical carrier lines such as OC3.The base rate (OC-1) is 51.84 Mbps. OC-2 runs at twice the base rate, OC-3 at three times the base rate (155.52 Mbps), etc. Planned rates are: OC-1, OC-3, OC-12 (622.08 Mpbs), OC-24 (1.244 Gbps), OC-48 (2.488 Gbps), OC-192(9.6 Gbps), and OC-768 (40Gbps).

DS3 Line

Backbone node Hardware (continued)

- Cisco System is one of the leading manufacturers of networking components and is one of the pioneers of internet backbone technology as we know it today.
- Telstra has activated the first 10 Gigabit Ethernet link on its Telstra Internet Direct (TID) backbone, the network that delivers high-quality broadband Internet services for business and home users across Australia. The upgrade to 10Gbps provides greater backbone bandwidth to ensure TID continues to lead the industry in performance and reliability, guaranteeing a high level of service for Internet users.
- The Cisco 12000 Series routers were used to power its new upgraded gigabit backbone http://newsroom.cisco.com/dlls/prod_022403f.html

Campus design network for a large scale campus



In this example we see a large scale network with room for upgradeability. By utilizing a layer 3 backbone core speeds can be accelerated and notes can connect to the core. This is an excellent representation of how the Internet is comprised smaller nodes connected to larger nodes.

Beyond hardware protocols and concepts

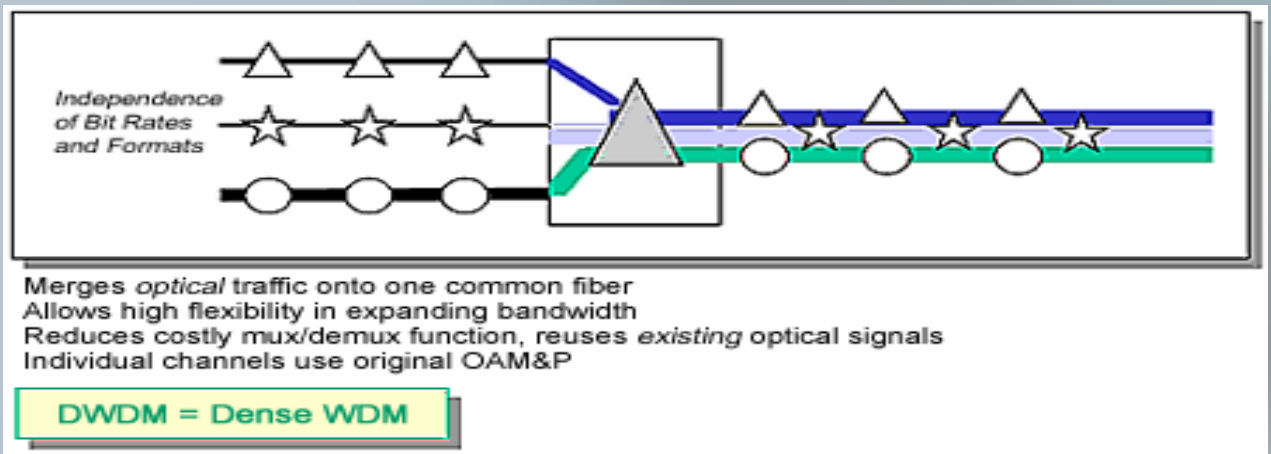
- Due to the fact that local network speeds are quite fast pushing speeds of gigabit and beyond, transportation of data from one area of the country and the world must be comparable if not substantially faster.
- WAN (Wide Area Network) Technology has increased at an outstanding rate. There are many associated methods of high speed data transport world wide that will be discussed.
- Campus networks can be considered WAN in some instances they are characterized by high-speed connectivity.
- Optical technologies such as SONET, DWDM, and DTP are being utilized for backbone technology speeds.

SONET/SDH and ATM

- SONET (synchronous optical network) is defined at OSI layer 1 and provides high speed signaling and encoding mechanism. The concept behind SONET was to provide phone companies of the world to connect their corporate offices to each other with high speed optical links.
- During the development of SONET the phone companies saw the need for data to traverse on the same lines. ATM (Asynchronous Transfer Mode) was developed to allow seamless integration of data with voice. Due to the nature of data transfer and the necessity for consistent high priority of voice there were many issue presented. ATM cells consist of a fixed 53 byte payload consisting of 48 byte payload with a 5 byte header.
- SDH (synchronous digital hierarchy) consists of the same standards as SONET but is used outside of the US. Optical carrier names are assigned to the links to specify bandwidth, OC-1, etc.

