UW i341 Networks & Dist Apps

Communications Media *(High Level Ver.)*

I Guided and Unguided Media

II Copper and Coaxial Cable

III Microwave

IV Satellite

V Fiber Optics

VI Wireless

- **Frequency Bands**
- **Cellular**
- **WLANS**

MEDIA SELECTION

The process of media selection involves more than deciding on solely the technical issues. One must select an architecture and topology, do a cost justification and work on the implementation details of installing the media. Other issues to be considered in the selection of media include:

* Selecting a vendor with a long term strategic product

* Determining current and long term connectivity and communications requirements

* Planning for the physical implementation including:
  - Cable runs
  - Locating processors and controllers
  - Jack location

* Facilities Planning

* Writing an RFP (Request for Proposal) and evaluating vendor responses

* Identifying major alternatives

* Evaluating the costs and savings associated with each alternative

* Staffing or contracting the skills required to design, install and maintain the network

* Managing the final bidding process with contractors

* Scheduling the actual installation, cutover and initiation using the new cabling system

Media Selection Criteria

Costs: This not only includes the cost of the medium, but ancillary costs such as additional hardware/software/diagnostic and network management tools required. The cost of future expansion is a key issue.

Speed: Factors affecting speed include meeting vendor specifications to run particular network applications at desired speed (example – Gigabit Ethernet/FastEthernet over copper, IBM specification requiring STP (shielded twisted pair) to run 16 Mb Token Ring).

Availability: Shared services (switched circuits), holidays and peak traffic times become critical issues. Satellite services in poor weather, during sunspot interference, times required for communications equipment outages and/or maintenance.

Expandability: To add new devices, or to add new locations

Designing for future requirements (LANs, MANs)

Security: Level of security desired and required

Analysis if ability to intercept and penetrate communications

Distance: Number of locations and their distance from data closets or wiring concentrators/hubs/switches.

Dealing with campus environments (inter-building considerations)

Environment: Right of Ways (easement restrictions) Physical Constraints (temperature, water or chemical exposure) Areas of high electrical or magnetic interference
Dealing with environmental issues (nature).

Media Comparison Chart

	Local Area	**Metropolitan**	**Wide Area**
Media:	Coaxial Cable	Coaxial Cable	Fiber
	Twisted Pair	Fiber	Satellite
	Fiber	Microwave	Microwave
	Wireless	Twisted Pair	Twisted Pair
Speed:	Very High	Very High	Low to High
Major Issues:	Facility Support Topology/Arch Media Availability Media Access/Owner	Distance Right of Way Line of Sight Media Access/Owner	Regulatory Issues Media Availability Support/Maintenance Media Access/Owner
Major Costs:	Labor/Installation Media Access Media	Labor/Installation Media Access Media	Tariffs Lease Fees
Ownership:	Private (Building Owner ?)	Private or Public	Private or Public

WIRE - CABLING

Wiring a building is an expensive proposition. According to sources (Network World), the costs of re-wiring limits most installations to buying and installing cable only one time per decade. In the government and education sectors, this is more likely one time every 20-30 years. It thus becomes critical to understand the wiring requirements of existing devices, and plans to support future applications when planning on a strategy to wire (or rewire) a building.

Most network managers choose to select a cable plan that gives them flexibility, including several types of wiring that not only support current application requirements, but additional future requirements to help prolong the life span of the cable plant.

Cabling Choices might include:

1. **Optical Fiber** for high and low speed LAN applications, imaging and video applications.

2. **Low grade unshielded twisted pair** for voice traffic.

3. **High quality unshielded twisted pair** for LAN traffic.

4. **Wireless** Technology for LAN traffic. (802.11x)

Why is cabling and media critical ?

Cabling is an extremely important portion of network reliability, as studies (IDG, October, 28, 1995) have disclosed that they have found 35 % of network downtime has been attributed to problems at the physical layer. This would include problems with cabling and connectors. As far as the monetary implications, network and data communications industry experts/journals indicate that media can account for up to 60% of the cost of a LAN.

Where to get help: (EIA/TIA Standards)

The best source of information and help available is the structured cabling specifications developed by the **EIA and TIA** (Electronic Industry association and Telecommunications Industry association. **EIA/TIA 568** is a commercial and industry building wiring standard that provides guidelines on how to design a structured cabling system. The EIA/TIA standard breaks a building into components including the backbone, wiring closets and horizontal cabling. The standard also specifies the type of cabling for each component.

The EIA/TIA standards are general enough to allow users a choice in design and media, this gives the advantage of designing a cable plant to meet every conceivable networking requirement, and the disadvantage of the standard being so general, the network manager is not given enough specific information, particularly in horizontal cabling.

There are **emerging philosophies** as far as **LAN cabling** goes:

1. Optical Fiber to the desktop

2. Unshielded Twisted Pair (UTP) to the desktop.

    Using Existing Category 3 cable plant
    Replacing Category 3 with Category 5
    Installing Category 5 Cabling system

3. Shielded Twisted Pair to the desktop, locations wired with IBM Cabling System (Type 1) cabling

4. Using Wireless Technology

    LANs using 802.11x (802.11A/B/G/N) – especially in ***green field*** scenarios.
    Decision based on duration at location, reliability/availability & security concerns.
    * Cellular infrastructure – coverage in buildings/campus.

Unshielded twisted pair to the desktop is an attractive alternative because it allows cabling systems to support data networking in the same manner they support telephone cabling. Optical fiber advocates cite the high bandwidth, immunity from electromagnetic interference and crosstalk as advantages over UTP. Currently fiber to the desktop is more difficult and expensive to install, trends that are changing due to clever innovations in technology and installation.

Twisted Pair - **true twisted pair consists of:**

Two solid copper conductors, each encased in a PVC (polyvinylchloride) sheath.

A copper conductor diameter between 20 AWG and 26 AWG (American Wire Gauge)

A twist rate for each pair of 2 to 12 twists per foot.

