

MEBS6000 Utility Services  
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# Information Technology in Buildings



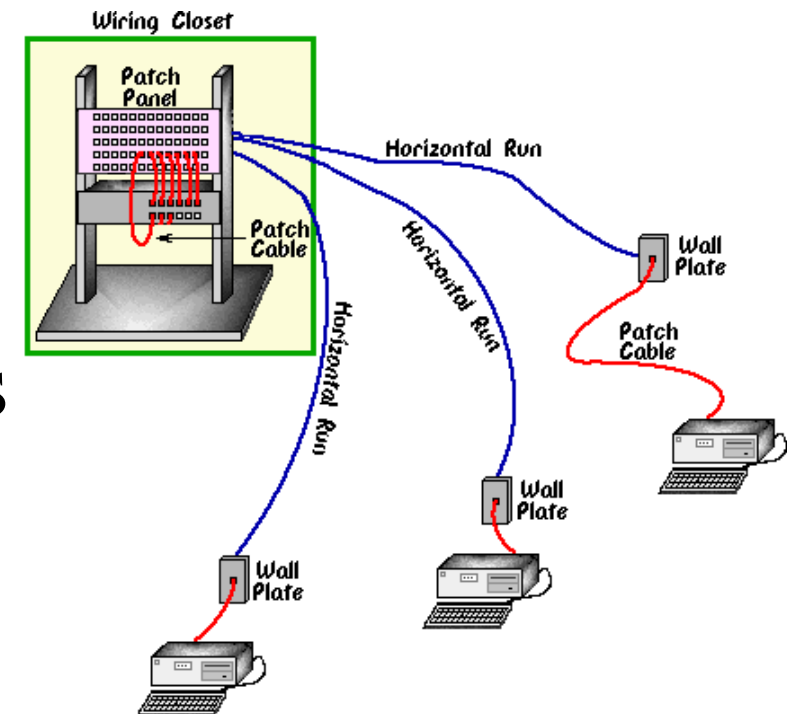
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Feb 2016

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- Information Technology and Buildings
- Space and Structural Requirements
- Cabling Management
- Networking
- Transmission Methods
- In-Building Wireless Systems





# IT and Buildings

- Information Technology (IT)
  - Influence people & many aspects of our life
  - Affect building design & requirements
  - Require the setting up of information systems
- Information systems
  - 1. User (voice, text, image & data networks)
  - 2. Building (bldg. mgt., energy, fire, security)
  - 3. Miscellaneous (public address, CCTV, etc.)

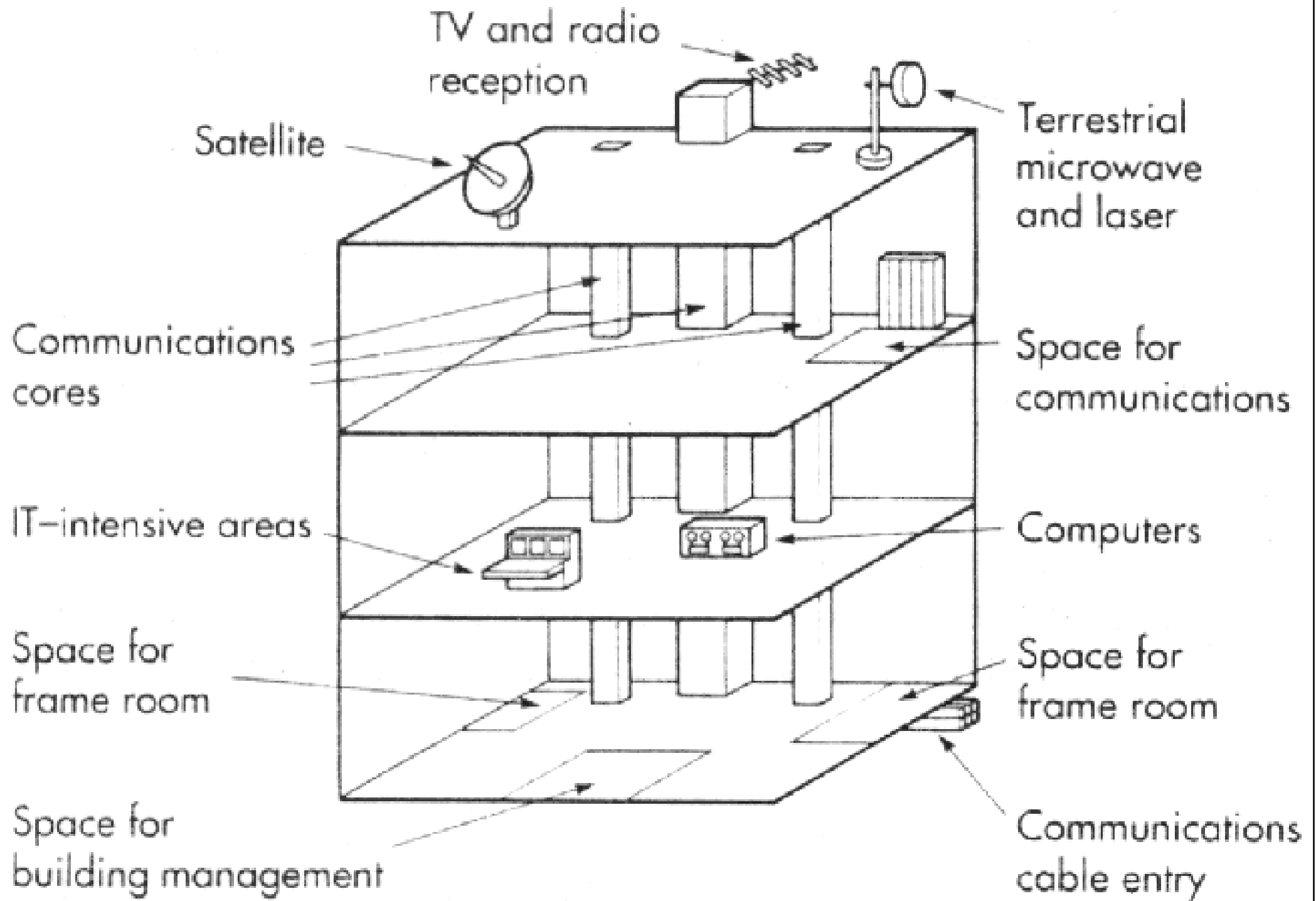
# User Information Technology

Voice and data networking  
PABX and telephones  
Information feeds  
External communications links  
Paging and messaging  
Video distribution  
Public address  
Electronic signage  
Access, movement control & security  
Energy management system  
Building automation system

# Building Information Systems

More  
user  
oriented

More  
building  
oriented



(Source: CIBSE, 1992. Information Technology and Buildings)



# IT and Buildings

- Information Technology (IT) in buildings
  - Systems of structured cable and wireless information technologies relating to buildings and building occupants
    - Building systems -- HVAC, lighting, daylighting control, energy monitoring, security access, and fire/smoke detection and alarm
    - Telecommunications -- voice, data, graphics, and audiovideo
  - Properly designed pathways and spaces are needed to accommodate the IT systems



# IT and Buildings

- The density and demand of IT equipment in buildings increase many times over
  - A robust and secure infrastructure is needed to support the growing and evolving demands of business and organisations (e.g. server rooms)
- Key factors for buildings to accommodate IT
  - Space requirements (for equipment & distribution)
  - Power requirements (electricity supply)
  - Environmental requirements (e.g. temperature)



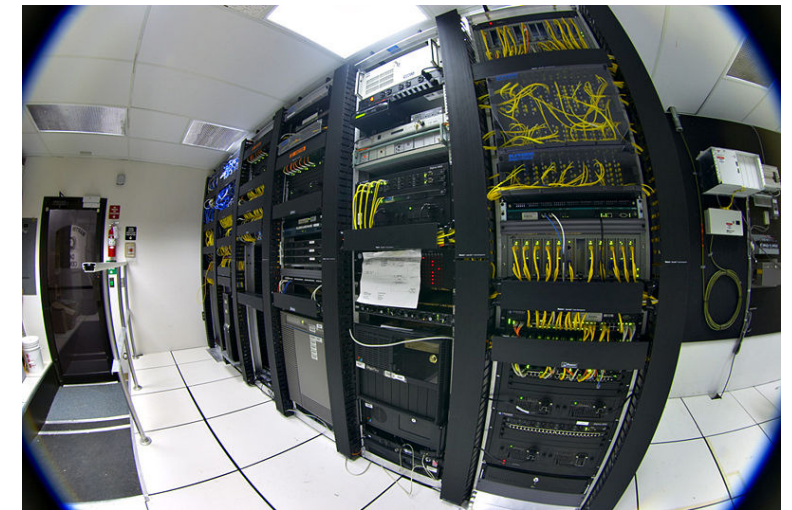
# IT and Buildings

- Major considerations

- Flexibility
- Accessibility
- Life cycle
- Cost-benefit

- Flexibility

- Building and IT infrastructure design must be flexible and adaptable to accommodate future new technologies (e.g. by scalable IT infrastructure)