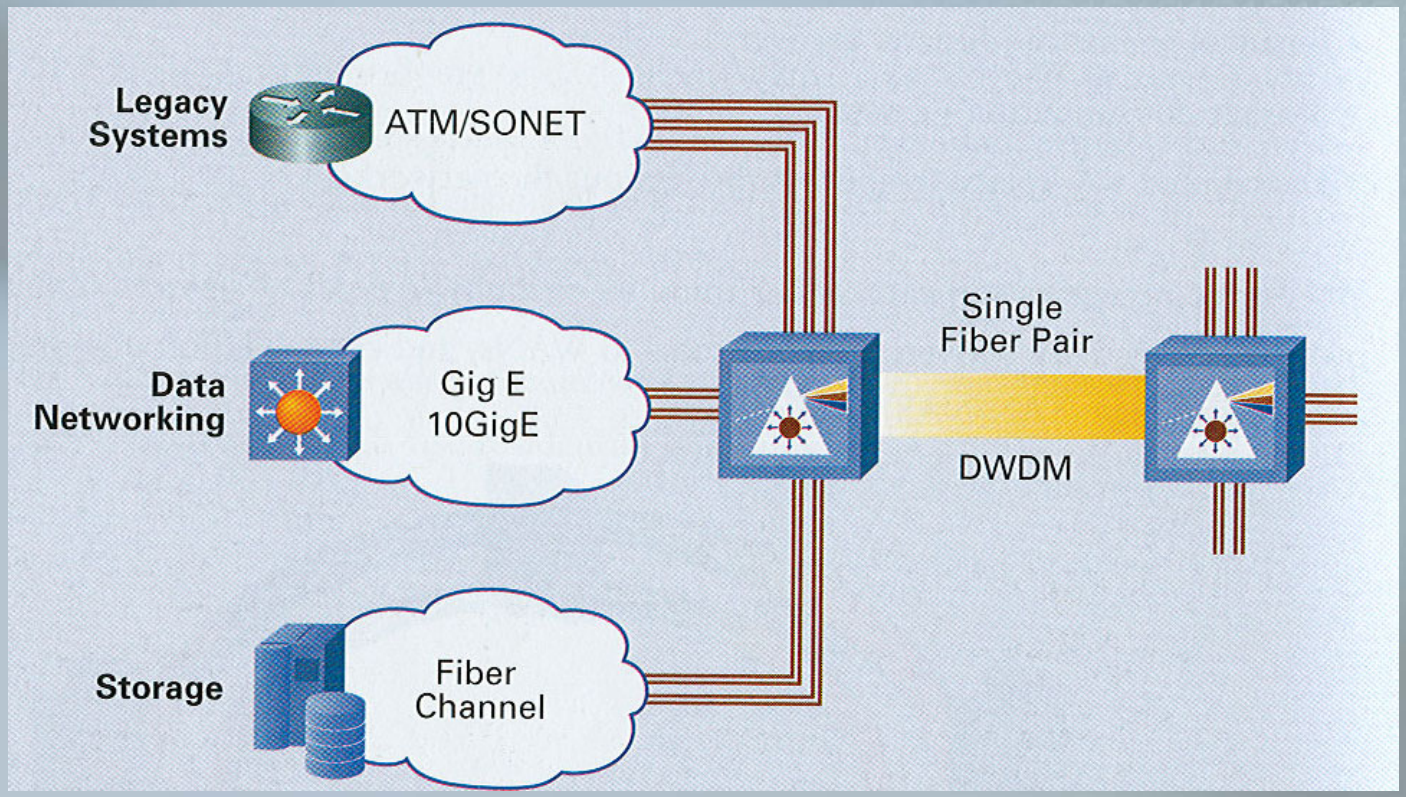
Beyond SONET

- Unmentioned in the CCNA (Cisco Certified Network Associate) Manual there are several other know standards that are on the uprising.
- CWDM (Coarse wavelength division multiplexing) uses wavelength specific pairs of GBIC's (gigabit interface converters) to combine up to 8 optical signals into one single fiber line.
- The only major drawback to CWDM is that it cannot be amplified, limiting its distance. 80km for a point to point connection and 30km for a ring circumference.
- DWDM (Dense wavelength division multiplexing) is similar to CWDM in that it uses a comparative multiplexing scheme, however more closely spaced signals allow for up to 32 signals on a fiber line.
- Future DWDM terminals will carry up to 80 wavelengths of OC–48, a total of 200 Gbps, or up to 40 wavelengths of OC–192, a total of 400 Gbps—which is enough capacity to transmit 90,000 volumes of an encyclopedia in one second.