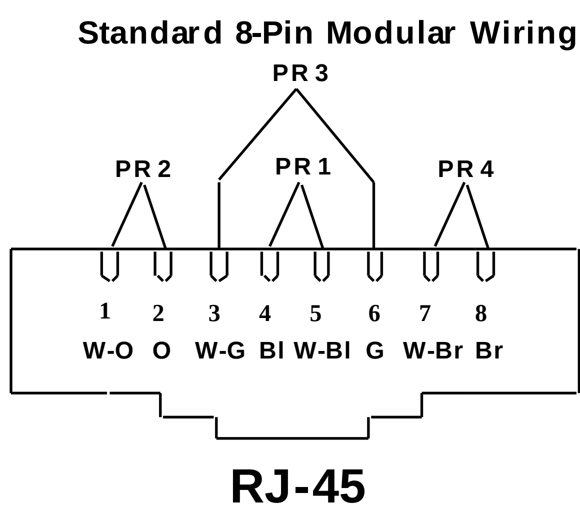
A color coding scheme involving set colors representing the tip and ring (or + and -) for each pair.

A characteristic impedance between 90 ohms and 110 ohms.

Twisted pair cable is susceptible to nonconductive electrical currents (i.e. magnetic fields). For this reason, the pair of copper conductors encased individually in an insulating material are twisted together. The twisting of the conductors helps make the cable immune to electrical noise and crosstalk.

The banded color coding scheme of twisted pair cable make a color pattern that identifies what conductors make up a pair, and what pair in sequence it is relative to other pairs within a bundle (multipair sheath). This is also used to determine which conductor is the tip and which is the ring (or + and - in the data world). The banding scheme uses two opposing colors to represent a single pair. One color is considered primary and the other color secondary.

In multipair cables, the primary color is responsible for an entire group of pairs (five pairs total). The first five pairs usually have the primary color of white. Each of the secondary colors (blue, orange, green, brown and slate) are paired in a banded fashion with white. The following illustration Cable-Figure 1, shows typical color allocation for RJ-45 (for PDS wiring).



Cable-Figure 1, Color Allocation for RJ-45

Important Terminology: (Basic Electrical Characteristics of a Cable)

Impedance: The total electrical resistance of a metallic cable to an electrical signal. The electrical impedance of a cable is significant since an impedance level too high or too low can adversely affect the distance an electrical signal can travel while still maintaining a recognizable pattern. An impedance mismatch between two cables spliced together (for example a horizontal distribution cable and vertical riser cable can cause signal reflections and/or decrease the strength of the original signal. When an electrical signal encounters a large change in the characteristic impedance of a cable (usually rated as ≥ 15 ohms) the signal can bounce or reflect off the new cable segment, leaving a weakened original signal still traveling in the original direction. The reflected signal can interfere with other signals being sent down the cable. This is extremely important in cable installations supporting high speed applications such as Ethernet or Token Ring over UTP which have specific distance ratings based upon electrical cable characteristics.

Attenuation: A measurement in decibels per thousand feet (dB/kft), which represents the loss of an electrical signal as it travels down a path. The loss of signal strength can adversely affect the ability of an end device to properly recognize and interpret a signal.

Capacitance: The amount of electrical signal that passes from one cable to another as a result of the difference between the electrical currents present in the two cables. This is measured in nanofarads per thousand feet.

The most important cable characteristic to monitor is the cable impedance, which best represents the ability of a cable to properly pass a communications signal.

Shielding

Any copper communications cable is susceptible to EMI (electromagnetic interference) or cross-talk. To protect against this type of interference which can be disruptive to communications signals, a shield, consisting of a braided mesh or solid metal conductor. At one end of the cable (typically the cross-connect end), the cable shield is connected to the telecommunications ground through either the mesh shield or a drain wire (a solid conductor in the mesh shield). While shielding can protect the integrity of a communications cable, it can have adverse effects by slightly altering the electrical characteristics of the cable. This can actually reduce the allowable distance with systems that are not intended for use with shielded cables (i.e. systems designed for UTP).

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. The deal is that is that 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. While 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.

* When pricing a complete wiring system, such as one installed to support a PBX and/or LAN, a price range of $300.00 to $450.00 per cable run can be used as a general guideline. This price includes installation labor as well as all physical components (plugs and receptacles). Cost will vary depending on the quality, quantity and type of installation (new construction, renovation, age of building and installation location).

Twisted Pair Cable Classifications (Categories):

In choosing to support particular network applications (especially LAN 10BASE-T/100Base-TX,1000 Mb Gigabit Ethernet, and Token Ring systems, and the associated wire and wire concentrator/hub components, it is important to recognize and understand the broad range of performance characteristics of cable options. The introduction of new wire hub (concentrator cards) can typically render obsolete a previously acceptable cable.

Twisted Pair Cable Classifications (Categories):

EIA/TIA Category	Applications (Source AMP Publ.)
Category 1	POTS Analog Voice Digital Voice
Category 2	ISDN (data) 1.44 Mbps T1 1.544 Mbps Digital Voice IBM 3270 IBM AS/400 and System/3X
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)
Category 5 Extended Frequency UL Level V	10 Base-tx (100 Ohm) 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

Testing the Installed Cabling

The IEEE has recommended two additional tests to qualify Category 5 cabling. The 1000BASE-T Task Force has made this recommendation for two reasons: First, Category 5 systems installed prior to the completion of ANSI/TIA/EIA568-A in 1995 may contain connecting hardware that does not comply with the standard. Second, the 1995 cabling standard did not specify two critical performance parameters return loss and Far-End Crosstalk (FEXT). Return loss defines the amount of signal energy that is reflected back towards the transmitter due to impedance mismatches in the link (such as those caused by connectors). Far-End Crosstalk is noise on a wire pair at the far end from the transmitter (i.e., at the receiver) caused by signal leakage from adjoining wire pairs. It is measured at each wire pair as Equal Level Far-End Crosstalk (ELFEXT) or as Power Sum ELFEXT (PSELFEXT) which sums the total noise from all adjacent wire pairs.