# IT and Buildings

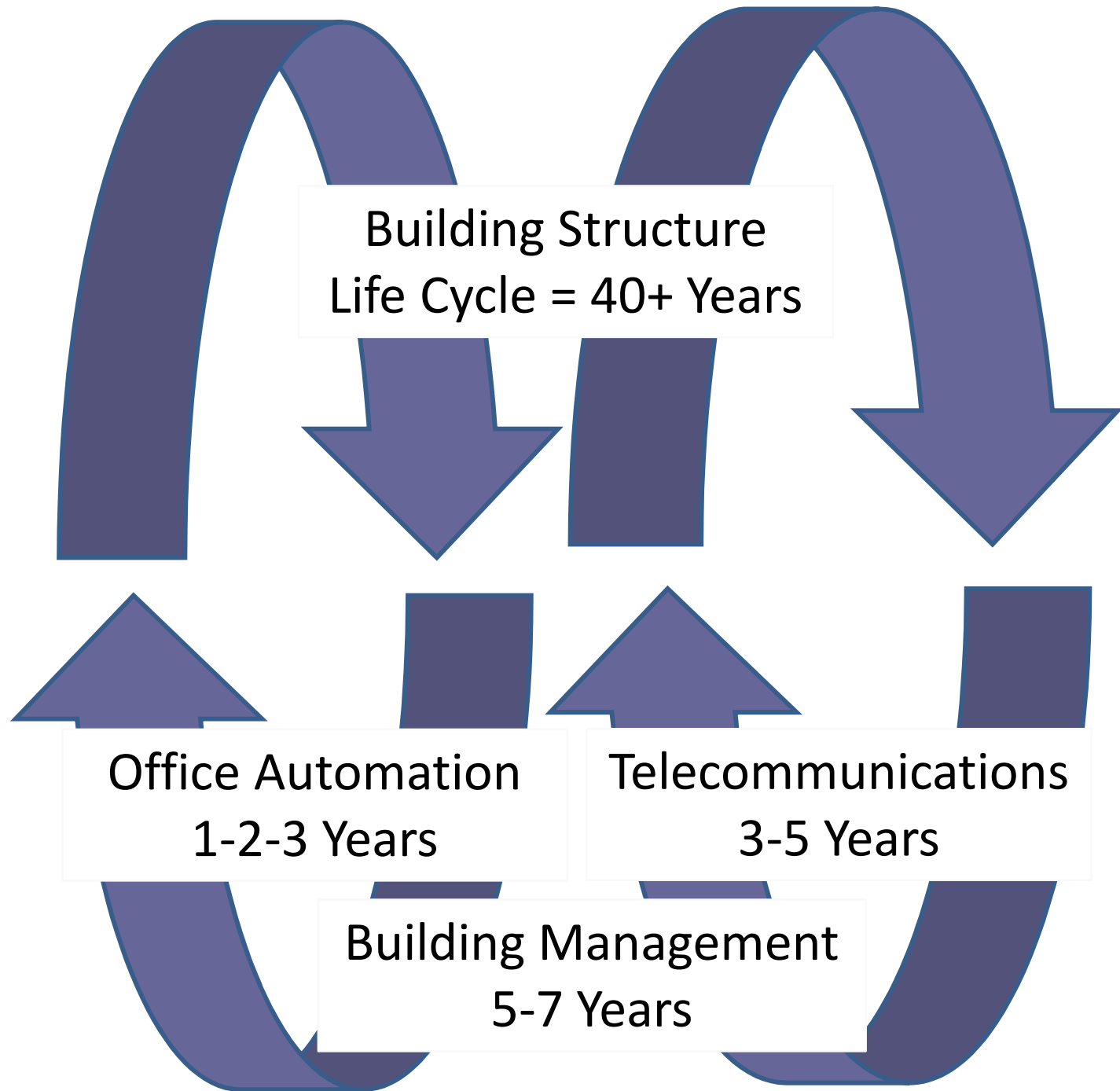
- Design for IT flexibility should consider:
  - Adequate power for future building/system expansion
  - Adaptable power and telecommunication cores, adaptable dedicated electrical and telecommunications spaces
  - HVAC delivery to dedicated IT spaces
  - Network security (vulnerabilities and reliability)
  - Strategically located branch takeoffs and utility stubs
  - Adaptable plenum systems -- either overhead or underfloor, coordinated with space needs for building services systems
  - Overhead exposed cable trays integrated with building services systems (HVAC, power, lighting, fire protection)



# IT and Buildings

- IT systems take up space, e.g.
  - In basements where cables enter, on desks, in risers, above ceilings, under carpets, in special equipment areas, on roofs and in car parks
- Life cycle considerations
  - The frames of buildings have lives of many decades during which the IT systems contained will be updated and replaced several times
  - With proper planning, it is not necessary to provide new cabling every time systems are changed or upgraded (cost savings)

Life  
Cycle  
Diagram





# IT and Buildings

- Emerging issues
  - Integrated building design practice
    - Use the same cable network for different systems
  - Interoperability across all systems
    - Among user IT and building operating systems
  - Building Information Modeling (BIM)
    - A master, intelligent data model to design & manage
  - Wireless communication technologies
  - Smart and intelligent buildings

# Infrastructure and systems for “intelligent building”

Infrastructure		
Sensors, Structured cabling, IP network, Wireless*, Plant rooms, Data rooms, Server rooms, Communications rooms, etc.		
Building systems (ICS) <sup>†</sup>	ICT systems <sup>†</sup>	Business systems <sup>‡</sup>
Building management HVAC controls Access control Lighting control Intruder alarm Security/CCTV Fire alarm Water management Waste management Utilities Stand-by generators UPS	Office automation (email, data, Internet)  Media/multi-media (voice, video, music)  Telephony (voice, fax, video conferencing, SMS, pagers)  IP-based applications <sup>§</sup>	Enterprise resource planning (ERP) Material requirements planning (MRP) Customer relationship management (CRM) Integrated command-and- control centre Integrated service/ helpdesks

\* The term ‘wireless’ is used as a generic term to cover communications and data links that do not require a physical connection; technologies employed include WiFi, Bluetooth, ZigBee, radio, NFC, RFID

† ICS – Industrial Control Systems; ICT = information and communication technology

‡ Only included to the extent that they are integrated with building systems, for example CRM – Access Control, ERP/MRP – Supply Chain Management

§ Relevant where they interact with building systems or sensors, for example RFID for tracking location of material or assets



# IT and Buildings

- Planning for IT (a dynamic process)
  - Consider carefully its own “information needs”
    - Present & anticipated use of information
    - Standard of service: speed of transfer, availability, error rates & user-friendliness
    - Corporate view of the rate of IT introduction
    - Geographical distribution of IT
    - Likely growth of, and ‘churn’ within, the organisation
    - Existing & proposed use of building stock
    - Assessment of the suitability of building stock for IT



# IT and Buildings

- Example: Planning and designing your IT Infrastructure
  - Part I: Networking
    - <http://blog.synyx.de/2014/02/planning-and-designing-your-it-infrastructure-part-i-networking-2/>
      - Networking hardware and your needs
      - LAN, WAN or CAN infrastructure
      - Network applications and bandwidth
      - Number of users and networked devices
      - Office layout, hardware & software components
      - Budget for the installation and maintenance



# IT and Buildings

- Example: Planning and designing your IT Infrastructure (cont'd)
  - Part II: Evaluating your requirements and designing your data center
    - <http://blog.synyx.de/2014/04/planning-and-designing-your-it-infrastructure-part-ii-evaluating-your-requirements-and-designing-your-data-center/>
      - Evaluate what you want and what you really need
      - Don't overbuild; Don't plan for now, plan for the future!
      - Cost of Ownership (vs. webhosting, cloud solutions)
      - Select a proper data center site

