i341

Networks and Distributed Applications

Communications Media

Intro:

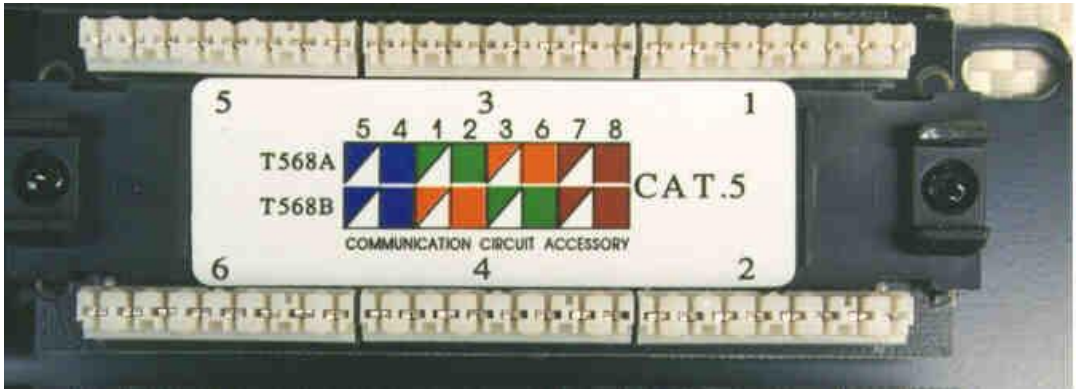
Differentiate guided and unguided media ?

Examples ?

Why are cabling & media selection critical in networks ?

Sources of Info on cabling/media ??

(EIA/TIA Standards)



UTP Cable

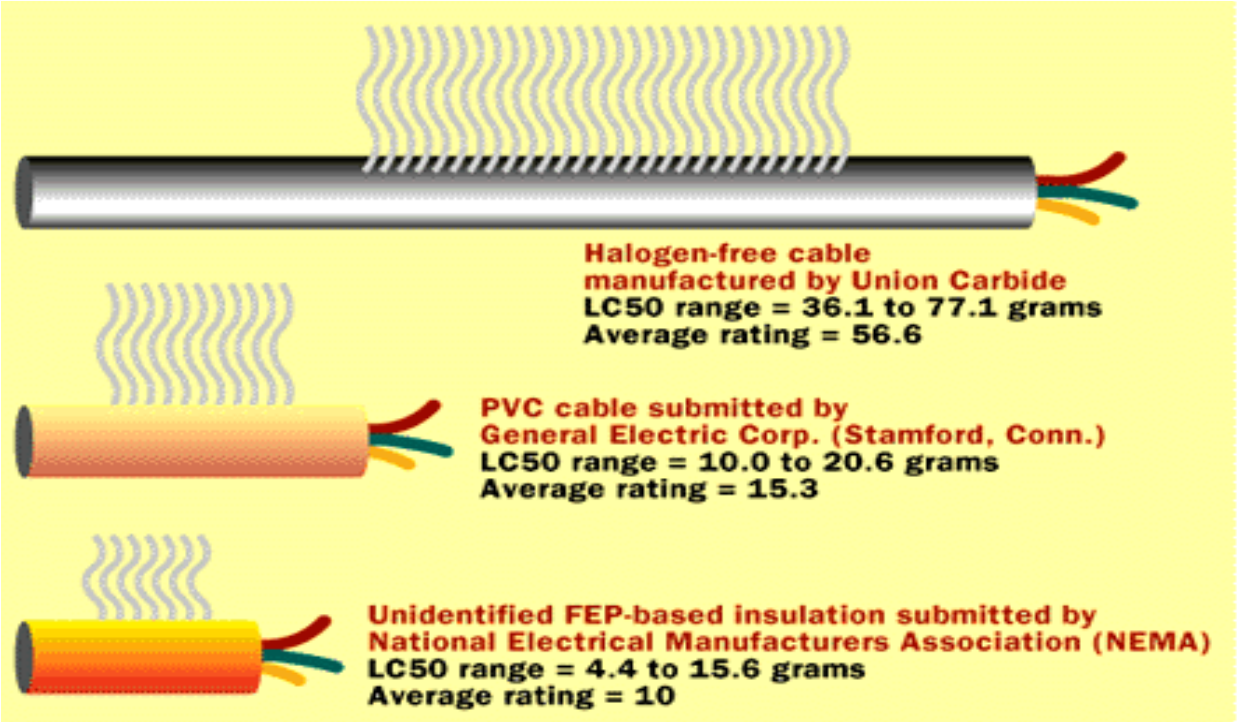
Category 3 **(100 Ohm) UTP** **UL Level III**	**10BASE-T** **4 Mbps Token Ring** **ISDN** **IBM 3270, IBM AS/400, Voice**
Category 4 **(100 Ohm) Low Loss** **UL Level IV**	**10BASE-T** **16 Mbps Token Ring** **100 Mbps Ether (100Base-T4)**
(100 Ohm) Extended Frequency **UL Level V**	**16 Mbps Token Ring** **100 Mbps Ether (100 Base-TX)**
Category 6 **Extended Frequency** **UL Level V**	**100 Base-Tx** **Gigabit Ethernet** **ATM/155 Mbps**

UTP Cable

CAT5: Category 5 is now basic. Cables belonging to Category 5 are either *solid* or *stranded*: Solid Cat 5 is more rigid, and the better choice if data needs to be transmitted over a long distance, while Stranded Cat 5 is very flexible and most likely to be used as patch cable. **Cat 5 cable can support 10 or 100 Mbps Ethernet, and has a capability of up to 100MHz.**

CAT5e: (which stands for Category 5, *enhanced*) cable goes along the same lines as basic Cat 5, except that it fulfills higher standards of data transmission. While Cat 5 is common in existing cabling systems, Category 5e has almost entirely replaced it in *new* installations. Cat 5e can handle data transfer at 1000 Mbps, is suitable for Gigabit Ethernet, and experiences much lower levels of near-end crosstalk (NEXT) than Cat 5.

CAT6: is the most advanced and provides the best performance. Just like Cat 5 and Cat 5e, Category 6 cable is typically made up of four twisted pairs of copper wire, but its capabilities far exceed those of other cable types because of one particular structural difference: a longitudinal separator. This separator isolates each of the four pairs of twisted wire from the others, which reduces crosstalk, allows for faster data transfer, and gives Category 6 cable twice the bandwidth of Cat 5! **Cat6 cable is ideal for supporting 10 Gigabit Ethernet, and is able to operate at up to 250 MHz**. Since technology and standards are constantly evolving, Cat 6 is the wisest choice of cable when taking any possible future updates to your network.



Plenum

A plenum is an area or duct where air is passed for circulation in a building. This includes air ducts as well as the area commonly found above most suspended ceilings. Smoke travels fast throughout a building, especially if the source is in an air plenum. Most twisted pair cables are encased in PVC or similar sheath. PVC is used for it's low cost and physical characteristics. Unfortunately, PVC and other similar plastic-based cable casings can give off extremely toxic fumes when heated or burned. In the event of a fire, toxic fumes would be transported throughout a building in a matter of minutes. The leading cause of death and injury in fires is smoke inhalation. Thus, the plenum rated cable is a cable encased in a material that has been certified no not give off toxic fumes when heated or burned. Cables that are plenum rated are referred to as plenum cables. This does not alter the electrical characteristics of the cable, it does increase the cost of the cable, and decrease the flexibility of the cable because of the increase overall diameter.