Correcting Problem Cable Installations

If the cabling link doesn't pass Category 5 transmission performance tests and the new return loss and Far-End Crosstalk tests, the problem is most likely in the connectors or patch cable rather than the horizontal cable. ANSI/TIA/EIA568A-1995 allows four connectors in a Category 5 link (see Figure 1 below). Connectors are the major causes of both return loss and far end crosstalk, and cable connector vendors have made significant improvements in connector performance since Category 5 connecting hardware was first introduced. Figure 1 shows a Category 5 UTP horizontal cabling system as per ANSI/TIA/EIA-568-A (1995).

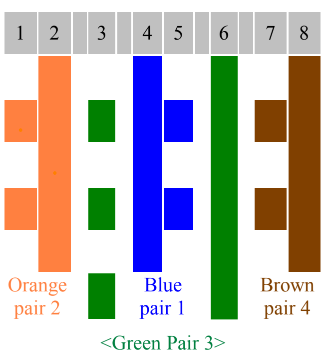
(See Comm. Media Detail) How to make a cat 5 Cable

(aka: How do I make a category 5 patch cable?)

There continues to be Controversies over standards and practices regarding the use and making of patch cords, & UTP cable in general.

568-B Wiring (RJ-45)

<RJ-45 Pins 1-8 Facing Up>

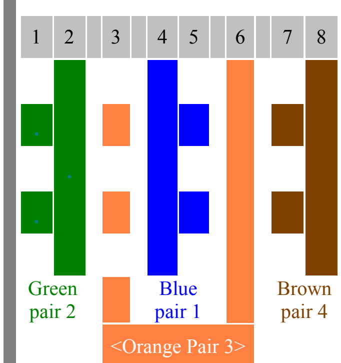


<<<<<568B Wiring>>>>>

Pair #	Wire	Pin #
1 - White/Blue	White/Blue	5
	Blue/White	4
2 - White/Orange	White/Orange	1
	Orange White	2
3 - White/Green	White/Green	3
	Green/White	6
4 - White/Brown	White/Brown	7
	Brown/White	8
568 B Diagram		

568-A Wiring (RJ-45)

<RJ-45 Pins 1-8 Facing Up>



<<<<<568A Wiring>>>>>

Pair #	Wire	Pin #
1 - White/Blue	White/Blue	5
	Blue/White	4
2 - White/Green	White/Green	1
	Green/White	2
3 - White/Orange	White/Orange	3
	Orange/White	6
4 - White/Brown	White/Brown	7
	Brown/White	8
568 A Diagram		

Notes for wiring diagrams above:

1. For patch cables, 568-B wiring is by far, the most common method.
2. There is **no difference** in connectivity between 568B and 568A cables. Either wiring should work fine on any system*. (*see notes below)
3. For a straight through cable, wire both ends identical.
4. For a **crossover cable**, wire one end 568A and the other end 568B.

5. Do not confuse *pair numbers* with *pin numbers*. A pair number is used for reference only (eg: 10BaseT Ethernet uses pairs 2 & 3). The pin numbers indicate actual physical locations on the plug and jack.

Controversies and Caveats : Category 5, 5E, and Cat 6 Patch Cables	
568B vs. 568A	For patch cables, 568-B wiring is by far, the most common wiring method. Virtually all pre-assembled patch cables are wired to the B standard. There is **no difference** in connectivity between 568B and 568A cables. Therefore, a 568B patch cable should work fine on a 568A cabling system, and visa-versa. To my knowledge, there has never been an issue with networks of up to 100 megabits. However, with the advent of Gigabit over copper cabling, it may very well become a factor at some point. We have conferred with several cable manufacturers, and many other technical resources, on this subject. The consensus is that mixing of the standards on patch cables should not cause a problem. Since Gigabit networks over copper cabling are in their infancy, and no one can say for sure, we would advise our customers to take the safe approach on all future patch cable orders. We now offer our custom cat 5E and category 6 cables in both 568A and 568B wiring schemes for this reason.
Cat 5E and Cat6	Category 5E and Cat 6 cables require a special offset connector that is different from a standard category 5 connector. In addition, the intricate assembly of these cables can be difficult to do in the field. They require sweep testing with sophisticated instruments to assure performance. This is why we do not recommend making of cat 5E and cat 6 patch cables in the field. For true cat 5E, or cat 6 performance, we strongly recommend our factory made cables. Category 5 E, 350 Mhz Custom Cables Category 6 Giga-Speed Custom Cables
Re-use of old cables	We have seen this happen time and time again. Perfectly good patch cables that have been working fine for years, get removed from their installation, and re-installed on the same, or different network. The result can be a nightmare. What happens is that the cable, over time, adapts to the way that it is bent in it's original installation. When these cables are removed and re-installed, they can either completely loose their connection, or develop intermittent problems. This is due to stresses that may be opposite to what they were originally subject to. If the integrity of your network is more valuable than the price of new patch cables, then we strongly suggest that you use brand new cables for all closet cleanups, network moves, etc.
Stranded vs. Solid wire	A true patch cable is made from stranded wire only. Almost all of the patch cables that are made have stranded wire. Stranded wire is specified for use in patch cables due to it's superior flexibility. There has been some talk recently, in the technical sector of the structured wiring community, regarding the possible use of solid conductors for patch cables. The reason for the spotlight on solid wire is that it is supposedly more stable, under a variety of conditions. Only a small portion of the technical community, subscribe to this notion. Therefore, we will continue to make our patch cables from stranded wire. We can make solid wire patch cables if requested. Please contact sales for a quote.