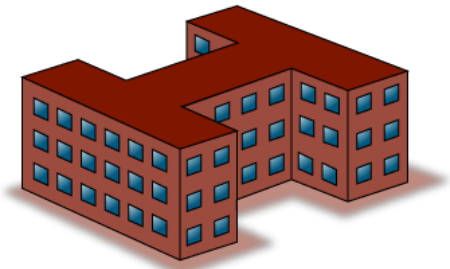




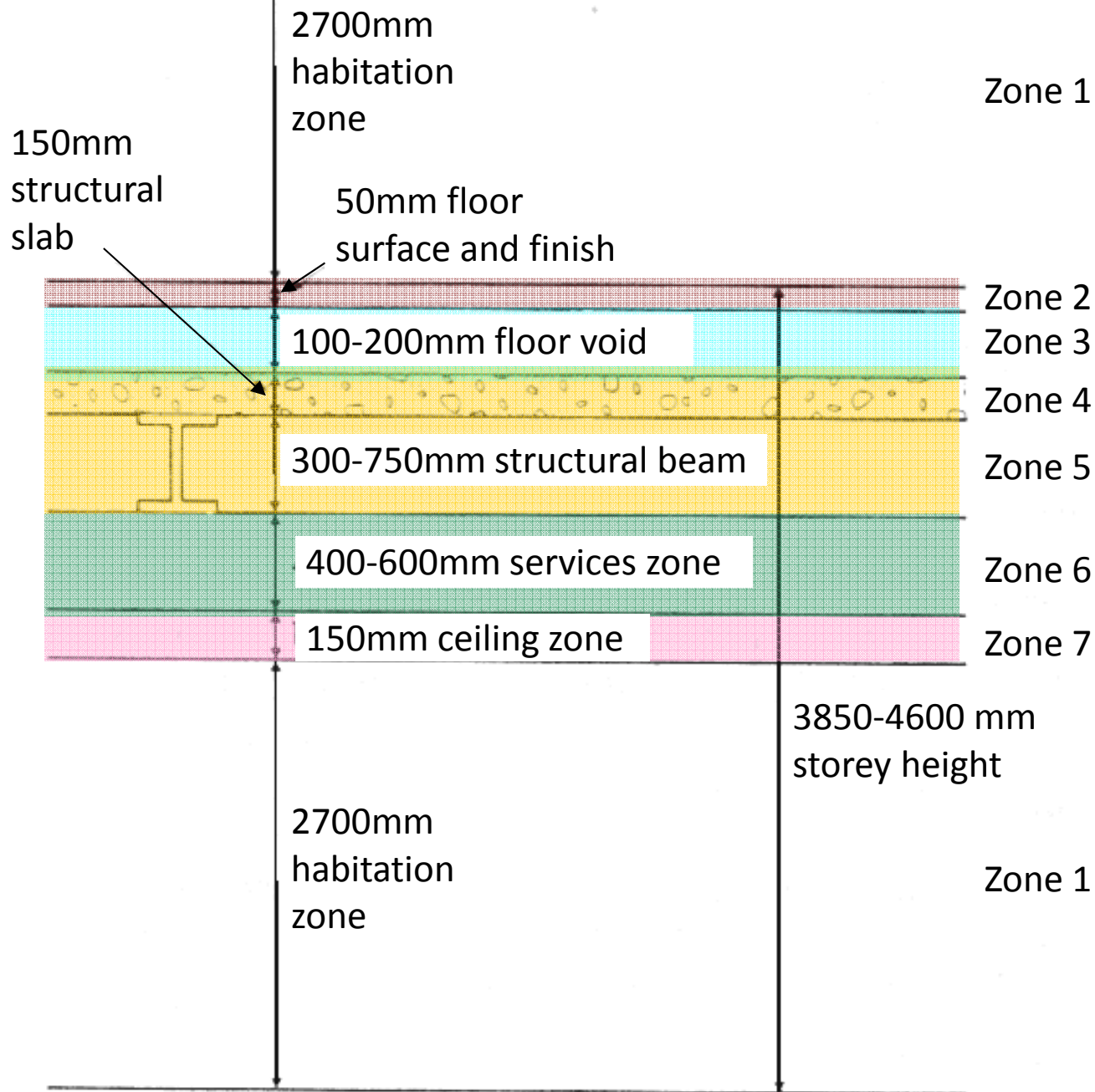
# IT and Buildings

- Following planning, the subsequent phases are important for implementing the IT:
  - 1. Design & procurement of systems and cabling
  - 2. Installation, testing & commissioning
  - 3. Operation, management, maintenance & modification
  - 4. Removal & recovery of redundant systems
- Critical for buildings with high IT demands
  - Such as data centres, high-tech offices

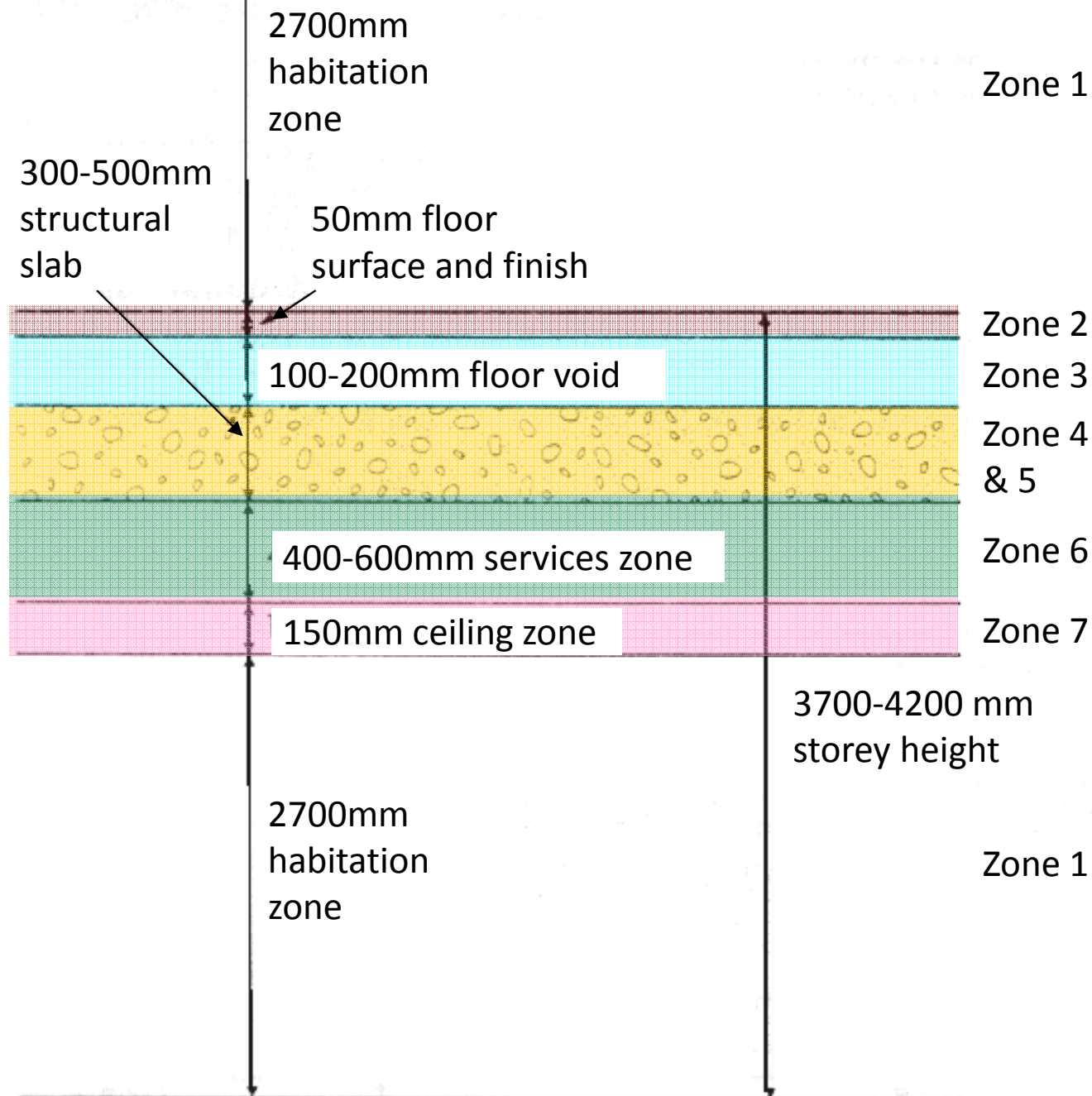
# Space & Structural Req's



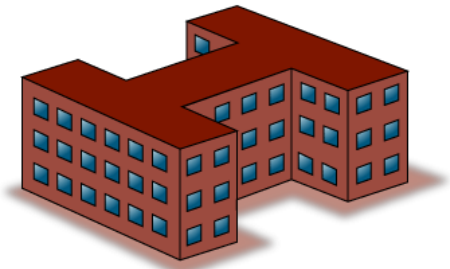
- Structural requirements
  - Integration of architecture, building services & structural engineering
- Vertical cable distribution
  - Designated cable ducts or riser space
- Horizontal distribution
  - Raised access floor if IT usage is high
  - Typical heights for zoning (Zone 1 to 7)
    - Steel frame
    - Concrete frame



Steel frame  
(3.85-4.6m  
storey height)



Re-inforced  
concrete  
frame  
(3.7-4.2m  
storey height)

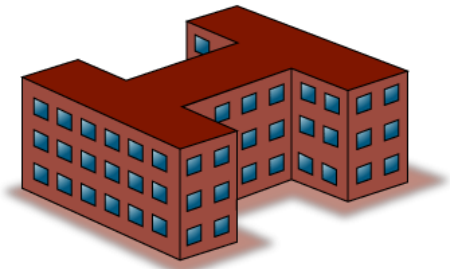


# Space & Structural Req's

- Floor loading

- Usually IT equipment will not exceed the floor loads, except where equipment densities are high
- Where point loads are high, load spreading must be used, such as for power equipment
- High volume of papers (very heavy!)
- Loads of raised floors
- Access areas
- Weight of power or radio equipment on roofs

# Space & Structural Req's



- IT equipment rooms

- Project planning

- Detailed knowledge of IT equipment often not known
- May consult the public telephone/network operators & equipment suppliers

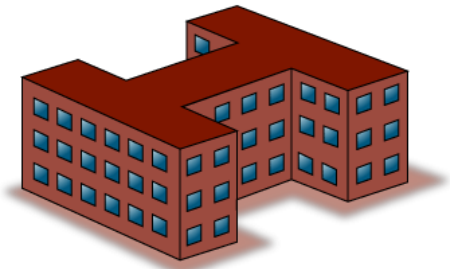
- Design considerations

- Voice and data services
- Distributed equipment rooms
- Components of IT systems