UTP Cable

Advantages of UTP ? ?

Ubiquitous, readily available, lots of sources/expertise, relatively inexpensive, supports LAN applications (Ethernet)

Disadvantages of UTP ? ?

Affected by EMI (electromagnetic interference), difficult to splice, limited capacity (compared to fiber, distance limitations)

UTP Cable Tester/Certification

CableTester

DSX-5000 CableAnalyzer™

Accelerates every step of the copper certification process

Versiv™ modular design supports copper certification, fiber loss, OTDR testing and Wi-Fi analysis

Unmatched speed for Cat 6A, Class F_A and all current standards

ProjX™ system manages job requirements and progress from set-up to systems acceptance, making sure all tests are completed correctly

Taptive™ user interface simplifies set-up, and eliminates errors

Analyze test results and create professional test reports using LinkWare™ management software

Graphically displays the source of failures including crosstalk, return loss and shield faults for faster troubleshooting

UTP Cable Tester/Certification

Network Tester

Visibility into network devices and application connectivity problems.

NetProve™ diagnostics – isolate device and application connectivity issues in seconds

Inline Gigabit vision - quickly troubleshoot network problems with powerful inline vision into 10/100/Gig traffic between switches, PCs, IP phones and other devices

Monitoring and authentication - identify spyware, malware, and viruses with port monitoring; troubleshoot authentication issues with 802.1x log

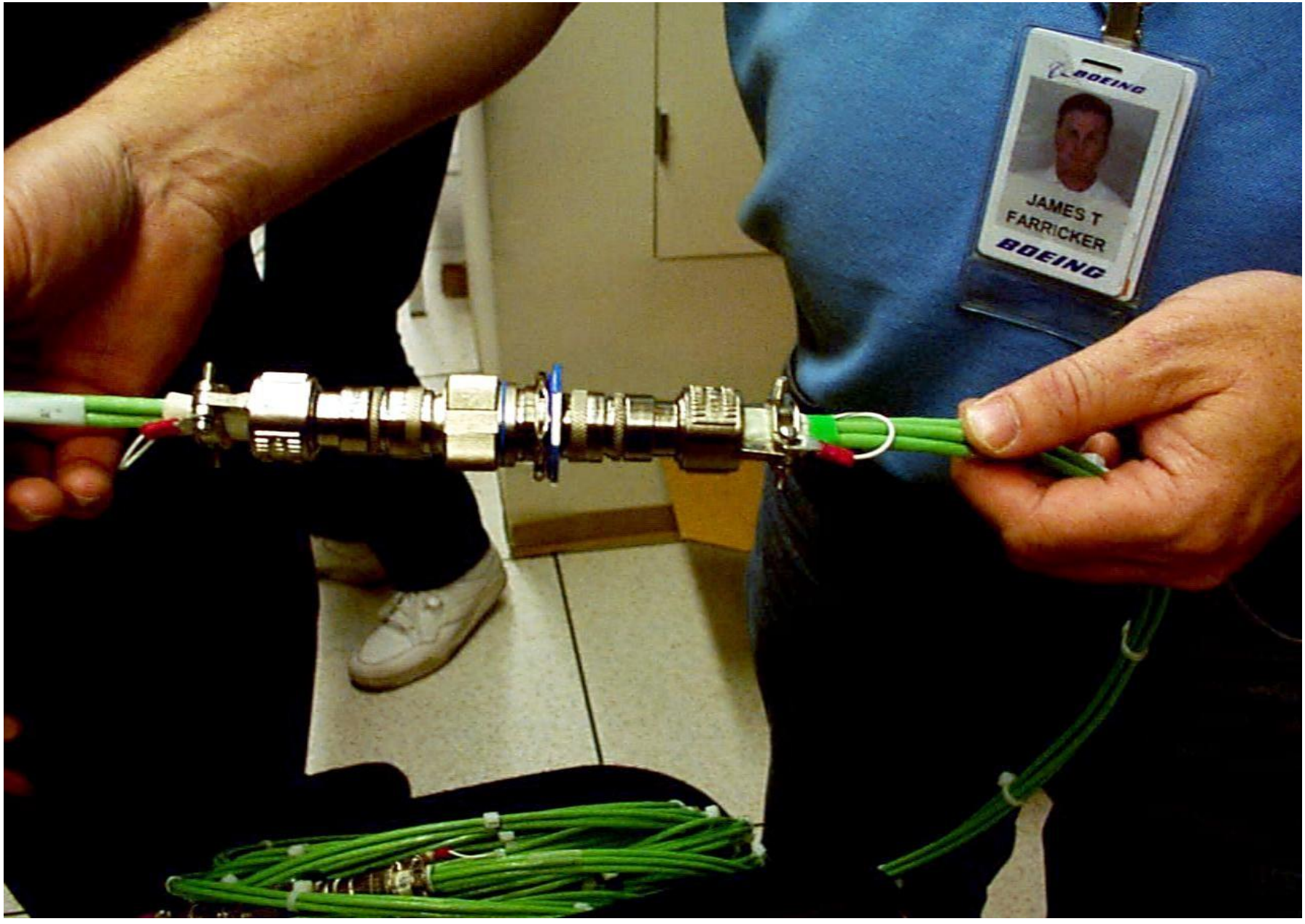
VoIP troubleshooting - connect inline for visibility into VoIP calls to quickly diagnose IP phone boot-up and call control problems and to measure key call quality metrics

PoE Measurements - verify readiness of PoE systems and troubleshoot PoE device problems