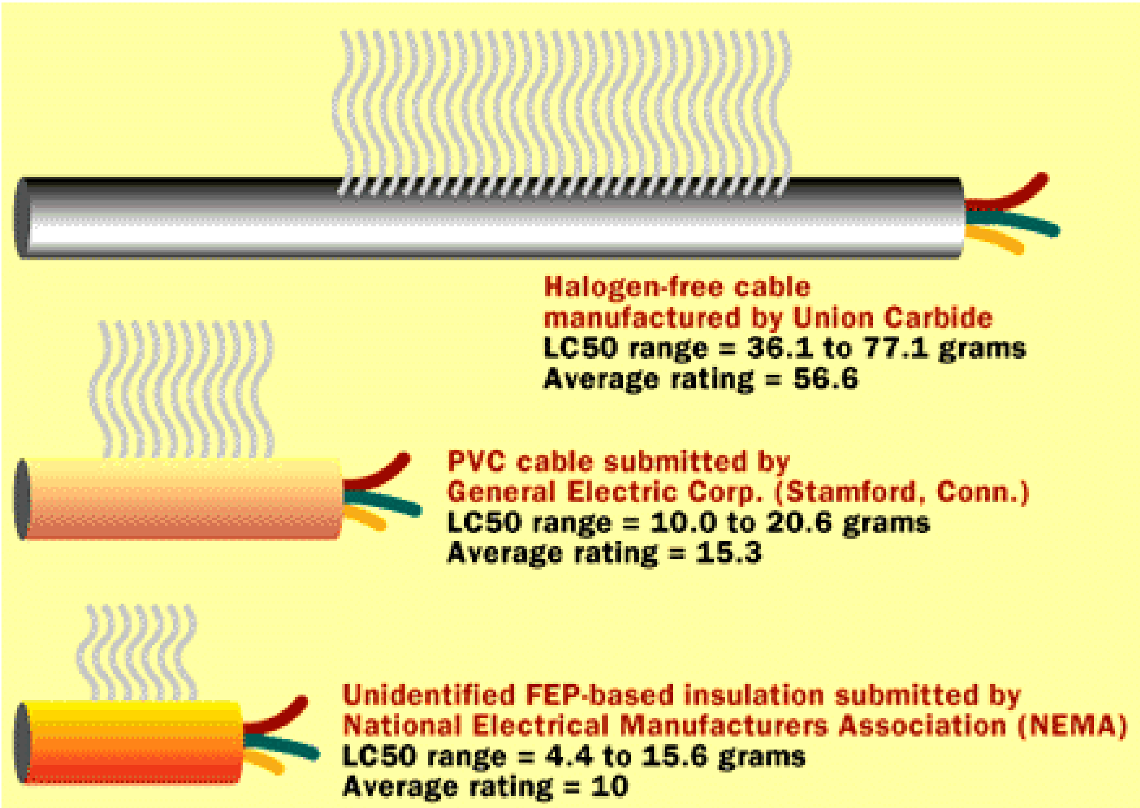
Toxic Cabling (The Importance of Sheathing and Plenum Rating)

Cabling: What You Don't Know Can Kill You

Source: Stephen Saunders, *Data Communications: Tutorials*, July 1996

Halogen cabling can emit toxic fumes in a fire. Many international governments have moved to less lethal alternatives.

There's something corporate networkers should know. A good deal of the cable they're now pulling at central sites and branch offices across the U.S. contains halogens--chemicals that give off toxic fumes when they burn. In a fire, halogen cable can release acid gases that sear the eyes, nose, mouth, and throat. The fumes can disorient victims, preventing them from escaping the blaze. They can cause severe respiratory damage. And they can kill. Recognizing this potentially deadly problem, a number of international governments have already standardized on zero-halogen cabling. But the U.S. National Electrical Code, which serves as the basis for local standards in 45 states, effectively forces net managers to use halogen-sheathed Category 5 UTP in the plenum spaces above ceilings and below floors in office buildings. And while some organizations that are exempt from local building codes - like the military and mass transit authorities, have banned halogen cabling from their networks, most net managers have little choice but to obey the law.



Twisted Pair Technical/Managerial Issues:

Documentation - survey of existing cable to show unmarked pairs, and general condition of terminations Often spare pairs are abandoned, bad circuits not punched out. Cable documentation should list point to point termination of all in-house cable.

Interference problems - worst source of interference has been analog telephone ringing signals. Combining wires from different applications - combining wiring for ASCII terminal running over 9600 Bps in same cable pair as Token ring might cause interference problems.

Suitability of existing cable - there are several ways to determine suitability of existing twisted pair - most obvious is continuity - ability to send a signal from one end of wire in the wiring closet to the end of the cable at the workstation. This may be tested with a volt-ohm meter (VOM) or a tone generator

Cable length - Determining how long existing cable should be is essential for successful high speed data applications. IBM Token Ring and Ethernet hub/switch distance from the wiring closet to workstation may not exceed 330 feet.

When documentation does not exist for cable lengths, an exotic test called Time Domain Reflectometery (TDR) can be used. TDRs send a short volt spike down the cable being tested, when this pulse encounters a change in cables conducting characteristics (fault or end in the cable), part or all of the energy is reflected back to the TDR unit, the test pulse and reflections are displayed, allowing precise measurement of cable distance.

Universal Wiring Systems - provide an integrated voice/date wiring strategy/plan that will grow as the organization does. Two of the most popular include:

AT&T PDS Premise Distribution System (see attached diagram)
IBM Cabling System (see attached diagram)

IDFs - Standard Telephone practices locate **Intermediate Distribution Frames** (IDFs) or wiring closets fairly close to the telephones they serve.

Cabling Note: - a consultant when asked said, considering the time necessary to locate, test and document existing wires, if its not justifiable or easier to add new cable - "Even when working with bad documentation - I could locate, test and document 15 existing pairs for less cost than running a new cable to one location.

Cable Test Equipment

TDR
TDR = Time Domain Reflectometer (measures cable lengths, locates impedance mismatches).

Tone Generator
Tone Generator and Inductive Amplifier = Used to trace cable pairs, follow cables hidden in walls or ceiling. The tone generator will typically put a 2 kHz audio tone on the cable under test, the inductive amp detects and plays this through a built-in speaker.