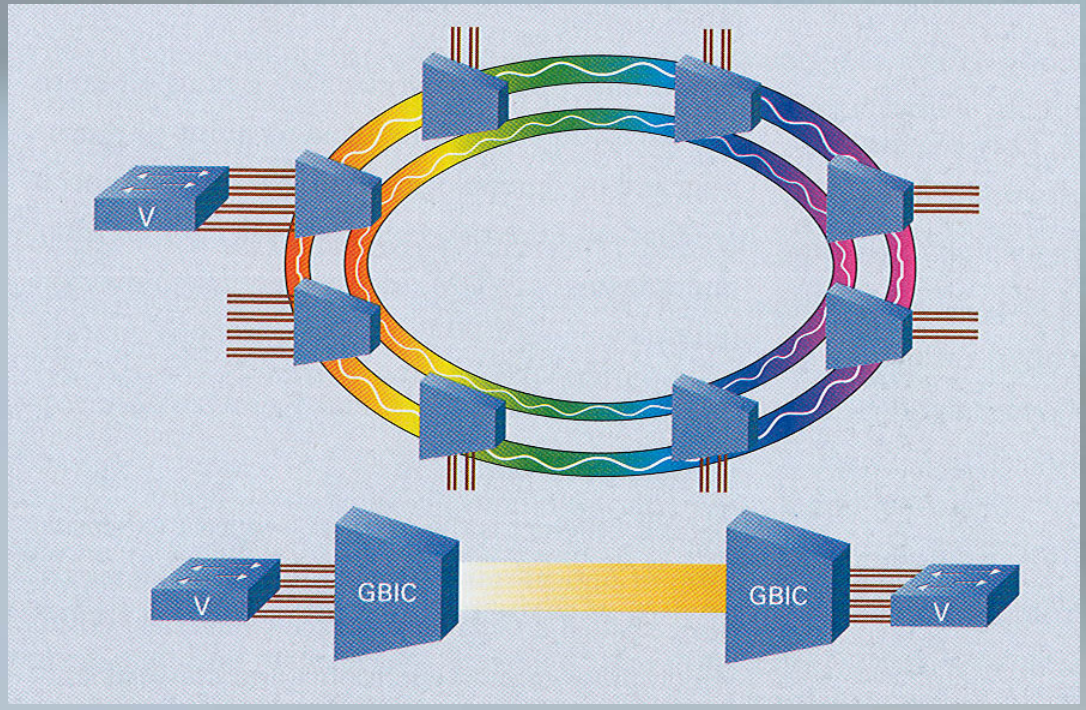
SONET Integration

- Implementation of DWDM to SONET



DTP

- DTP (dynamic packet transport) utilizes framing technology from SONET/SDH
- By utilizing a bidirectional, counter-rotating ring structure for metro applications DTP provides fault tolerant solution in the event of failure at a node or fiber facility.
- DTP also provides the bridging of dark fiber or unused fiber lines.



Fiber design and multiplexing technology

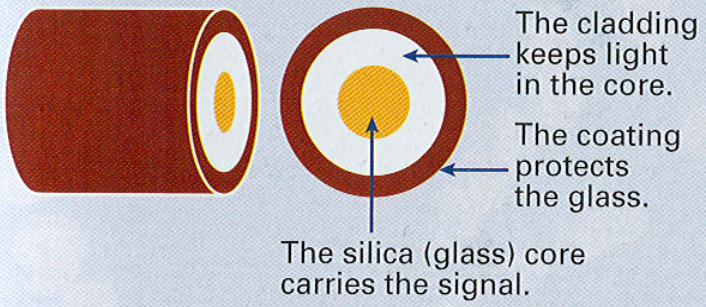
Fiber Basics

The two types of optic fiber are multimode and single-mode.

With *multimode fiber*, light propagates in the form of multiple wavelengths, each taking a slightly "different" path. Multimode fiber appears primarily in systems with short transmission distances (under 2 km).