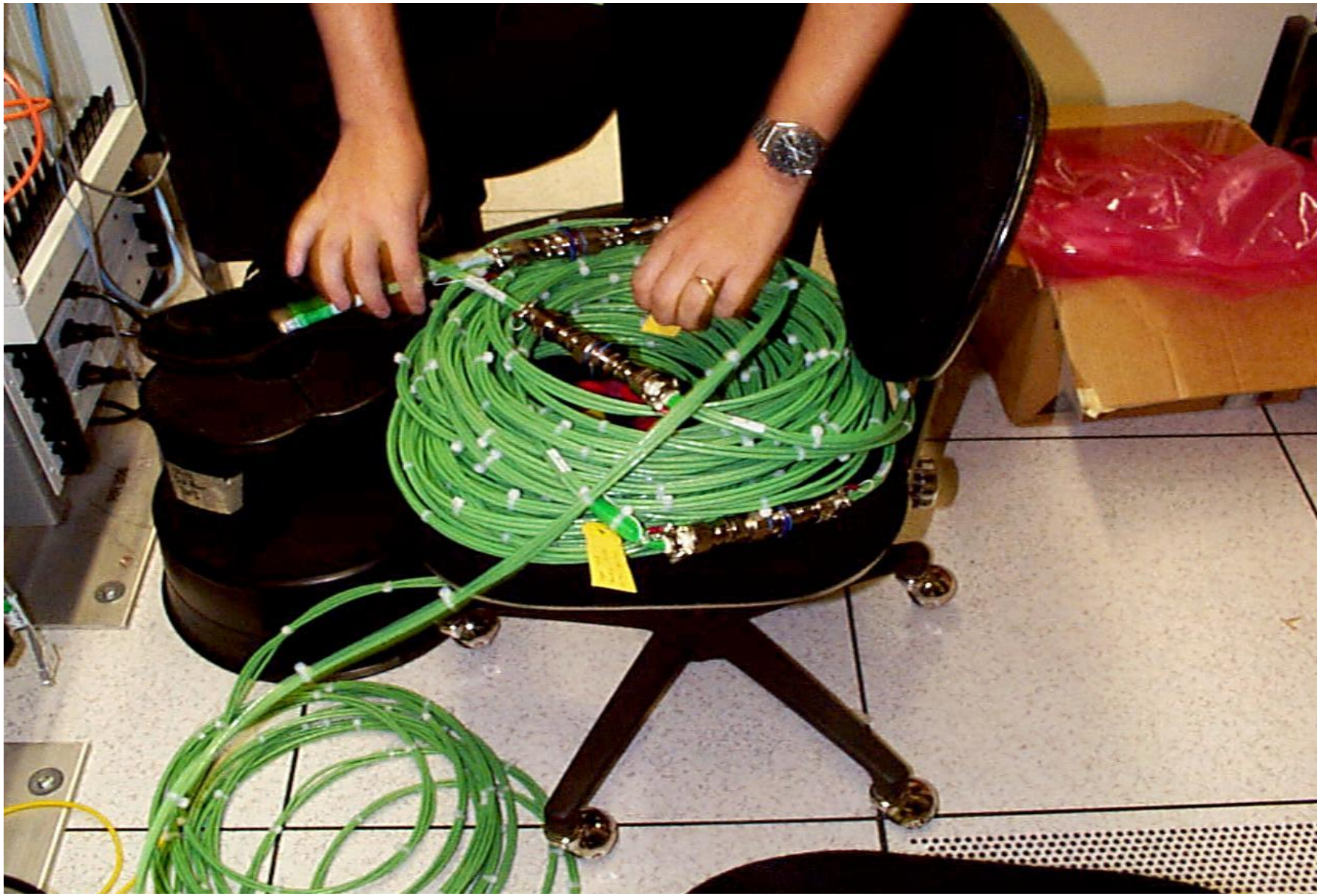
Spot available network resources – See MAC and IP addresses, subnet and services offered by active servers, routers and printers

IntelliTone digital signaling - quickly and safely locate cables on active network

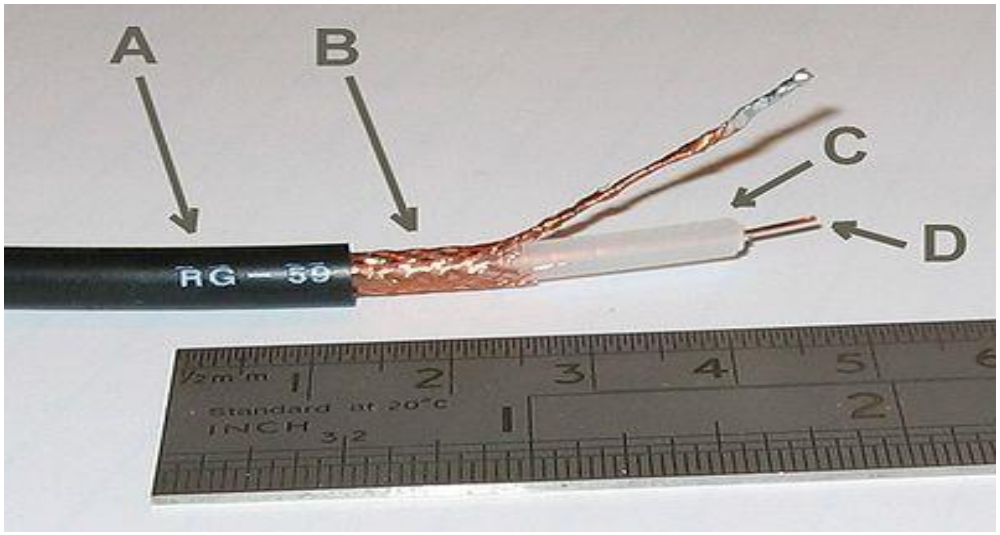
UTP Cable (ISS)



UTP Cable



Coaxial Cable



RG-59 flexible coaxial cable is composed of:
A: outer plastic sheath
B: woven copper shield
C: inner dielectric insulator
D: copper core

Coaxial cable, or **coax**, is an electrical cable with an inner conductor surrounded by a flexible, tubular insulating layer, surrounded by a tubular conducting shield. The term coaxial comes from the inner conductor and the outer shield sharing the same geometric axis. Coaxial cable was invented by English engineer and mathematician Oliver Heaviside, who first patented the design in 1880

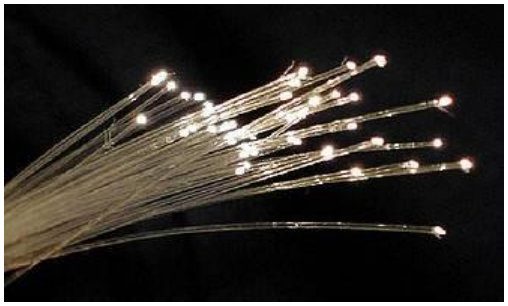
What applications use coaxial cable ?

What do the terms baseband and broadband mean ?

Fiber Optic Cable

Fiber Optics (FO) has now been installed for some time by telephone companies in place of copper plant supporting long distance services as well as private companies implementing local advanced data communications networks.

Fiber Optic communications converts a signal into a light form, which is then fired in a pulse through optical fibers. Optical fibers can be made out of glass or plastic, and either a laser or LED (depending on the type of fiber optics technology employed) carries the pulse of light.



Multimode fiber optic cable is used for short and medium distance applications, for example: 10/100/1000 Mb Ethernet over 62.5 micron fiber.

Single Mode fiber optic cable is primarily used for long haul communications applications, example: SONET for digital voice/data transport at speeds up to 140 Gbps (on each pair), 10 Gigabit Ethernet

Fiber Optic Cable

Advantages of Fiber as a Medium

Bandwidth - higher speeds supported (wider bandwidth) than metallic conductors, ability to multiplex many channels over 1 cable.

Electromagnetic Non susceptibility - not effected by electromagnetic radiation. Special conduits required to shield metallic cables not necessary for Fiber. Fiber does not generate cross-talk, therefore multiple fibers can be routed through one common cable, simplifying network design

Signal Attenuation - signal loss much less than metallic, where attenuation increases relative to frequency.

Electrical Hazard - absence of sparks alleviates danger of electrical shock or short circuit conditions. **This makes FO more suitable in potentially dangerous industrial condition**s such as petro-chemical operations, refineries, chemical plants and grain elevators.