Wire-map Tester
Wire-map tester: checks a cable for open or short circuits, reversed pairs, crossed pairs and split pairs.

Noise Tester
Noise tests, 10Base-T: the standard sets limits for how often noise events can occur, and their size, in several frequency ranges. Various handheld cable testers are able to perform these tests.

Fiber Optic Test Equipment

Continuity tester: used to identify a fiber, and detect a break. One type resembles a f/o connector attached to a flashlight.

Fault locator: used to determine exact location of a break. Works by shining a very bright visible light into the strand. At the break, this light is visible through the cable jacket.

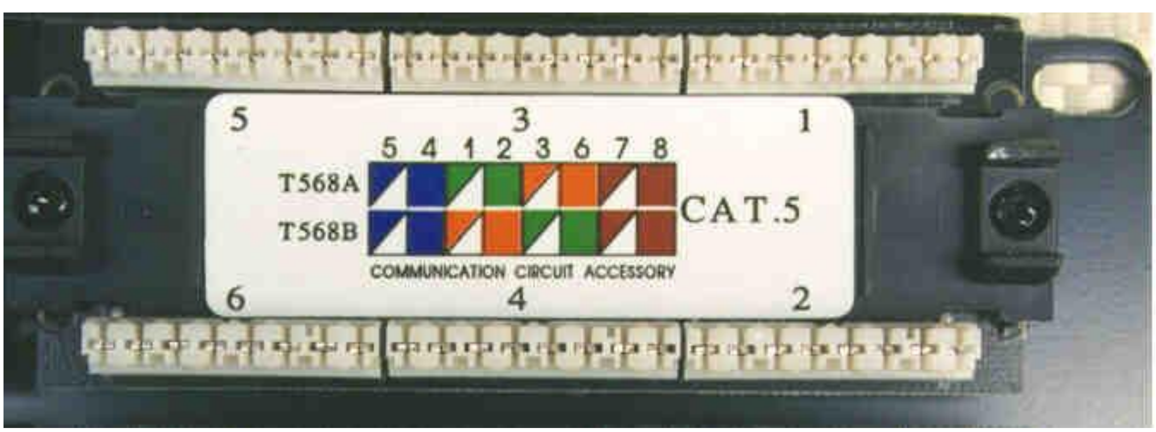
Tone Generator and Tracer: used to identify a cable mid-span or to locate a strand at its far end. Similar in purpose to the tone testers used on copper cable. The tone generator imposes a steady or warbling audio tone on light passing down the cable. The tracer detects and recovers the tone from light lost through the cable jacket as a result of bending the cable slightly.

Optical Source and Power Meter: used to measure the end-to-end loss through a f/o strand, or system of cable, connectors and patch cables. Measurements are more accurate than an OTDR, but an expensive item.

Optical Time Domain Reflectometer (OTDR): used to measure the length of a cable, and detect any flaws in it. Can also be used to measure end-to-end loss, although less accurately than a power meter.

Fiber Talk set: allows using a pair of f/o strands as a telephone line.

Typical Wiring Layout



Punch Down Block

Wiring Closet **User Work Area....**

[HUB]<===>[PANEL]+===+[BLOCK]+==========+[WALL]<=====>[STATION]

Where ...
HUB = concentrator
PANEL = RJ-45 Modular Patch Panel
BLOCK = Telco Splice Block (Typically 25-pair)

Crossconnect: NorTel BIX1A, AT&T 110 and similar crossconnect blocks accommodate 4-pair, 25-pair or larger cables on the same mount. The same type of mount can be used for the voice field as well as data.

Telephone-only (66) blocks are seldom used except for low-speed data circuits such as are used for IBM 3270 terminals. The newer types of crossconnect mentioned above cost about the same and accommodates growth much better. (The standard AT&T 110 and its BIX equivalent are rated at Cat 5).

LOBE CABLE = Cable run from user wall plate to wiring closet
WALL = User area wall face plate
STATION = User workstation network adapter
=====> = RJ-45 connector
=====+ = Punch down termination (also called an insulation-displacement/displacing connector, or IDC).

MICROWAVE

Microwave communications is the term used to describe point-to-point radio frequency communications using centimeter and millimeter wave transmission. 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, including:

Mountains
Swamps
Tundra
Islands & Sounds

Microwave is also a viable alternative in cases where cable facilities are hard to install & maintain

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

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 & receivers be no more than 30 miles)
Interference from radio waves
Adversely affected by weather
Transmission insecure

Satellite Communications

Satellite communications transmission technology offers the capacity to carry data, voice and video communications traffic. Satellite communications has been used extensively in many areas of the world, and has become an integral part of the communications infrastructure of most countries. This includes developing nations as well as those with the more advanced technology networks.

Recent advances in satellite communications technology have provided transmission systems that are easy to install, very cost-effective and can easily accommodate addition of new sites/locations.