# Components of IT systems

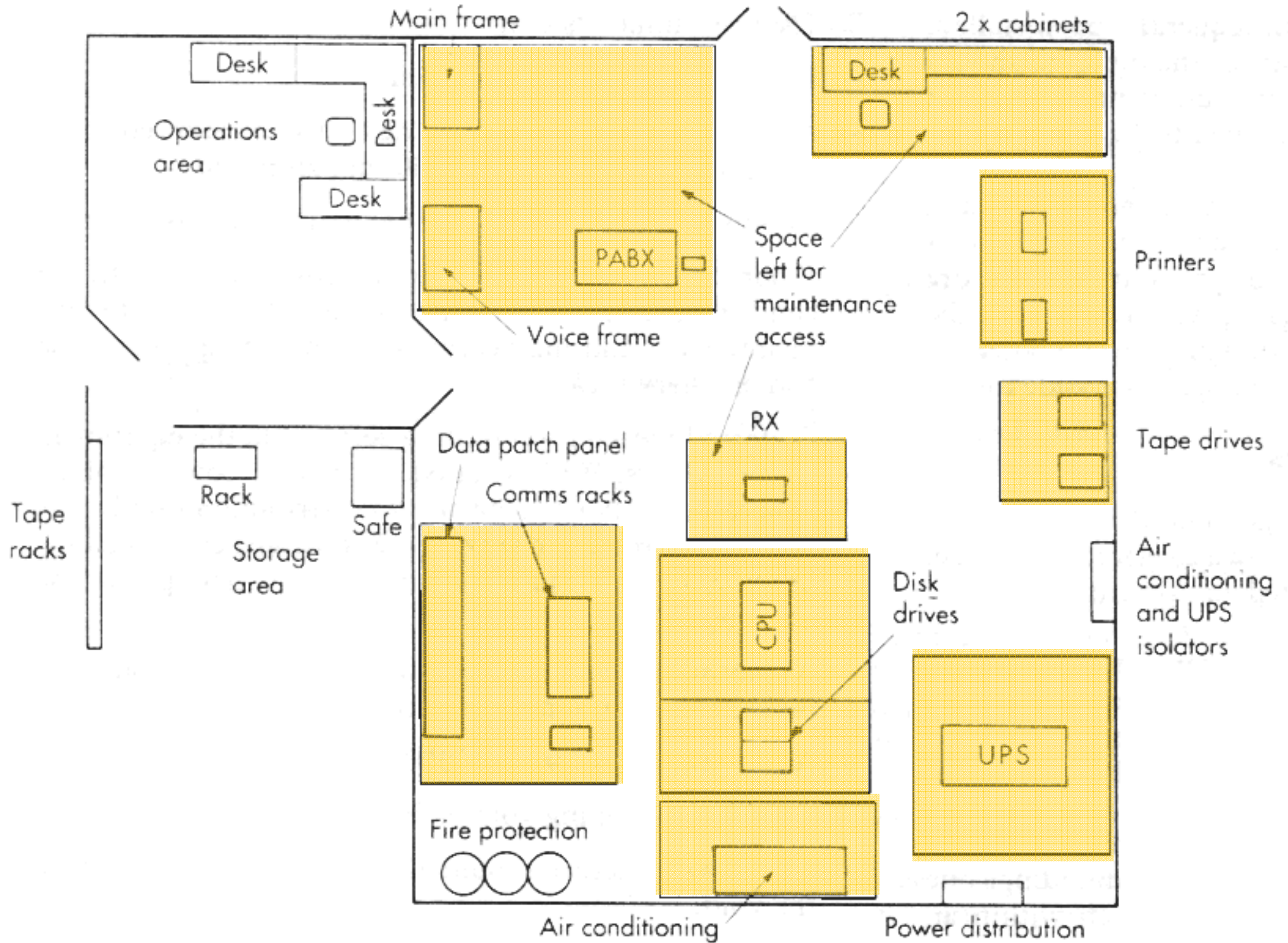
<b>System</b>	<b>External service</b>	<b>Equipment</b>	<b>Internal distribution</b>
Telephone	Telephone lines	PABX	Extension wiring Network links
Central computer	Network links	CPU	Terminal wiring
Departmental computer	Network links	CPU	Terminal wiring plus network
Local area network	Gateway or data link	Distributed processing	Internal wiring Bridge links
Information system	Network link to service	Controller wiring	Display terminal provider

# Space & Structural Req's



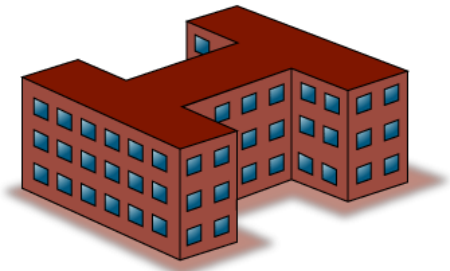
- General equipment rooms: design considerations
  - Minimum room height, floor void, ceiling void
  - Sufficient floor loadings
  - Access for installing, operating and maintenance of equipment
  - Environment suitable for operating the equipment
  - Room finishes easily cleaned
  - Floor areas allowed for all equipment, staff, services, storage, etc





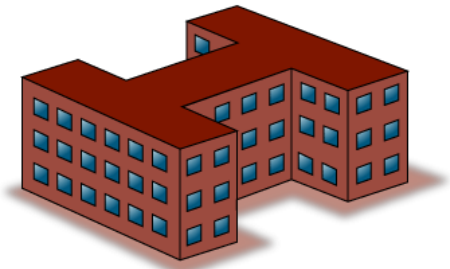
(Source: CIBSE, 1992. Information Technology and Buildings)

# Space & Structural Req's



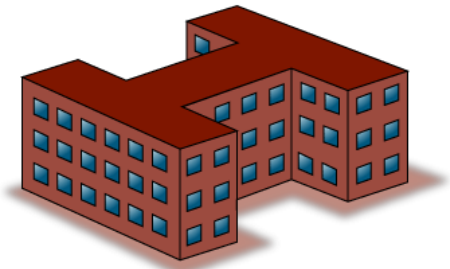
- General equipment rooms: design considerations (cont'd)
  - Future expansion allowance
  - Access for equipment deliveries
  - Preferred methods of locating services
    - Within raised floor void: power cabling, data cabling, HVAC pipework, air distribution supply, fire detection/protection services
    - Within suspended ceiling: lighting, air distribution return, fire detection/protection services

# Space & Structural Req's

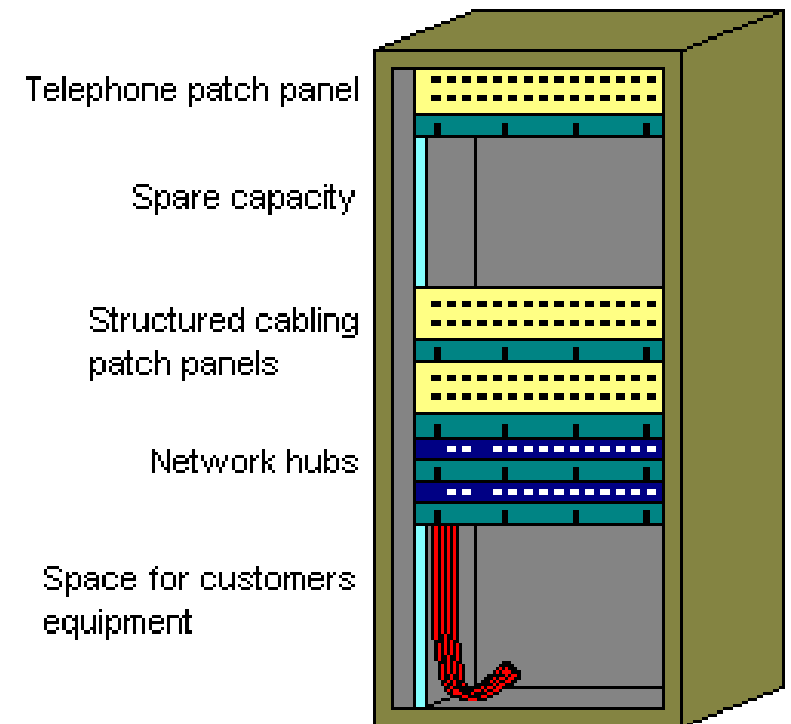


- Major sub-systems:
  - Lead-in or entrance facilities, including cable entry and cable entry chamber
  - Telecommunications and broadcasting equipment (TBE) room [*Equipment room*]
  - Secondary TBE room [*Telecomm room*]
  - Vertical riser (backbone)
  - Horizontal distribution facilities

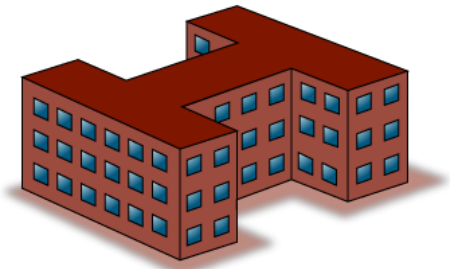
# Space & Structural Req's



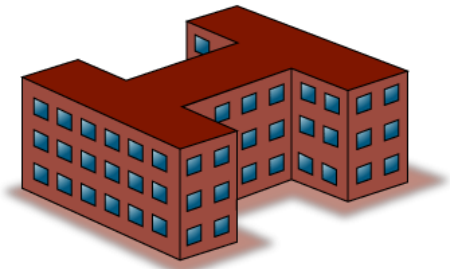
- Major sub-systems: (cont'd)
  - Telecommunications closets
  - Accommodation for subscription TV receiving system
  - TV/FM outlets
  - Telephone sockets
  - Cables
  - Rooftops



# Space & Structural Req's



- Space planning
  - IT fit-out: equipment is known
  - “Speculative” building: equipment not known
  - Electrical closets & communication closets
  - Minimum areas for equipment
    - Consult telecom operators or follow standards
- A common planning grid is recommended
  - Floor grid
  - Ceiling grid



# Space & Structural Req's

- Entry points and equipment rooms
  - Entry points for cables & services
    - Multiple routing to reduce risk of disruption
  - Radio systems (e.g. antenna mounting)
  - Frame rooms (may also houses the PABX)
- Maintenance access
  - Areas for maintenance and safety
    - Consult telephone operators & suppliers
  - Access
    - Clearly separate groups, compartments or rooms
    - Used by operating staff and maintenance staff