Disadvantages of Fiber as a Medium

Expensive

Difficult to splice (sophisticated equipment, “clean” environment

Use an Optical Power Meter to Optimize Alignment for Maximum Link Robustness

Refer to Compete Installation Manual for Details

Power Meter Procedure

1. At site A, attach and power up a light source (media converter, or 850nm optical light source)
2. At site B, attach an 850nm Optical Power Meter set to read dBm to the “To Switch” ST connector on the rear of the transceiver with a jumper cable (must be 200-600 microns in diameter)
3. Fine align the transceiver with thumb screws to obtain the maximum receive light intensity. Repeat on opposite side.
4. Expected values in dBm are:

Air Link Distance (m)	Received Power for Model A		Received Power for Model B	
	μW	dBm	μW	dBm
10	266.7	-5.7	1190	-0.8
50	26.3	-15.8	118	-9.3
100	7.6	-21.2	34	-14.7
150	3.6	-24.5	16	-18
200	Not Applicable		9.2	-20.3
250	Not Applicable		6.0	-22.2

Microwave Communications

Microwave communications is the term used to describe point-to-point radio frequency communications. Digital microwave refers used to describe RF wave transmission in very high bandwidth. Most existing digital microwave systems are in the radio frequency transmission range of 18-23 GHz.

Microwave is a viable alternative in places not easily wired, and/or where cable facilities are hard to install & maintain including: Mountains, Swamps, Tundra, Islands & Sounds

Microwave is popular in places less densely populated with low traffic volumes where fiber facilities would be underutilized for long time to come.

Microwave Communications

Advantages:

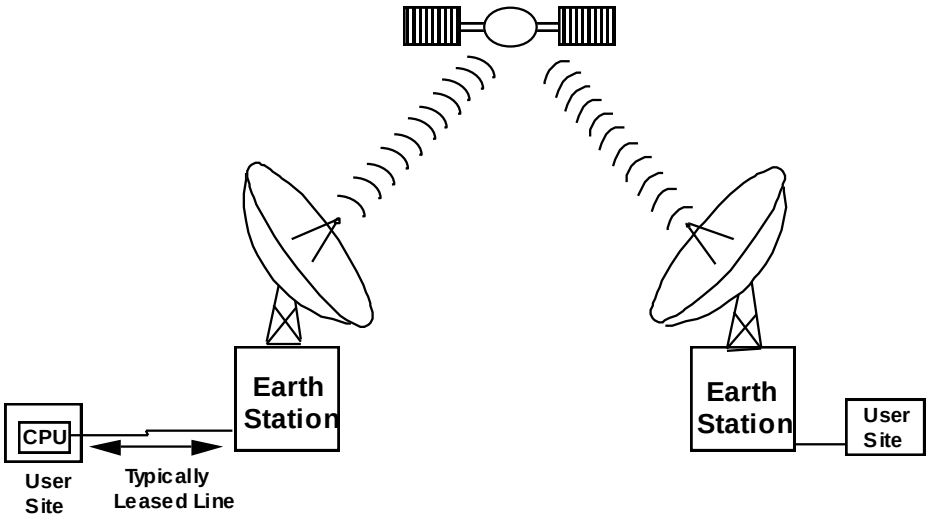
Speed (high speed microwave systems available)
Cost effective
Easy to Install/Implement (if available frequencies - governed by FCC)

Transmission speeds to 45 Mbps (per set of transmitter/receivers)

Disadvantages:

Limited to line of sight (curvature of the earth necessitates microwave transmitters and receivers be no more than 30 miles)
Interference from radio waves
Adversely affected by weather
Transmission insecure

Satellite Communications



Important Satellite Terminology:

Geosynchronous orbit: turns at same orbit as Earth, 22,500 miles up, requires 3 to 4 degree space between geosynchronous satellites to prevent interference. Satellites tend to wander as the Earth is not perfectly symmetrical, this is why satellite dishes must be constantly re-aligned (usually every 30 days) or have sophisticated auto-tracking capability.

Transponder: the transponder is the core of the satellite transmission system, making possible the actual transmit and receiving of data, Typically satellites have 24-48 transponder spaces, each one divided into subchannels. The transponder receives weak signal from earth station, amplifies it - changes frequency and retransmits. Satellites typically transmit and receive at different frequencies (to prevent interference on uplink/downlink).

Footprint: area of the earth where a signal may be received. Satellites can have a footprint from several hundred to several thousand kilometers. Signals from satellites with narrow, more directional footprints are stronger (proportionally) than those with wider footprints. Generally Ku-band satellites have a narrower footprint than C-band

Satellite Communications

Satellite Transmission Advantages:

High transmission rates
Communicate simultaneously to any number earth stations
Cost is not distant dependent (NY - Chicago costs the same as NY - LA)

Satellite Transmission Disadvantages:

Satellite propagation delay .5 to .7 sec
Sensitive to sunspots
Vulnerable to eavesdropping/interception
Interference with microwave transmission
Constantly re-aligning Satellite dishes
Interference from elements (rain and fog)

Satellite Transmission and Protocols

The unique characteristics of satellite have major effects on the efficiency, even practicality of supporting certain data communication data link protocols. Two important factors of satellite transmission are the 250 millisecond (one way) propagation delay, and the relatively high amount of noise on satellite channels. These factors must be considered when designing a network and choosing communications components and the data link protocols they will support.

According to literature, a protocol such as IBM's Binary Synchronous (Bisynch) at different message sizes and only effectively achieve a link efficiency of approximately 45 % (depending on message size and data rate).

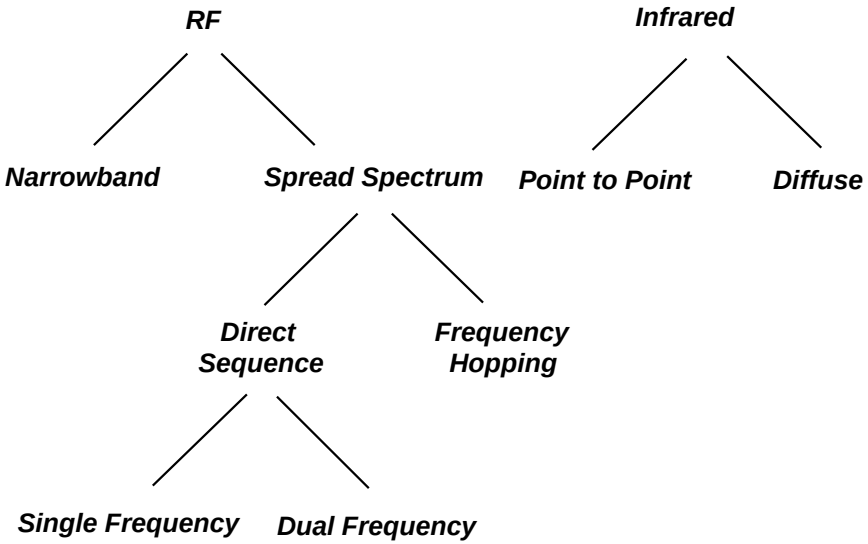
Sliding Window Protocols such as TCP/IP, SNA and X.25 permit multiple blocks to be outstanding and unacknowledged without stopping the sender from transmitting. The most efficient protocols for transmission over satellite are bit-serial protocols such as HDLC and IBM's SDLC. These types of protocols still require receipt of each frame from the receiving station, but the transmitting station may continue to send frames up to the limit specified in a counter (contained in each frame). This counter, which is incremented within the transmission of each frame, defines a frame window or *modulo* - that is the number of frames that can be outstanding before it must wait for an acknowledgment from the receiving stations.