In *single-mode fiber*, light can propagate in only one mode. Single-mode fiber usually appears in long-distance and high-bandwidth applications.

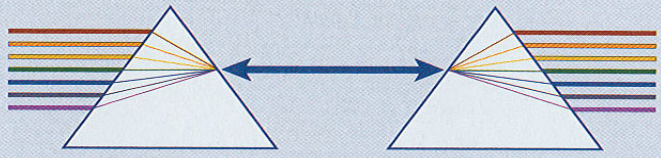
Multimode Fiber



Multiplexing

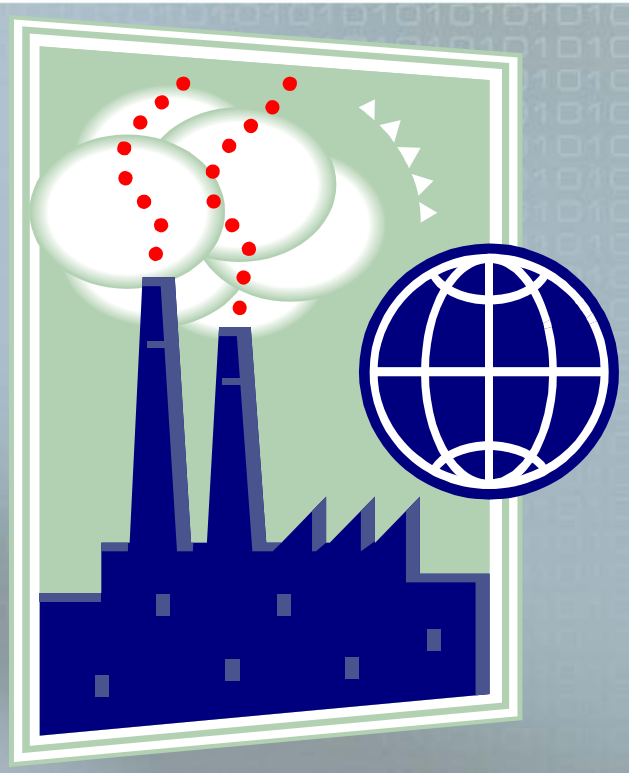
Multiplexing is the process of combining multiple signals over a single wire, fiber, or link. Time-division multiplexing (TDM) brings in lower-speed signals assigns them time slots, and places them into a higher-speed serial output. The receiving end reconstructs the signals.

One of the properties of light is that light waves of different wavelengths do not interfere with one another within a medium. Because of this property, each individual wavelength of light can represent a different channel of information. Combining light pulses of different wavelengths, many channels can transmit across a single fiber simultaneously. This process is *wave-division multiplexing (WDM)*.



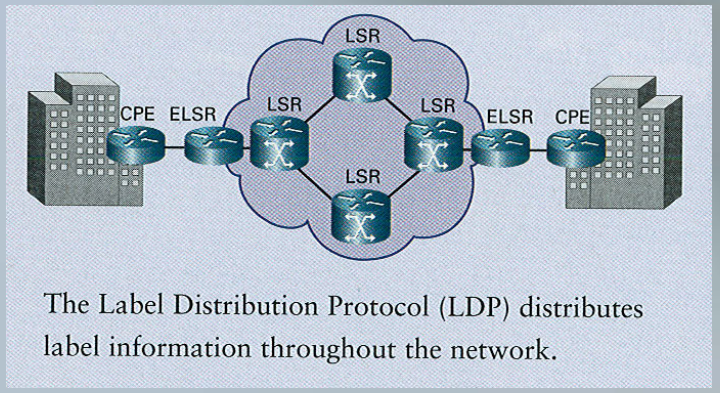
Frame Relay as a solution to connectivity over a large span of backbones

- Frame relay is noted as one of the most used WAN (wide are network) technologies.
- It generally is more cost effective then a leased line due to the fact that a dedicated line from one point to another is not needed.
- Frame relay hence the name is utilized by sending frames or packages of information to another location.
- Virtual circuits are established between frame relay routers which are able to be interconnected via various DTE's (data communication equipment)