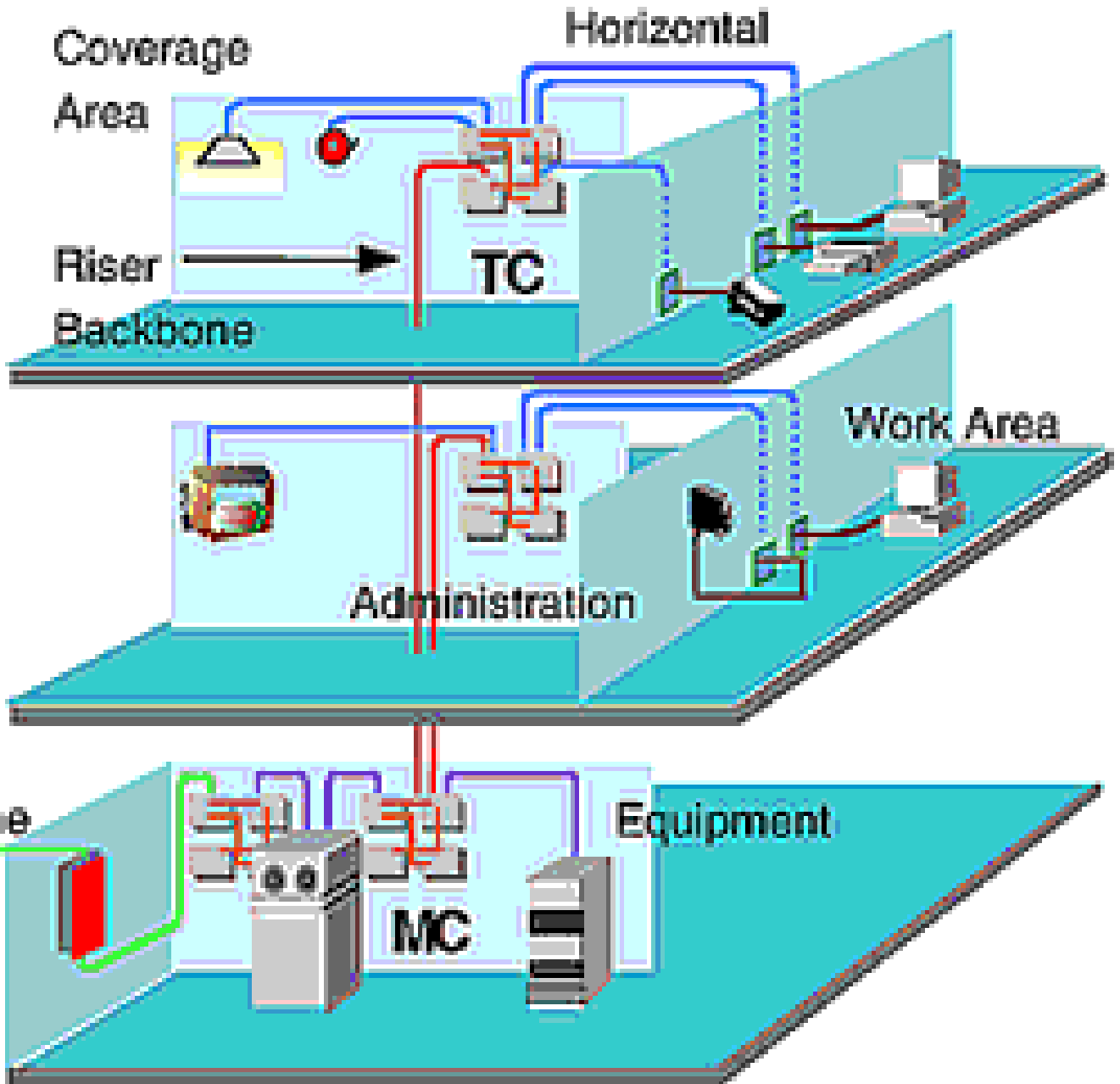
# Cabling Management



- Structured cabling system (SCS)
  - A set of cabling and connectivity products that integrates the voice, data, video, and various management systems of a building (e.g. safety alarms, security access, energy systems, etc.)
    - Give saturation wiring & flexibility
    - Radial architecture connection (back to closet)
    - Suitable patching to facilitate maintenance
  - Once the main components of the system is installed, it do not change

TC = telecomm closet

# Structured Cabling Subsystems



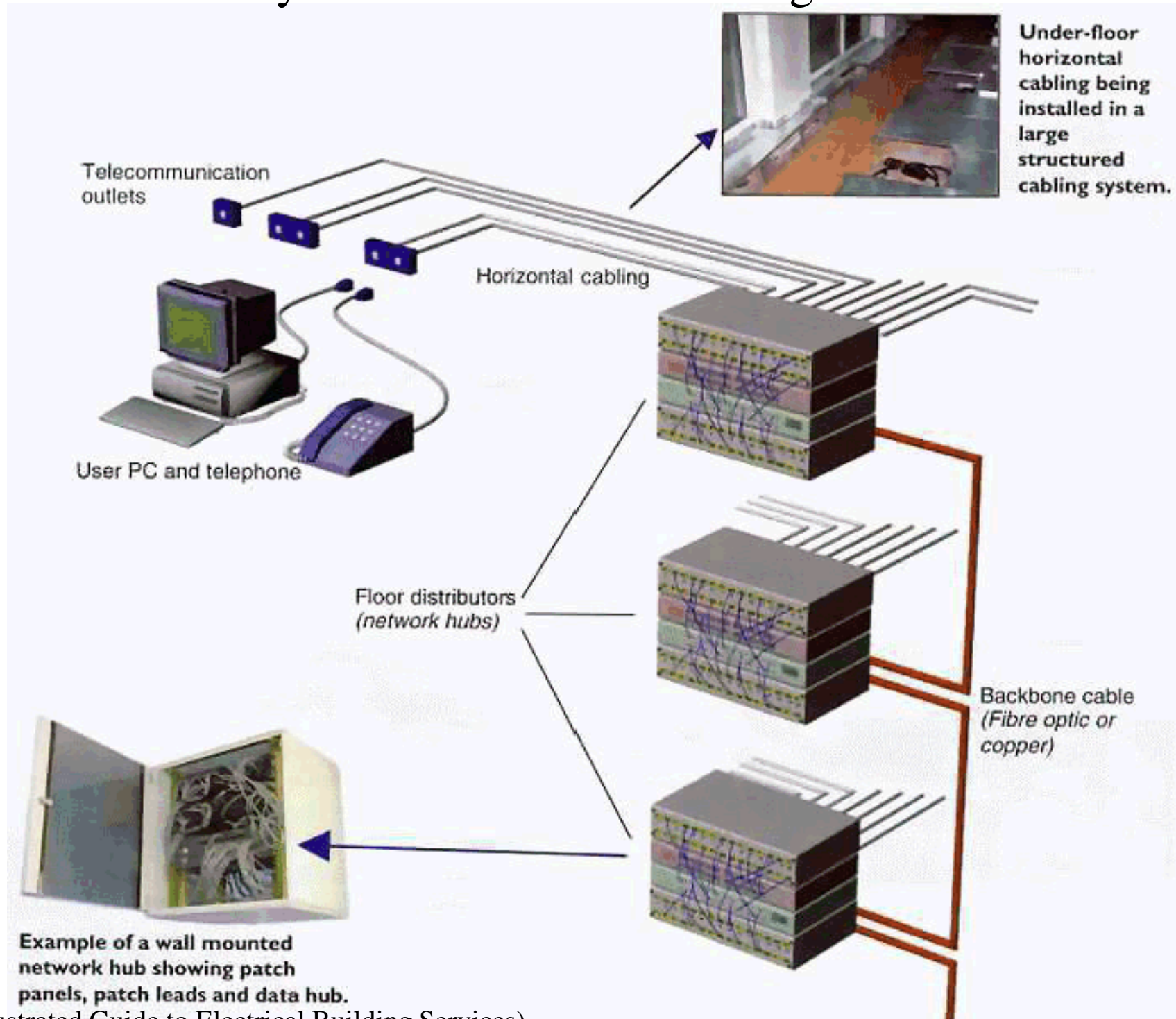


# Cabling Management



- Industry standards to address the cabling and cable-delivery methods (pathways & spaces)
  - Such as EIA/TIA 568, ISO/IEC 11801
  - Based on a structured subsystem architecture
- 4 key components of structured cabling
  - Telecommunication outlets
  - Horizontal cabling
  - Patch panels and floor distributors (data hub)
  - Backbone cable

# Basic layout of a structured cabling installation



(Source: Illustrated Guide to Electrical Building Services)