Wireless Communications

Wireless technology has becoming increasingly popular, as they allow connectivity where wiring would be difficult, or in electrically noisy environments not practical for wired devices. Selection of wireless products is dependent upon applications specific variables such as:

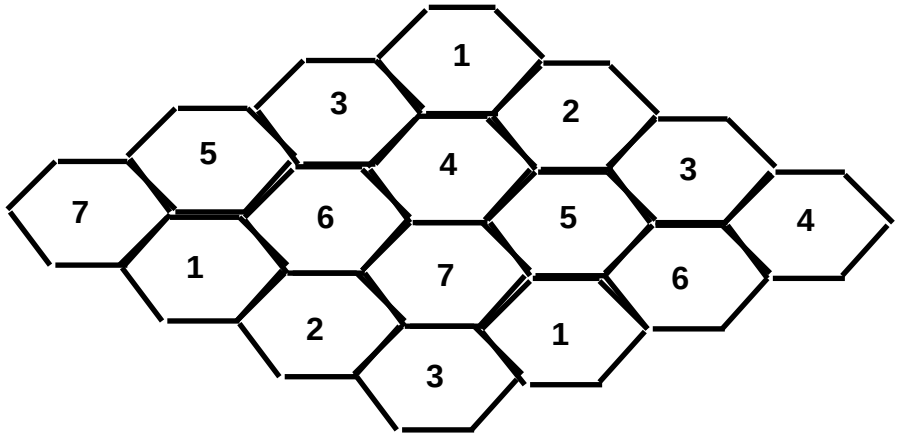
- **Distance**
- **Speed and Throughput**
- **Security**
- **Susceptibility to Interference (Unlicensed RF)**

The two major classes of wireless transmission technologies used today are RF (radio frequency) and infrared technologies. RF technologies are available in narrowband RF and spread spectrum RF. Spread spectrum is available in direct sequence and frequency hopping technologies. Infrared contains line of sight (point to point) and diffuse technologies.



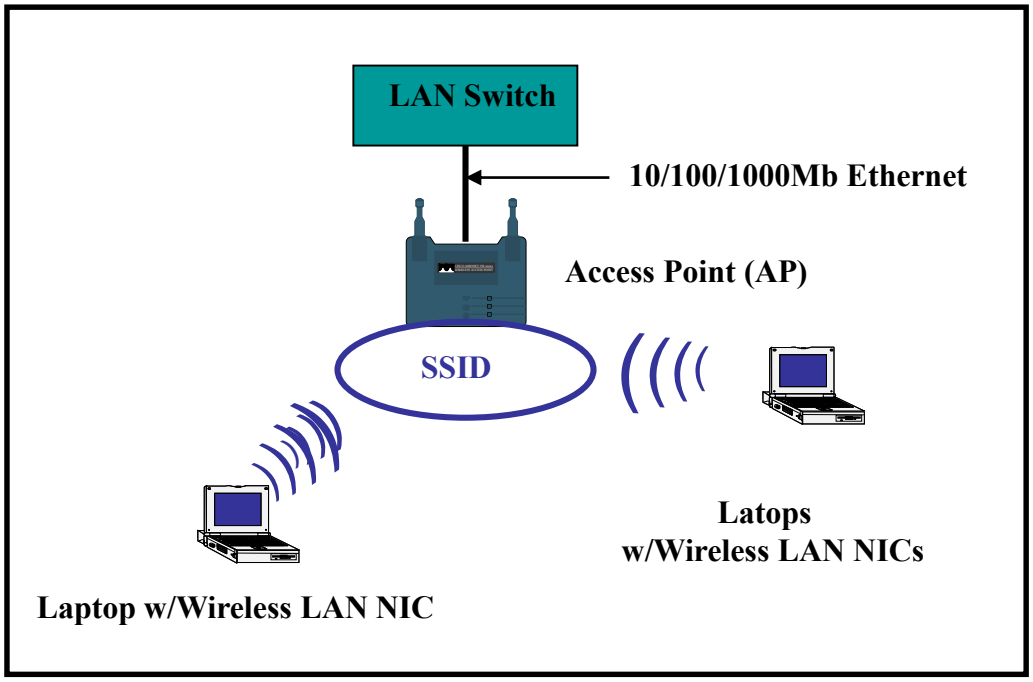
Wireless Communications

The **quality of a wireless channel** can fluctuate greatly during a single session, whether voice or data, resulting in high error rates and dropped data packets. The majority of wireless transmission problems occur at cell boundaries, when signal are switched from one cell to another



Wireless Figure, Cell Structure

Wireless Communications



Typical Wireless LAN topology

Wireless LAN standards:

IEEE 802.11 is addressing standards in wireless networking. 802.11b/g is the predominately installed WLAN while 802.11A/N is gaining wide acceptance

Wireless Communications

Advantages:

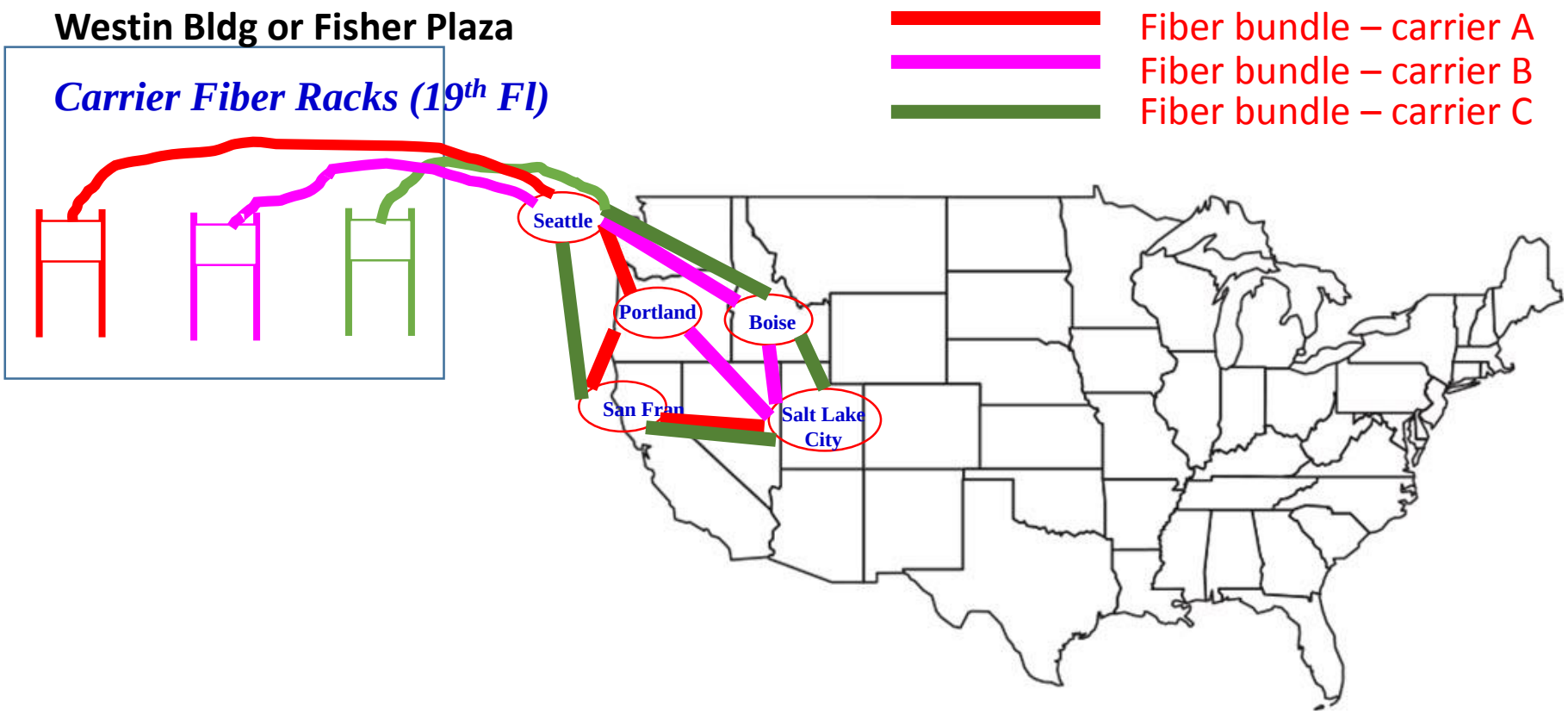
Speed (high speed systems available – 802.11A/N (5GHz)
Cost effective (versus wiring)
Easy to Install/Implement (unlicensed frequencies)