MPLS bagging and tagging for traffic engineering

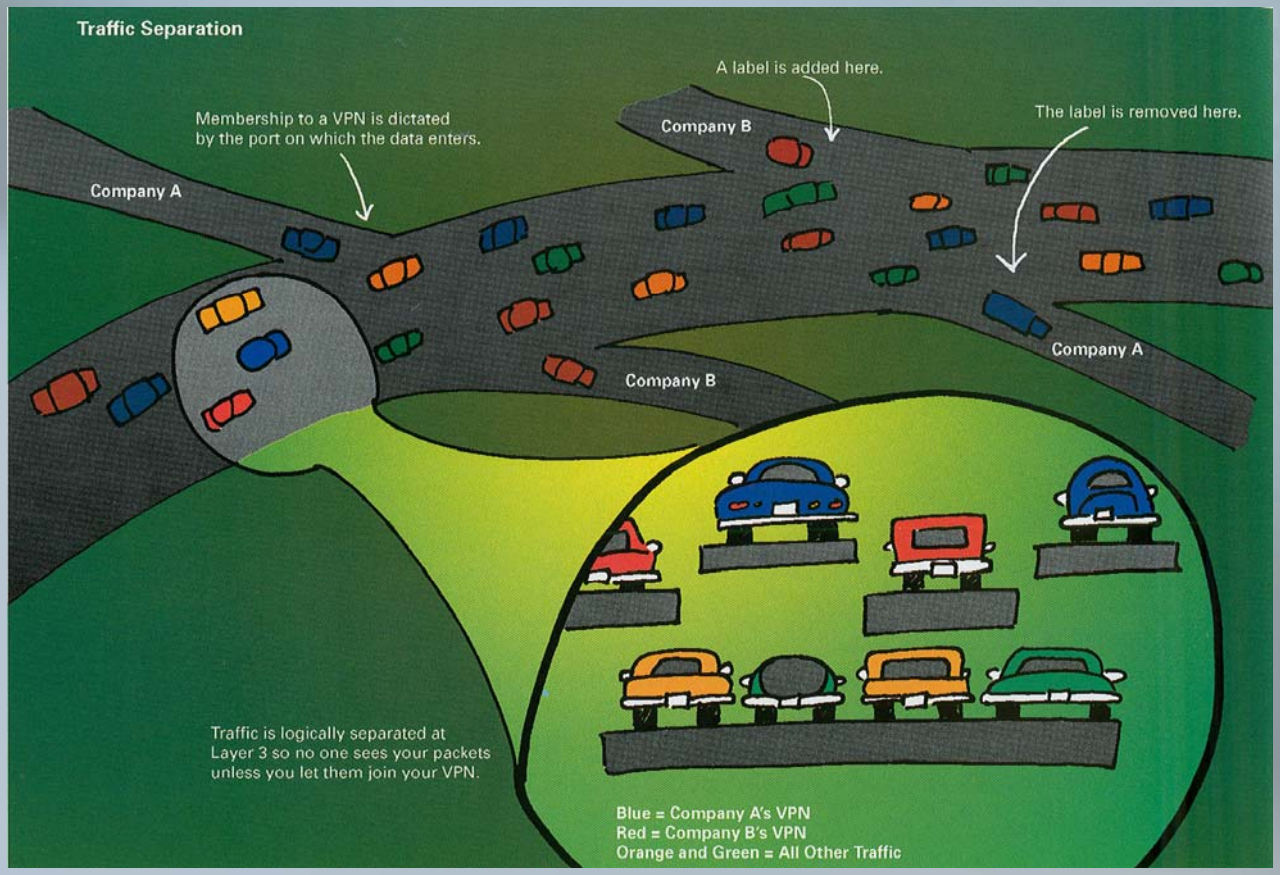
- MPLS (Multiprotocol label switching) operates at Layer 2 of the OSI model and is a key WAN/Backbone technology
- Originally developed by Cisco Systems MPLS is a method that allows fast data transport, and an alternative to leased lines, frame relay, and ATM
- MPLS utilizes an encapsulation scheme to enable identification tagging based on destination to be added to the packet when the packet reaches a service provider edge router.
- Once this tag is added it is then sent to the MPLS core, once the routers read the label, apply the appropriate services, it is then send to the desired destination based on the label.
- By utilizing this technology QOS services can be applied providing seamless data transmission that is secure and fast.



The Label Distribution Protocol (LDP) distributes label information throughout the network.

Example of MPLS labels applied and routing performed

- Simply enough the application of different types of labels can provide different types of transport. IP destination address, IP source address, QOS parameters, Specific Routes, VPN membership, Other Protocols.