# Cabling Management



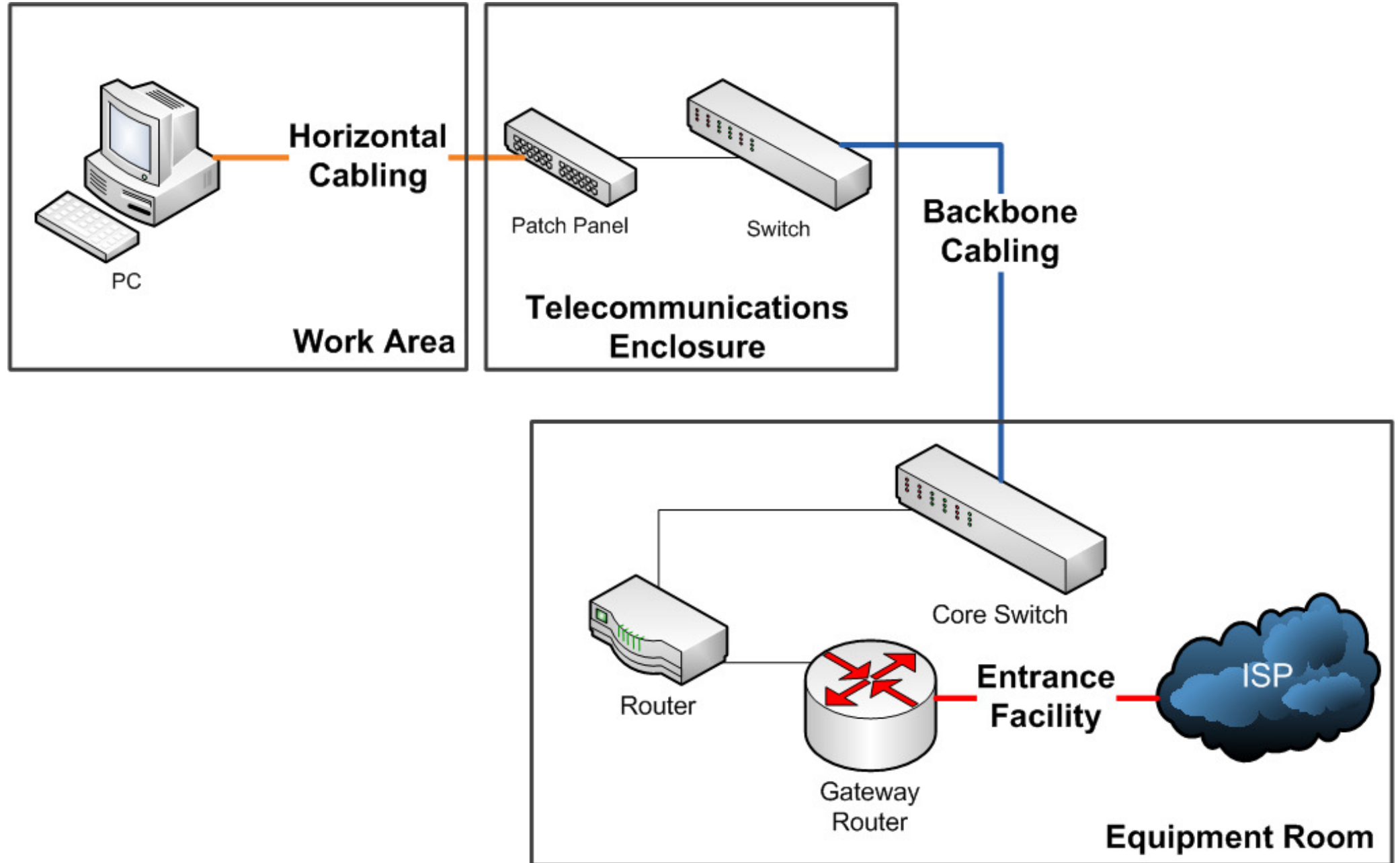
- Six subsystems of structured cabling:
  - Entrance Facilities
    - The point where the telephone company network ends and connects with the on-premises wiring at the customer premises
  - Equipment Rooms
    - House equipment and wiring consolidation points that serve the users inside the building or campus
  - Backbone Cabling
    - Connects between the equipment/telecom rooms on different floors

# Cabling Management



- Six subsystems of structured cabling: (cont'd)
  - Horizontal Cabling
    - Inside wiring or plenum cabling that connects telecom rooms to individual outlets or work areas on the floor
  - Telecommunications Rooms or Enclosure
    - Connects between the backbone cabling and horizontal cabling
  - Work-Area Components
    - Connect end-user equipment to outlets of the horizontal cabling system

# Structured cabling network diagram



# Cabling Management



- Steps to design a structured cabling system
  - 1. Select the standards to follow (e.g. ISO 11801, EIA/TIA 568)
  - 2. Horizontal cabling
  - 3. Backbone cabling
  - 4. Positioning & design of telecomm closets
  - 5. Cable containment system
  - 6. Cable administration system
  - 7. Earthing scheme & testing

# Cabling Management



- Cable routing recommendations
  - Data & voice follow the same routes
  - Good labelling for identification
  - Duplicate routes (increase reliability for high priority equipment)
  - Secondary distribution: most demanding
    - Normally follows a rectangular grid (street & avenue)
  - Allow for future expansion/changes

# Cabling Management



- Distribution strategy
  - Cabling routes, capacity, distribution methods, outlet types, flexibility & allowance for future growth
  - Major requirements:
    - Primary plant locations & sub-distribution points
    - Load centres
    - Management and maintenance
    - Redundancy & extension allowance
    - Cable types & termination facilities
    - Flexibility



# Networking



- What is a (computer) network?
  - Simply, a collection of computers and other devices connected in a way that allows them to share information and resources.



- Why Network?
  - Devices can be shared
  - Easier to manage
  - Easier to maintain
  - Less expensive for equipment & software



# Home computer network

Hub or  
Ethernet Switch or  
IP Sharing

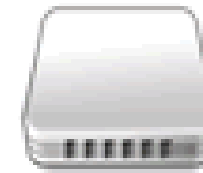


Network Cable



ADSL ATU-R

Splitter



Phone Line



Telephone



PC

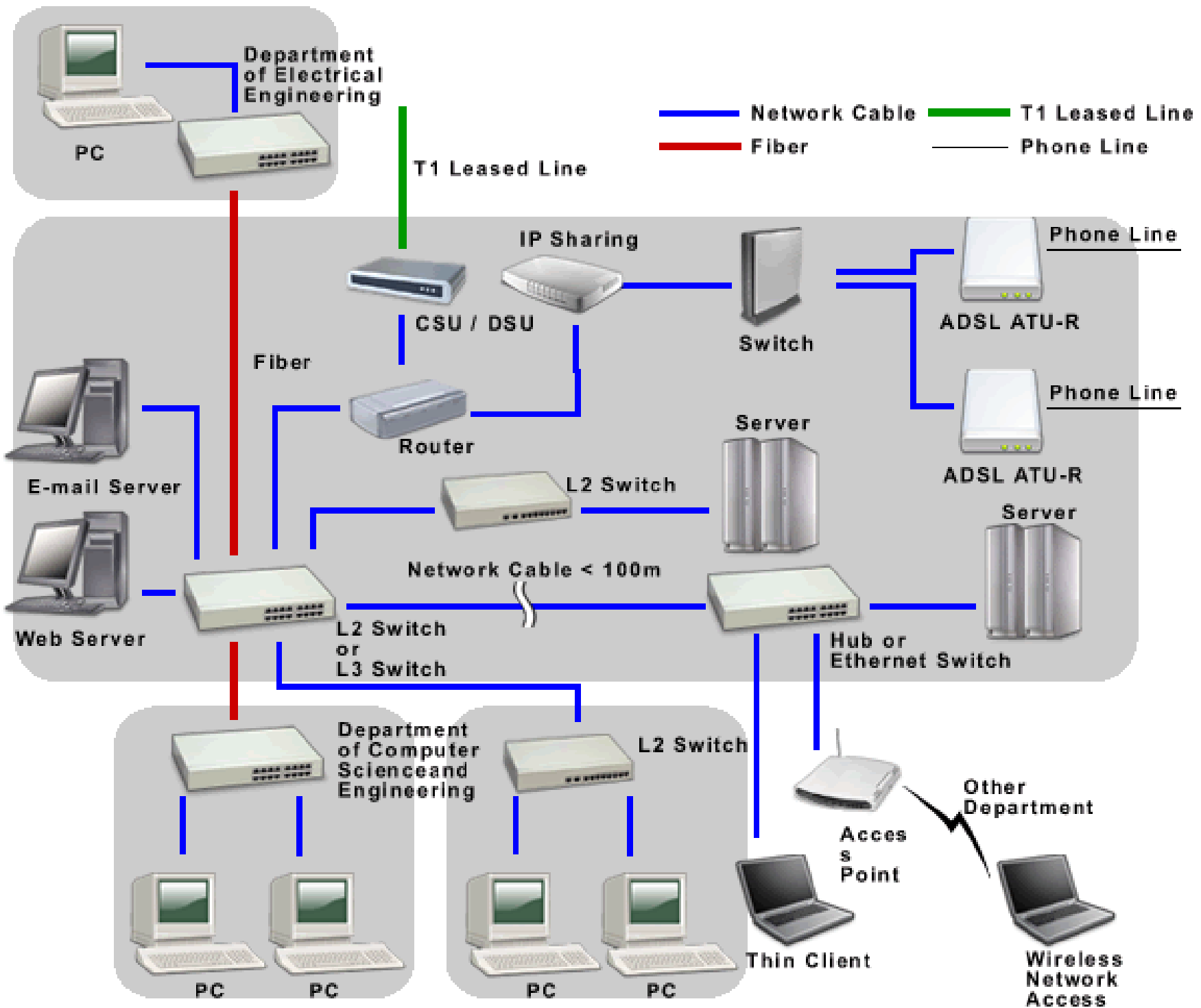


PC

— Network Cable  
— Phone Line

What network do you have at home?