Disadvantages:

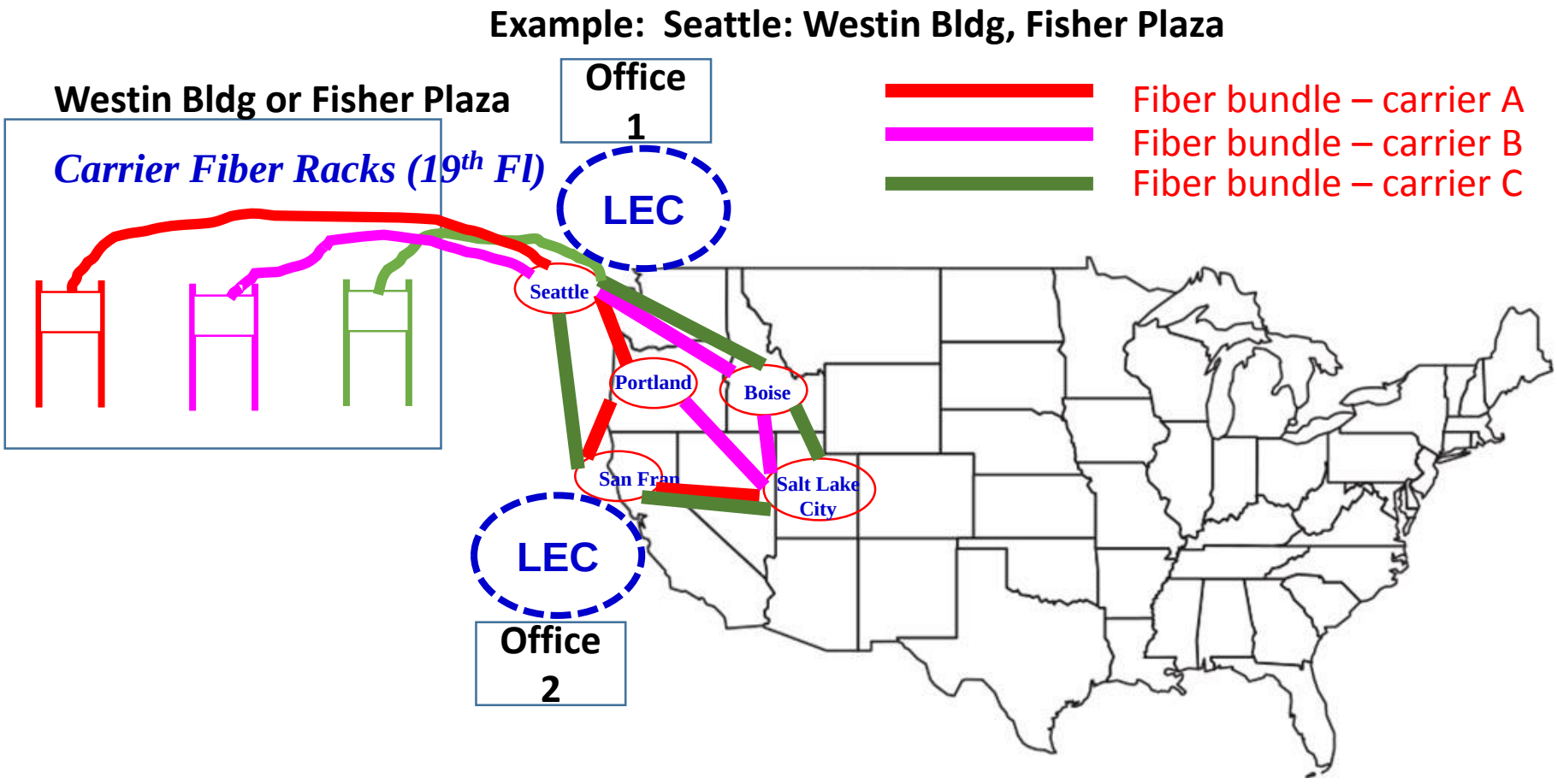
Distance/Cell Size
Interference - adversely affected by other 802.11 WLANs (RF/Spectrum Mgmt)
Transmission insecure

Carrier Hotels (where carrier long distance, inter-city fiber infrastructure) terminates in a city.

Example: Seattle: Westin Bldg, Fisher Plaza



Carrier Hotels (where carrier long distance, inter-city fiber infrastructure) terminates in a city.



Free Space Optics (FSO) Technology Overview

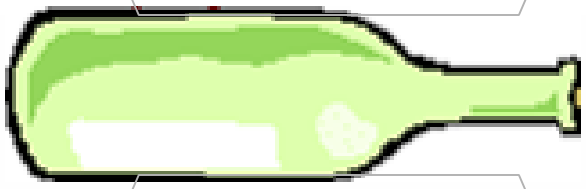
TERABEAM®

Why Free Space Optics (FSO)?