Big Changes in China

- Dec 27, 2004 (AXcess News) Beijing - China advanced its nation's communications infrastructure by launching Cernet2, a high-speed Internet backbone.

  Cernet2, a high-speed internet backbone, connects 25 universities in 20 cities. Cernet, or the China Education and Research Network, has been able to achieve a monstrous speed of up to 40 gigabits per second during a trial run conducted on 7 December. This is a record for real-world applications, where the average speeds are about 2-10 GPS for universities. http://www.axcessnews.com/technology_122704a.shtml

- China Railcom has chosen technology from Cisco for the second phase expansion of their Internet backbone network, CRNet, Cisco Systems, the worldwide leader in networking for the Internet, announced Thursday.

  Following the expansion work, CRNet will offer a 10G link connecting Beijing, Shanghai, Guangzhou, and 125 other Chinese cities, making it one of the world's largest broadband networks.

  CRNet is a high-speed public network, offering a range of integrated services including dial-up and DDN access, as well as value-added services like VPN, VPDN, IP voice, and video conferencing. http://english.people.com.cn/200204/19/eng20020419_94369.shtml

With all the speed everyone wants in...

- Its no surprise that the evolution of the speed of internet backbone connectivity has a direct correlation on the type of media that can be shared over it. With speed pushing into the gigabit per second marks there is no limit to the type of data that can be shared. Locations of databases change they now can be stored offsite in data warehouses for safety and security purposes. Audio, Video, Data can now be shared at record speed.
- With the possibilities of data transfer over the internet being endless so are the devices used to connect to it. From PDA's, to cell phones, to laptops, to desktops. With that being said the topic of IP Addressing becomes a possible issue. During the development of the internet the concept of growth of a superscalar level was never thought of.

What exactly is an IP Address?

- An IP Address is an identifier for a computer or device on a TCP/IP network. Networks using the TCP/IP protocol route messages based on the IP address of the destination. The format of an IP address is a 32-bit numeric address written as four numbers separated by periods. Each number can be zero to 255. For example, 1.160.10.240 could be an IP address. Within an isolated network, you can assign IP addresses at random as long as each one is unique. However, connecting a private network to the Internet requires using registered IP addresses (called Internet addresses) to avoid duplicates.
- The four numbers in an IP address are used in different ways to identify a particular network and a host on that network. Four regional Internet registries -- ARIN, RIPE NCC, LACNIC and APNIC -- assign Internet addresses from the following three classes.
- Class A - supports 16 million hosts on each of 126 networks
- Class B - supports 65,000 hosts on each of 16,000 networks
- Class C - supports 254 hosts on each of 2 million networks

  www.webopedia.com

- That seems like plenty, but we are running out regardless with the addition of cell phones requiring unique IP Addresses. New age GPS and tracking systems are utilizing the overwhelming need to obtain internet access. Cars, taxis, busses, etc it just doesn't seem to end.

The IPv6 Solution

- IPv6 is a 128bit addressing strategy that will allow for many more IP Addresses. For example with the previous IP Addressing strategy 2^32 or 4 billion hosts, however with IPv6 2^128 which yields 3.4028236692093846346337460743177e+38 should be enough to cut it for the next few years.
- IPv6 uses CIDR short for ***C****lassless* ***I****nter-****D****omain* ***R****outing,* an IP addressing scheme that replaces the older system based on classes A, B, and C. With CIDR, a single IP address can be used to designate many unique IP addresses. A CIDR IP address looks like a normal IP address except that it ends with a slash followed by a number, called the *IP network prefix.* For example:
- 172.200.0.0/16
- The IP network prefix specifies how many addresses are covered by the CIDR address, with lower numbers covering more addresses. An IP network prefix of */12,* for example, can be used to address 1,048,576 former Class C addresses.
- CIDR addresses reduce the size of routing tables and make more IP addresses available within organizations.
- CIDR is also called *supernetting*