# Office/Enterprise computer network

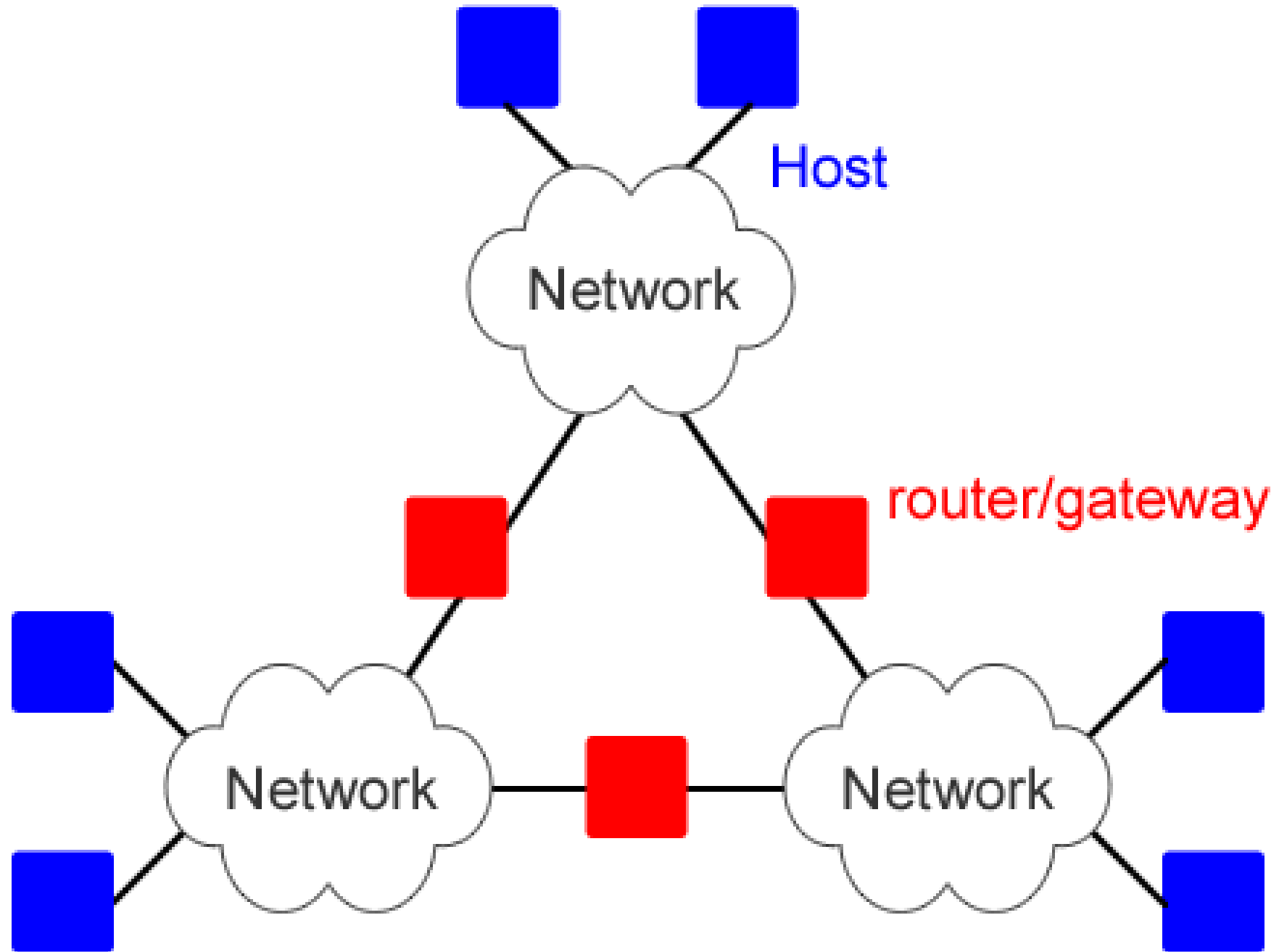


# Networking

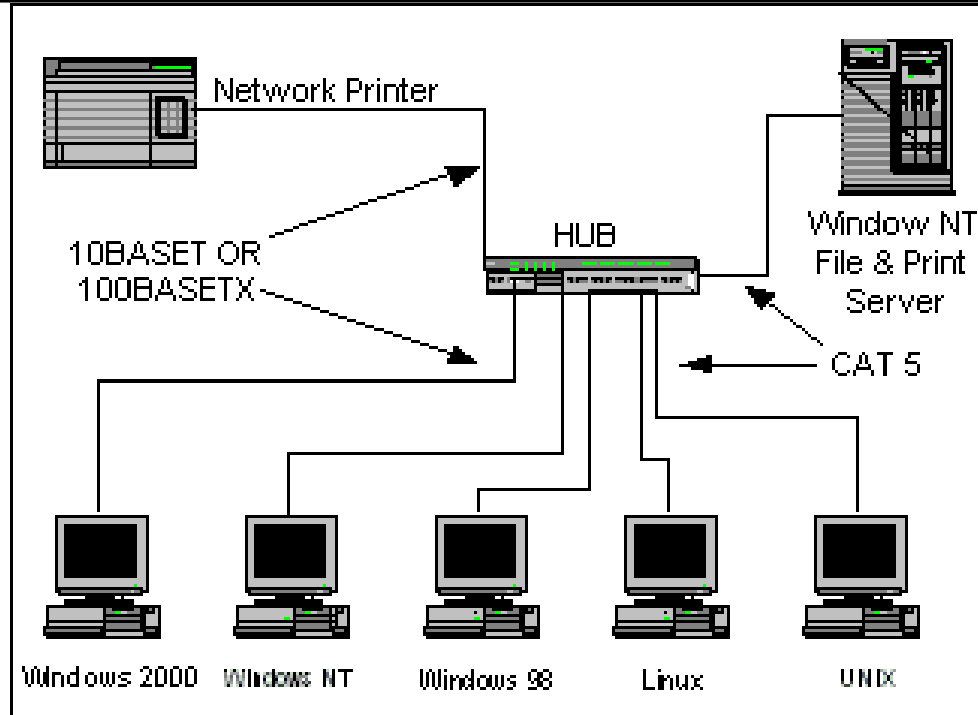


- Local area network (LAN)
  - A computer network that spans a relatively small area, and with high-speed switched connections
- Wide area network (WAN)
  - A system of LANs connected over any distance via telephone lines and radio waves
- Other types of network
  - Metropolitan area network (MAN)
  - Campus area network (CAN)
  - Home area network (HAN)