The "Last Mile" Bottleneck Problem

Wide Area Networks between major cities are extremely fast

- Fiber based
- >10-40 Gbps

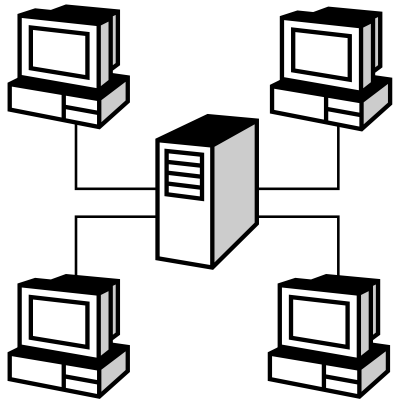


The connections in between are typically a lot slower

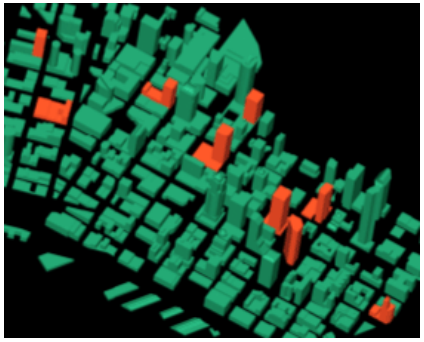
- 0.3-1.5 Mbps

Local Area Networks in buildings are also fast

- >100-1000Mbps



Only about 50 % of commercial buildings are lit with fiber

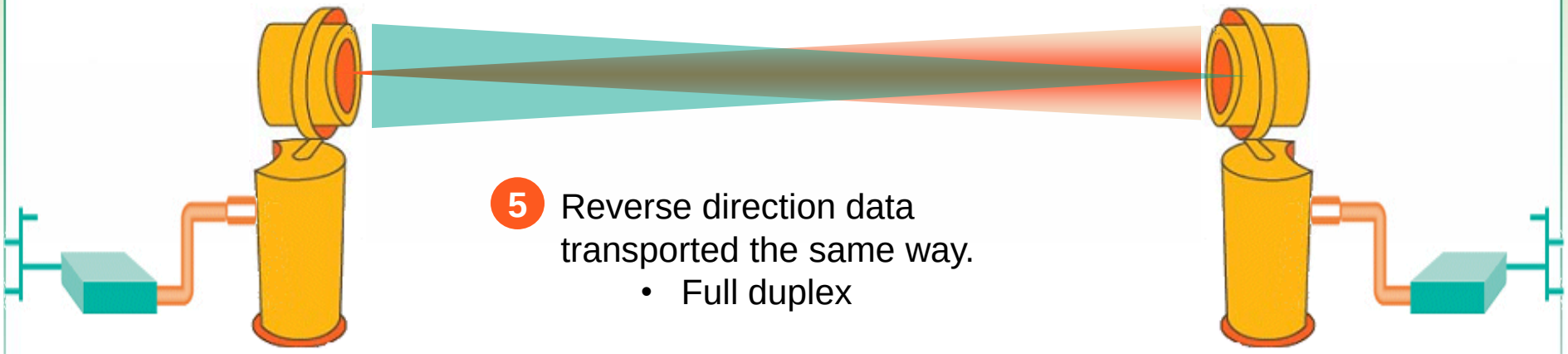


Why Free Space Optics?

How FSO Works

2 Transmitter projects the carefully aimed light pulses into the air

3 A receiver at the other end of the link collects the light using lenses and/or mirrors



5 Reverse direction data transported the same way.

- Full duplex

1 Network traffic converted into pulses of invisible light representing 1's and 0's

4 Received signal converted back into fiber or copper and connected to the network

Anything that can be done in fiber can be done with FSO

Why Free Space Optics?

Very Narrow and Directional Beams

- Beams only a few meters in diameter at a kilometer
- Allows VERY close spacing of links without interference
- No side lobes
- Highly secure
- Efficient use of energy
- Ranges of 20m to more than 8km possible

Why Free Space Optics?

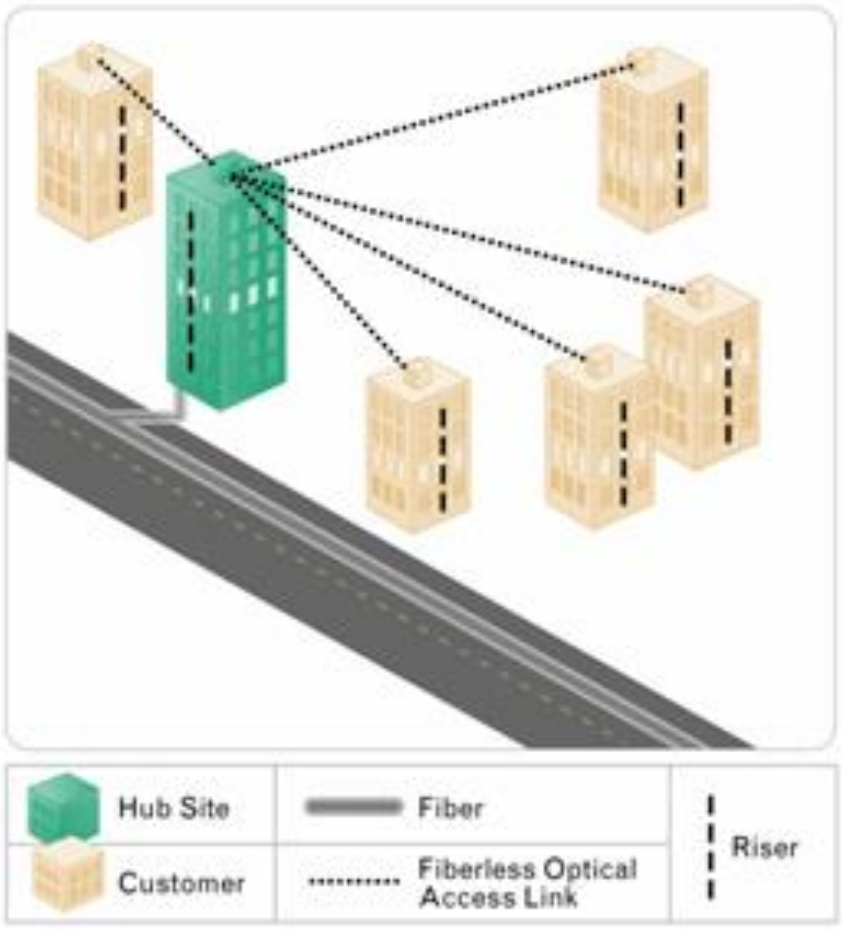
Deployment Behind Windows

- Rapid installations without trenching and permitting
- Direct connection to the end user
- Bypasses the building owner
  - No roof rights
  - No riser rights

Why Free Space Optics?