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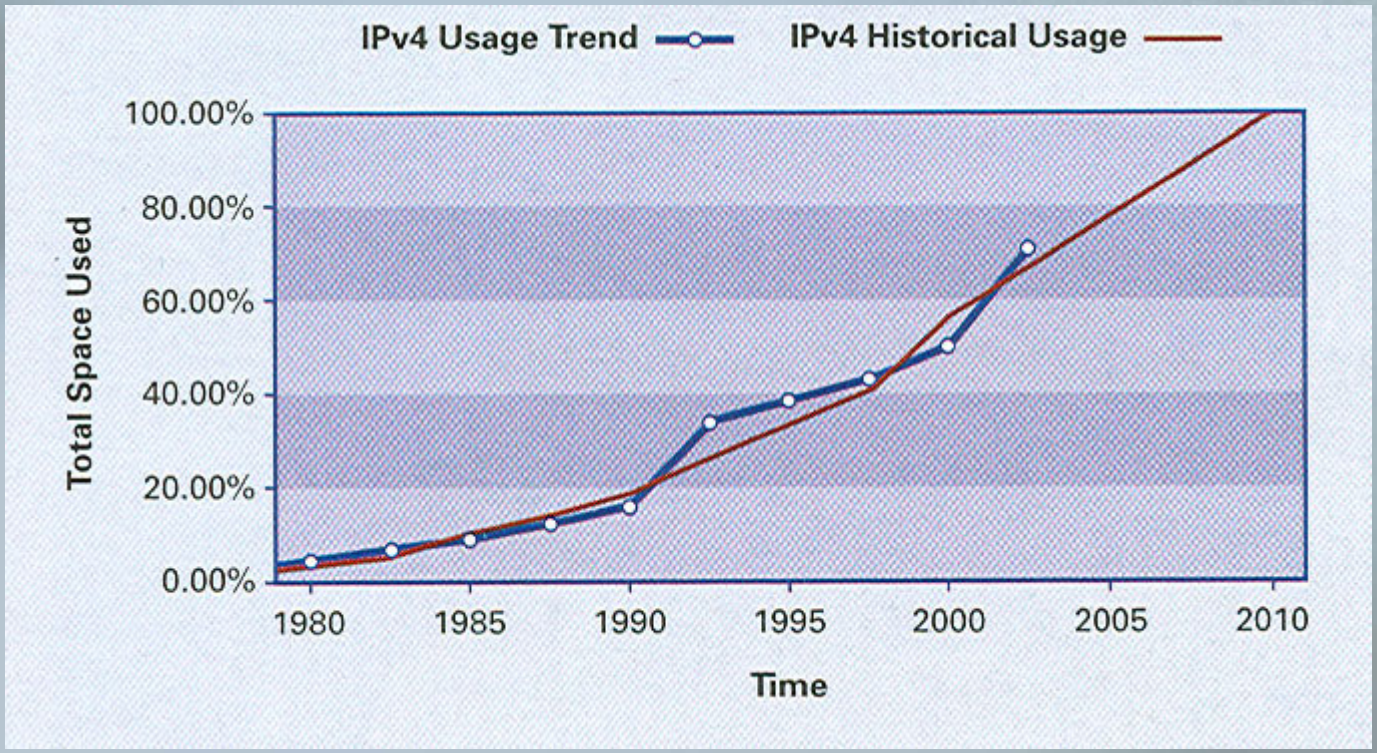
One billion IP addresses left

- Although it seems like allot we are running out quite fast and with growth the way it is now



Understanding NAT (Network Address Translation)

- In current standards with IPv4 the predecessor to IPv6 one of the technologies that is being utilized is what is called NAT or Network Address Translation. NAT allows large corporations to have one real IP Address that is what is considered an outside IP address and have the computers and networking devices behind that one address utilize just that one address. The way this setup works is a Router or Gateway creates a series of private IP addresses. For example with an outside IP like 128.205.10.100 all the internal PC's will have 192.168.1.100...254
- This can also be considered IP Masquerading since the outside IP acts as the main IP address and connection to the other nodes of the internet.
- The limitations to this that if outside access is desired for many PC's utilizing the same ports it is possible for there to be limitations caused by this.

Beyond IPv6 conclusion

- It's no surprise that with the ability to add so many new devices with a unique outside IP address the possibilities are endless. For example in China a taxi cab company is seeking to add an IP enabled device in every cab. To be able to provide drivers with statistics, mapping, and other info.
- Despite the numbers the US is still reluctant to begin the massive efforts to make conversions to the new standard well Europe and ASIA lead the way.
- It is imperative that in order to ensure the connectivity of future devices tangible IPv6 must be rolled out in a global scale

Conclusions Questions?

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