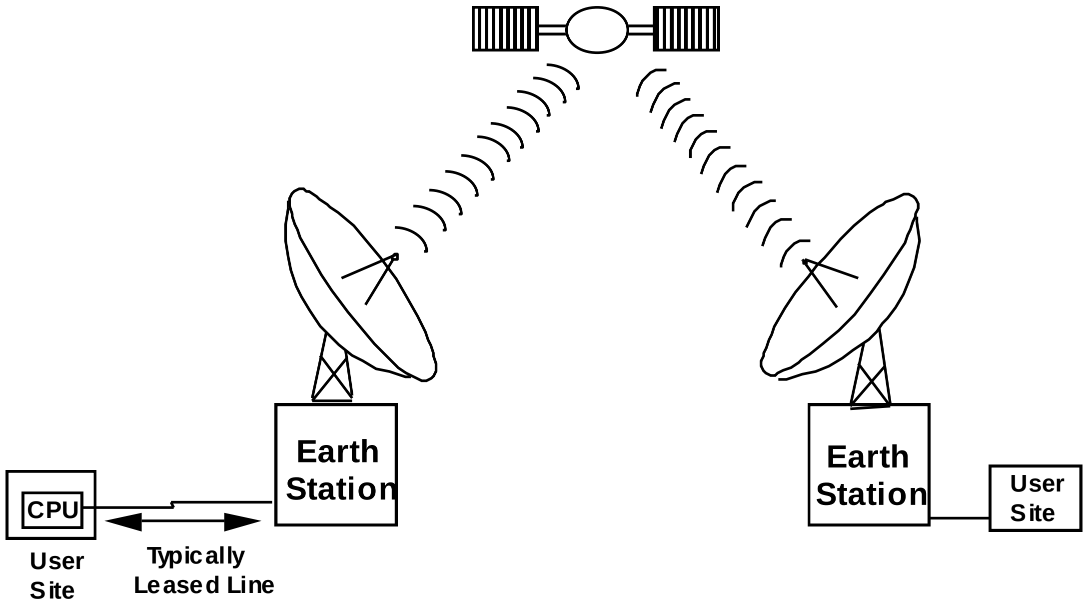
Overview of Satellite System Components.

Satellites are communications devices which receive a signal from the ground station, amplify it, and broadcast it to all earth stations capable of "seeing" the satellite, and thus receiving its signals. End user transmissions are not originated nor terminated at the satellite (except monitoring systems)(. The satellite itself is an active relay, similar to how relays are utilized in terrestrial microwave communications systems.

Satellite communication involves three basic elements including;

space segment
signal element
ground segment.

The following diagram, Satellite Figure-1, illustrates the basic components in a satellite communications system.



Satellite Figure-1, Satellite Communications System Components.

The space segment is comprised of the mechanics of the satellite orbit, allowing the satellite to achieve earth orbit (launching), and the design of the satellite itself. The signal element is the frequency spectrum used for communicating by satellite, and addresses the effects of signal attenuation, modulation techniques and use of protocols to insure proper transmission and reception. Finally, the ground segment, which includes the construction and placement of earth stations, types of antennas used for different applications, multiplexing and multiple access (contention) systems that allow fair and efficient use of satellite channels.

Today's satellites carry voice, data, fax and video. Satellites use microwave transmission - electromagnetic radiation in 3 gig to 30 gig frequency range. Frequencies used by satellites are approved by the ITU (International Telecomm Union).

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)

COMSAT decided on the new geosynchronous system and in 1964 contracted Hughes Aircraft to build its first satellite, launched in 1965 called Early Bird, which increased phone capacity across the Atlantic by 2/3s.

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 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 (DataPro Report on Satellite Communications: Technology Briefing, 1991), 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 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.

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)

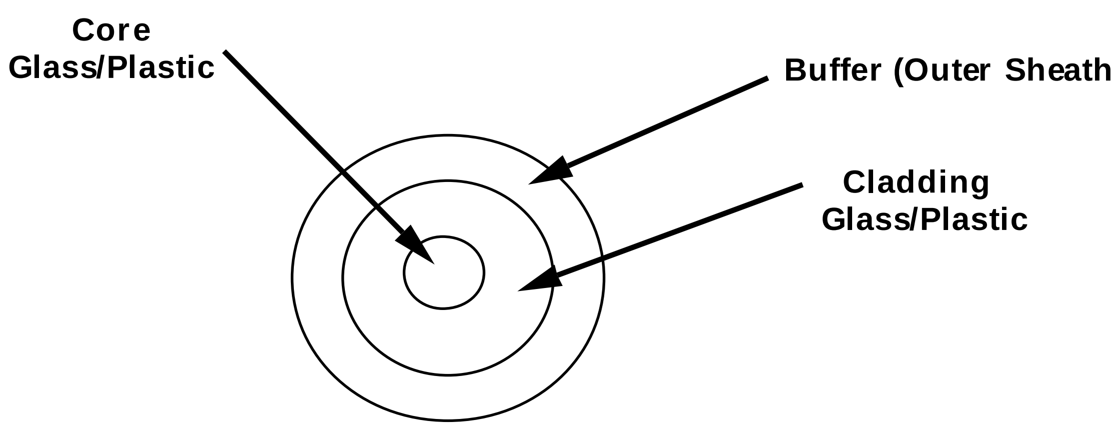
Border Crossing:

One of the best places to utilize satellite services is international, since (as was pointed out), to install a dedicated circuit one must coordinate with 3 LECs just to cross the border, making the link expensive as well as difficult to troubleshoot.

FIBER OPTICS

Fiber Optics (FO) although a fairly new communications medium, 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 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. The signal in its light form bounces through the fiber because the single optical fiber has a high index of refraction while it is embedded in a material with a lower index of refraction. The following illustration, Fiber Figure-1 shows the physical composition of a fiber optic cable.



Fiber Figure-1, Fiber Optic Cable Cross-Section

Inner Core: the actual light path. The fiber core must be incredibly pure. The diameter of the core is measured in microns. For example, Ethernet or FDDI over fiber media uses 62.5 micron multimode fiber. (Single and Multimode discussed later on..).

Cladding: The main composition difference between the core and the cladding is their respective density. The higher density of the cladding serves as a boundary to keep light signals from escaping the inner core layer.

Outer Cover: The outer sheath is made of plastic, steel strand, Teflon, and provides additional strength to the cable.

Fiber Light Sources:

Fiber will use either LEDs (on Multimode fiber) and Lasers (on Single mode fiber), as the light source. The major differences are cost and the distances supported over the fiber

LEDs (Light Emitting Diodes)
LD (Laser Diode)

LEDs are semiconductors that emit light when biased in a forward direction.

LDs - convert electrical to light encoding quickly and can be used for very high transfer rates. LDs can couple higher levels of optical power into Fiber Optic cables resulting in greater transmission distance than possible with LEDs, and transmit further at these higher rates.

There are two basic types of fiber optic cable design and construction; **multimode**, which includes stepped-index and graded index, and **single mode**.