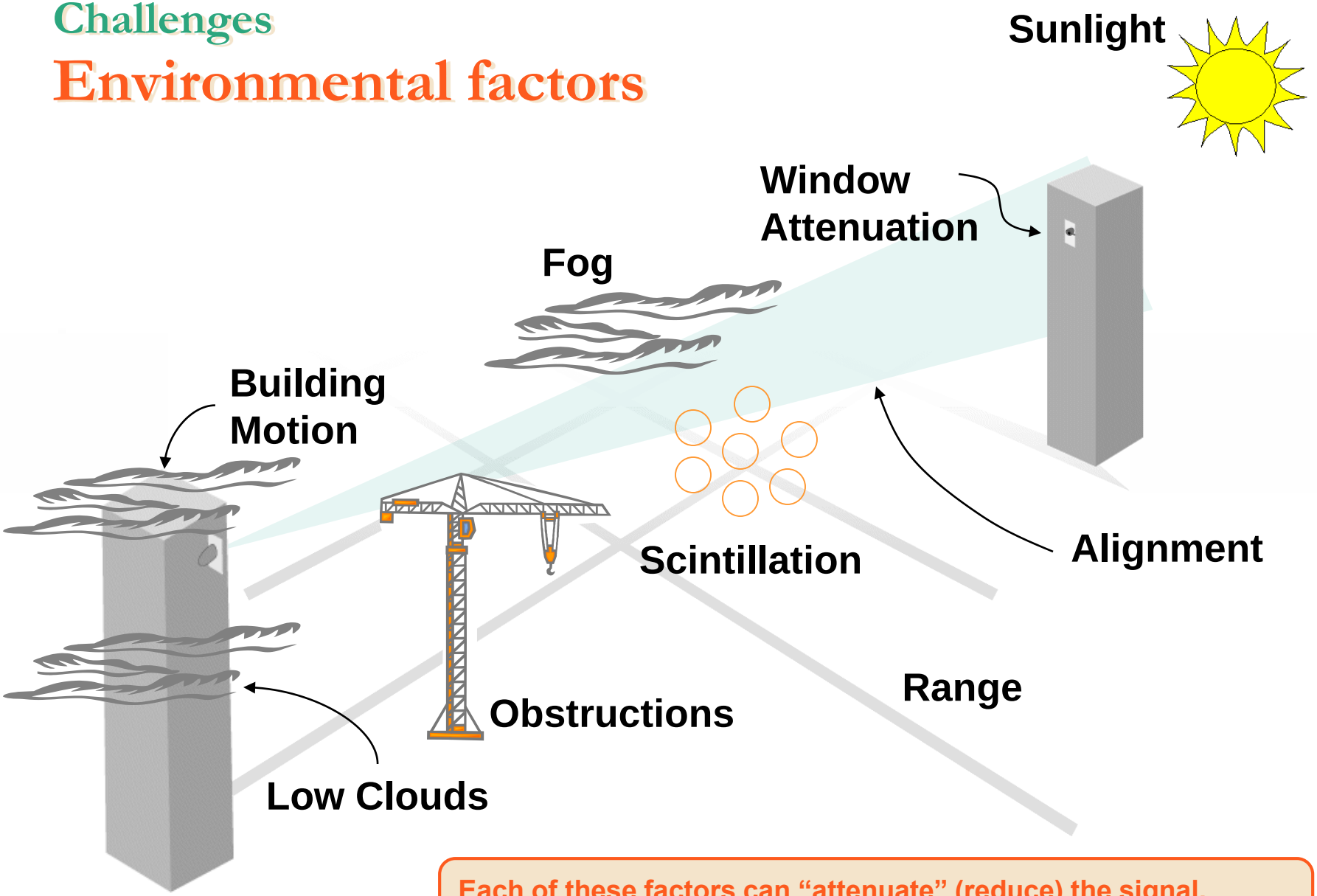
The FSO "Value Proposition"

- No interference
- Unlicensed
- Easy to install
- Through the window (or from the rooftop)
- No trenching, no permits
- Fiber-like data rates



Challenges

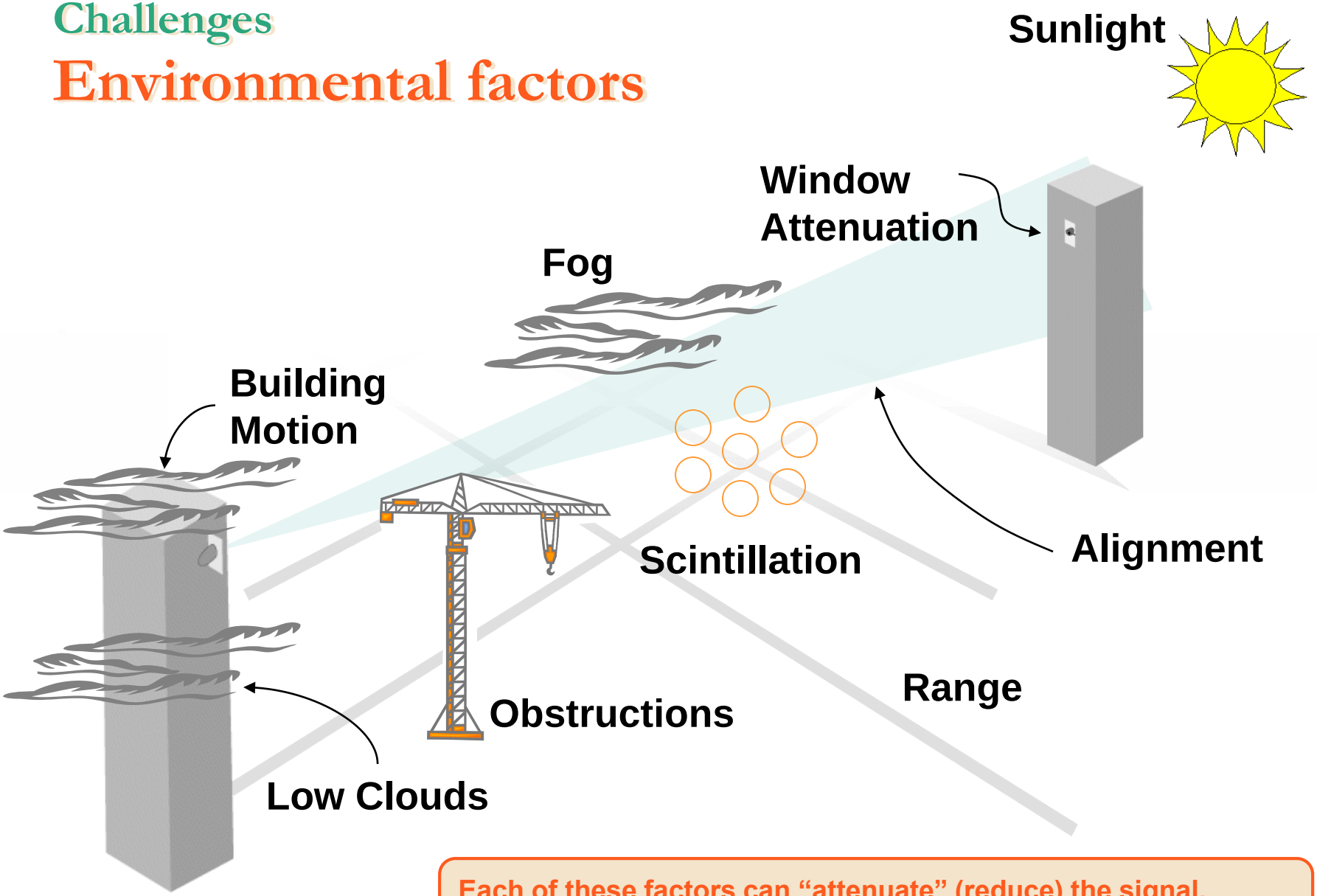
Environmental factors



Each of these factors can “attenuate” (reduce) the signal. However, there are ways to mitigate each environmental factor.

Challenges

Environmental factors



Each of these factors can “attenuate” (reduce) the signal. However, there are ways to mitigate each environmental factor.

Acknowledgements/Sources

Terabeam (FSO provider) – *now part of Proxim Wireless*

Fluke Networks (world class provider cable/network test gear)
http://www.flukenetworks.com/