Multimode fiber optic cable is used for short and medium distance applications, for example: 10 Mb Ethernet over 62.5 micron fiber (10Base-F), and FDDI (Fiber Distributed Data Interface) 100 Mb Fiber Token Ring Technology.

Single Mode fiber optic cable is primarily used for long haul communications applications, for example: SONET for digital voice/data transport at speeds up to 2 Gbps (on each pair), IBM Channel Extension at 17 MBytes/second and ATM (Asynchronous Transfer Mode) supporting speeds of up to 622 Mbps.

Fiber Termination: (important - to be discussed)

ST connector
MIC (FDDI) connector

Use of Fiber Patch Panels

Fiber Connectors and Splices:

Connecting and splicing technologies kept the price of fiber more than copper media and have deterred the advancement of fiber for many data communications applications (particularly Local Area Networks).

Splicing methods - gluing, welding or metal connectors. In each case there is some degree of signal loss between the spliced fibers.

What does fiber dB loss mean to the user or application using fiber ?

There is typically an acceptable loss level for fiber connections that is unique to each fiber application and the speeds and distances supported over the fiber.

How would one know about losses and retransmission ??

1) Testing and Signing off on each fiber pair with installer -

2) Use of fiber optic troubleshooting devices.

3) Device interface statistics or use of Protocol Analyzers.

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.

Isolation provided eliminating the requirement for common groun**d** as needed by metallic conductors.

Conduit Requirements - Since no electrical energy is transmitted over fiber, most building codes permit Fiber cable to be installed without being run through a conduit.

This can be considerable cost savings - the cost of installing a conduit required for conventional cables is usually estimated at $2,500 for a 300 ft metal pipe

Security - Absence of radiated signals makes optical fiber transmission acceptable in secure environments, they are difficult to tap (unlike metallic cables)

Weight and size - Fiber smaller and lighter, important in environments where space is at a premium. Because of weight and size fiber easier to install.

Example/Comparison - FO/Copper cable carrying approximately 100,000 telephone conversations (144 fibers). FO cable would be 1 inch in diameter and weigh 6 ounces per foot, Copper coax of same capacity would be 3 inches in diameter and weigh 10 pounds per foot.

Durability - Glass fibers have the same tensile strength as steel wire of the same diameter, Cables with optic fibers are reinforced with a strengthening member inside the cable and a protective jacket on the outside of the cable. FO cables can thus easily be pulled through openings in walls and floors without being damaged, FO cable had better corrosion resistance than copper wire and probability of loss at splice locations is very low.

Disadvantages of Fiber Optics

Cable splicing - to extend cable lengths, they must be spliced together, each fiber end being precisely aligned to allow the maximum of light to be transmitted between spliced fibers. Expensive and in some cases - requires expensive tools and specially trained technicians.

Cost - High quality low loss FO cable costs between $1.50 and $2.00 per meter, typical FO modem with transmission range of 1 Km costs approximately $600 per unit.

Widespread Application of Fiber Optics

100/1000/10000 Mb Ethernet - Fiber version of new Ethernet LAN specification 100Base-FX, Gigabit Ethernet using 1 pair of fiber (single-mode or mm), can be extended up to 2 Km.

SONET new carrier optical multiplexing hierarchy specifying new series of OC (Optical Carrier) rates ranging from OC-1 (51.4 Mbps) to OC-192 (10 Gbps). OC-192 is being deployed extensively over WANs as OC-192 (typically over DWDM), and LANs/MANs as 10 Gigabit Ethernet.

Fiber Optic Troubleshooting Tools :

OTDR (Optical Time Domain Reflectometer) - analyzes cable integrity by measuring the timeequired for the light signal to reflect from a surface (cable end), or break in the fiber. The OTDR sends a fiber pulse into the transmission medium and measures how long it takes the pulses reflection to return. Return delay indicates possible cracks, fractures or discontinuity. OTDRs detect and localize faults i a fiber link. The OTDR consists of a light emitter and an oscilloscope. OTDRs from vendors are now specialized for LANs, undersea or long haul fiber links.

Power Meter - is a light emitting device and receiver (2 separate components) that measures dB loss end to end. It can be a great tool to analyze fiber problems, especially certifying and signing off on fiber pair installs by installation teams.

Fiber Connectors - There are a lot of different types of connectors, but the ones commonly found in LAN/MAN/WAN installations are:

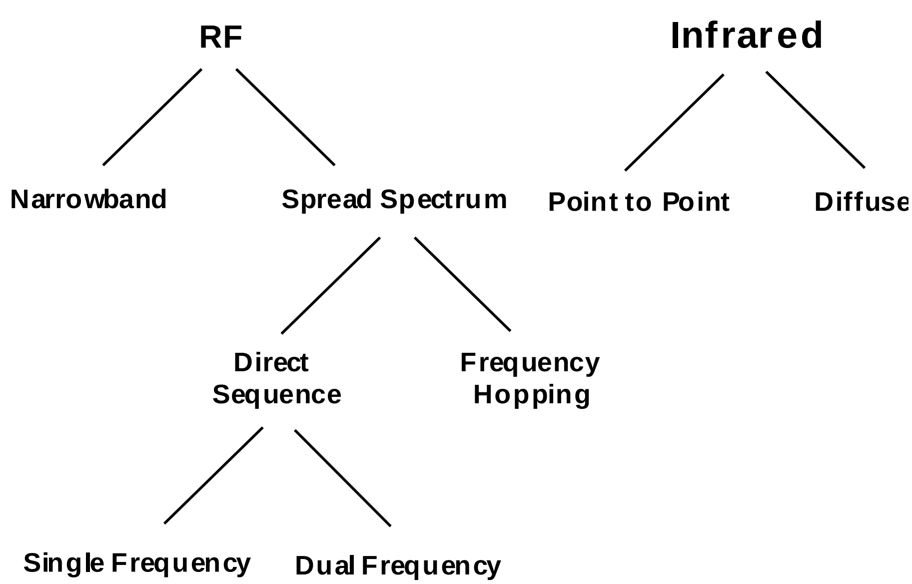
SC - A push-pull connector. The international standard. The SC connectors are recommended in SP-2840A. The SC connector has the advantage (over ST) of being duplexed into a single connector clip with both transmit/receive fibers.
ST - Keyed, bayonet-style connector, very commonly used in 10BaseF/100 Base-FX
FSD - Fixed Shroud Device, such as the FDDI MIC dual-fiber connector.

WIRELESS

Wireless technology is becoming increasingly popular, as they allow connectivity where wiring would be difficult, only temporary 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 Figure-1 (Stacks, Feb/94) shows the basic wireless transmission technique types:



Wireless Figure-1, Wireless Transmission Techniques

Spread Spectrum:

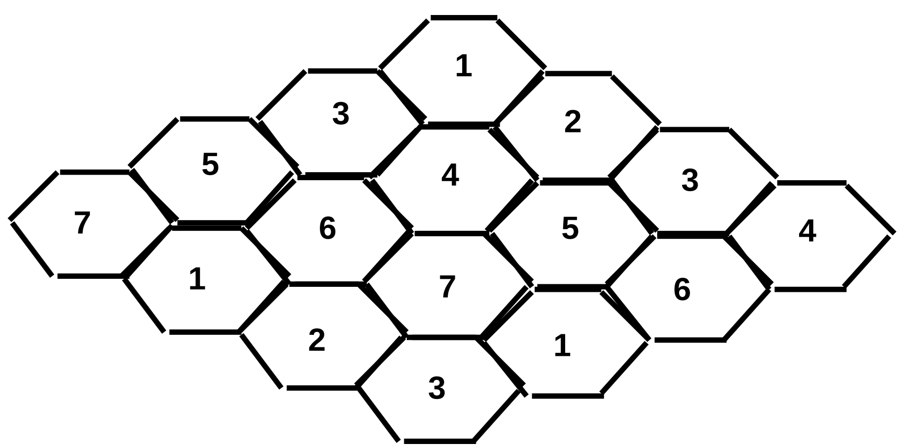
Spread Spectrum is a technology that sends on several frequencies simultaneously. The two types of Spread Spectrum RF used in wireless products today are: Direct Sequence and Frequency Hopping. Both of these Spread Spectrum approaches distribute power and information across a frequency spectrum range. Spread Spectrum technology is not licensed by the FCC since the individual power of each frequency is much less than other RF devices using the same spectrum and interference does not occur.

Frequency hopping distributes a binary zero or one across dedicated frequencies in a timed, sequential manner. The sequential use of a known, random ordering of frequencies provide a unique signature that only the specified receiver can decode.

Private packet, circuit switched cellular and packet over cellular are technologies which are in widespread use today and likely to increase in the near future.

Satellite services are mostly used for unidirectional paging and bi-directional stationary transmission systems.

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

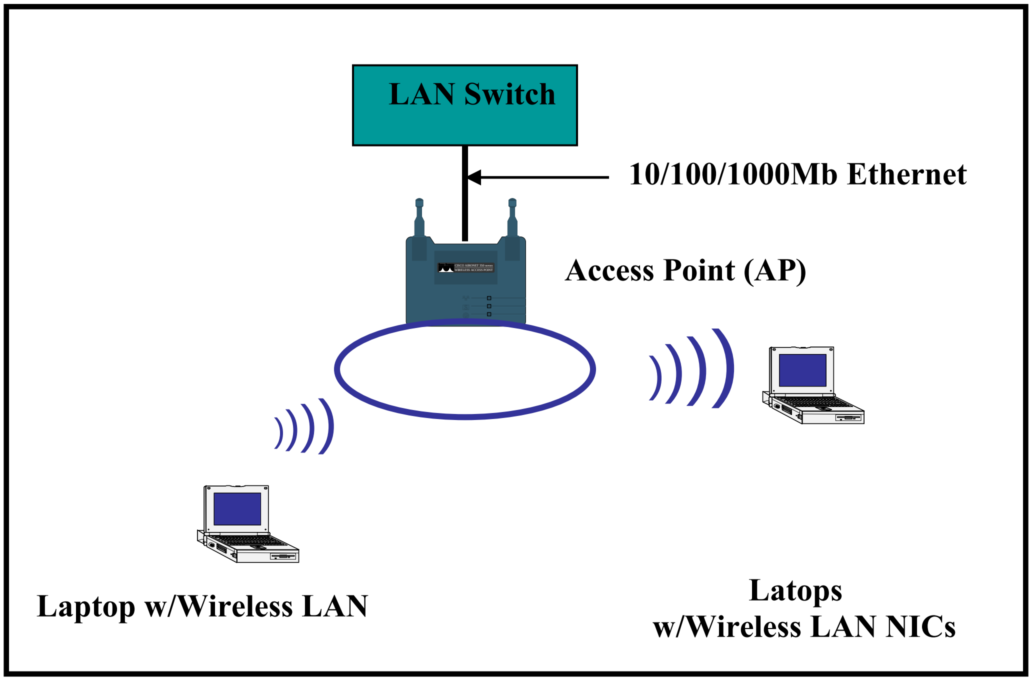
Wireless LANs

Wireless LANs have become increasingly popular as companies and organizations come up against limitations which prevent typical wired solutions.

Wireless LAN standards:

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

Typical Wireless LAN topology



Typical RF Wireless LAN Topology – 802.11 a/b/g/n

Typical Wireless LAN Problems

1) Interference - existence of significant amounts of steel reinforced concrete, metal cabinets can have significant adverse affects on distances and system throughput.

2) Microwave Ovens - some products operate in the same range (2.4 GHz) and are severely affected (adversely) by "leaky" microwave ovens.

3) Does not scale for performance reasons, either higher speeds required for some applications (desktop video, multimedia, file transfer, web browser) or number of nodes supported comfortably (vendor dependent).