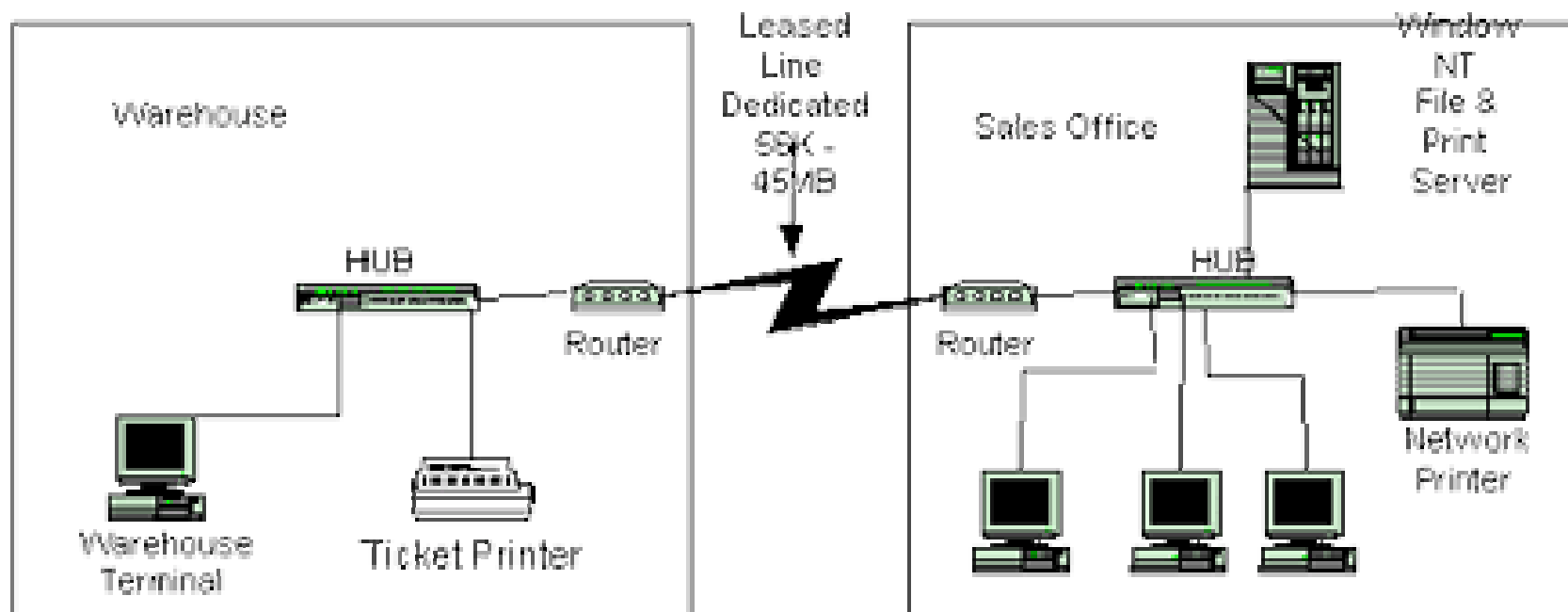
# Internetworking concept



# Local Area Network (LAN)

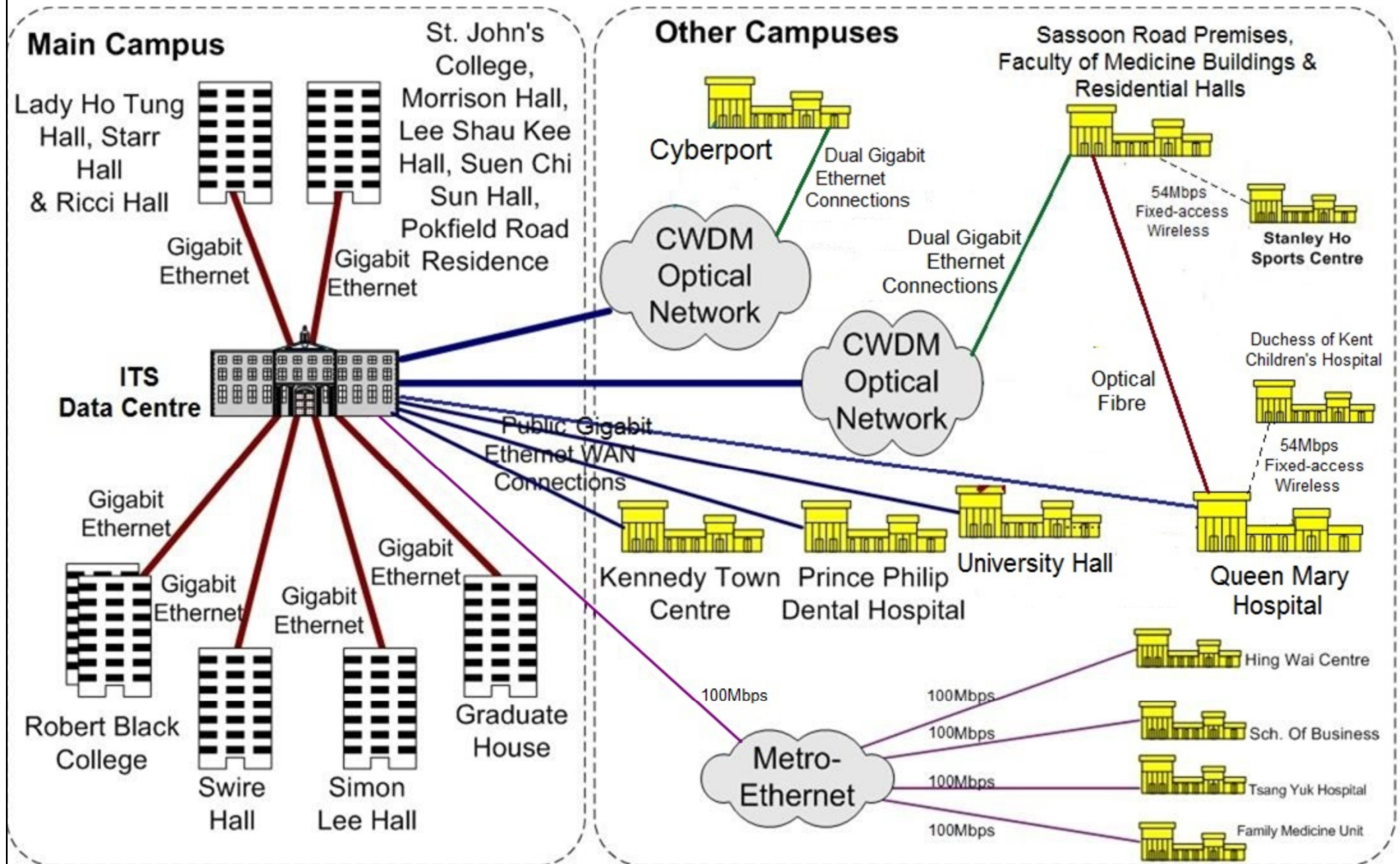


Local Area Network



Wide/Metropolitan Area Network (WAN/MAN)

# Example of network infrastructure -- HKU



**Computer Network of HKU Remote Campuses and Residential Halls**

# Networking



- Ideal LAN
  - As easy to use as an electrical distribution system
    - One-time installation (plugged in)
    - Widespread access (any device/component)
    - Application independence
    - Excess capacity, easy maintenance & administration
  - Current obstacles
    - No single standard
    - Diverse requirements
    - Cost \$\$ of transmission media
    - Sophisticated functional requirements

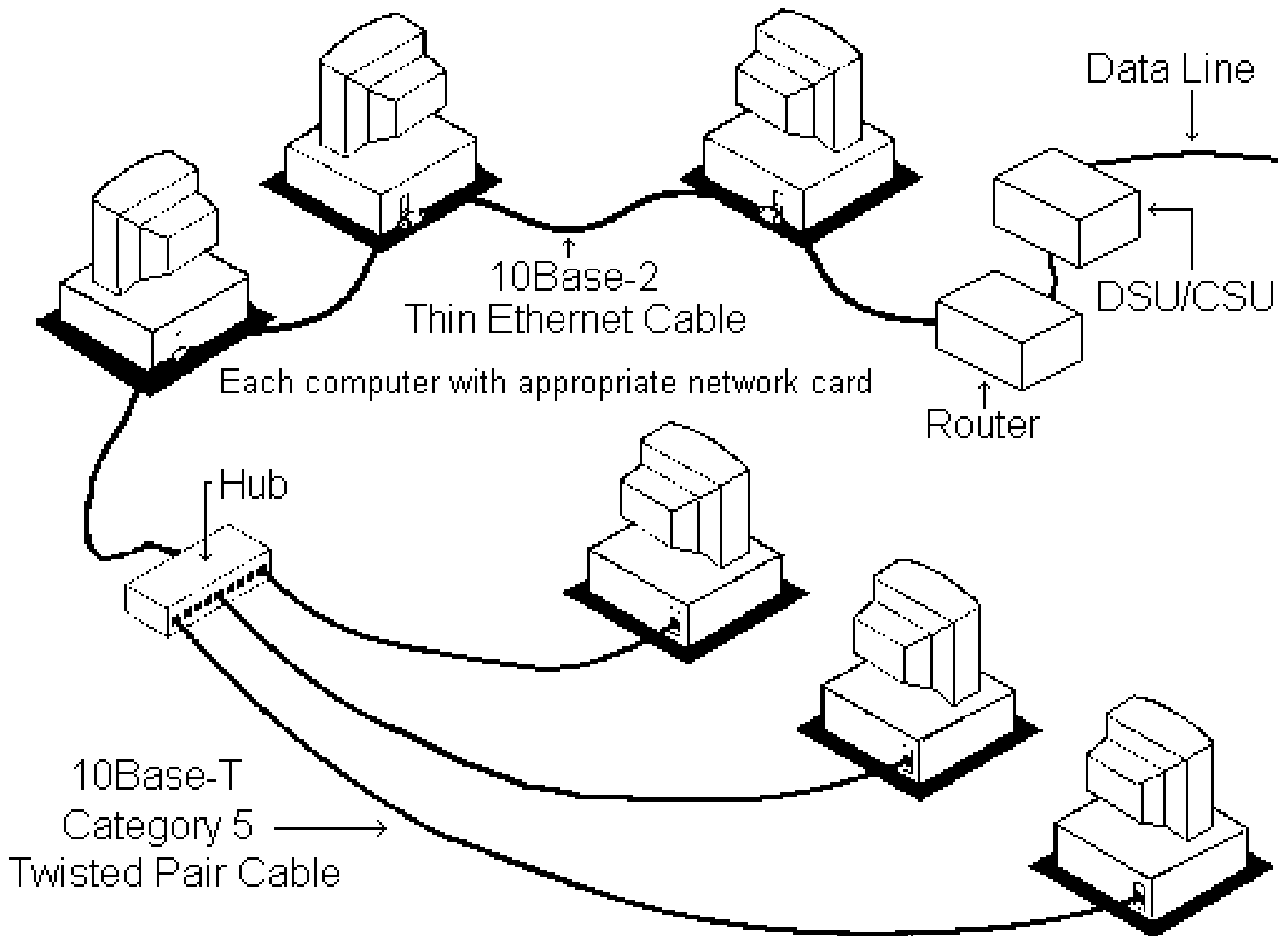


# Networking



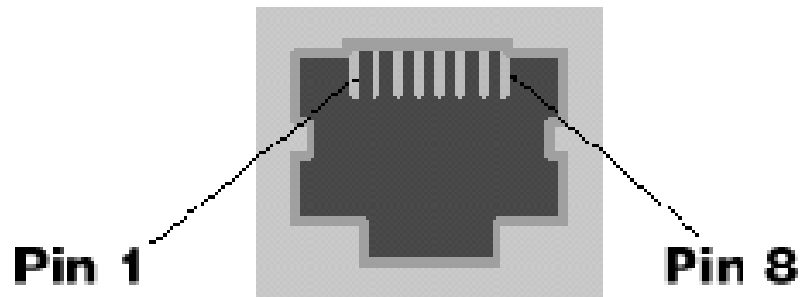
- Common LAN standards
  - Ethernet
    - ISO 8802-3 by Digital Equipment Corp., Intel Xerox
    - Peer-to-peer connection: carrier sense multiple access w/ collision detection (CSMA/CD)
    - Speed: 10 to 100 Mbps
  - ARCNET
    - ARCNET = Attached Resource Computer Network
    - Developed by Data Point Corp.
    - Star or bus topology, peer-to-peer token-passing
    - Speed: 2.5 Mbps

# Example of Ethernet system



# Ethernet port and connector

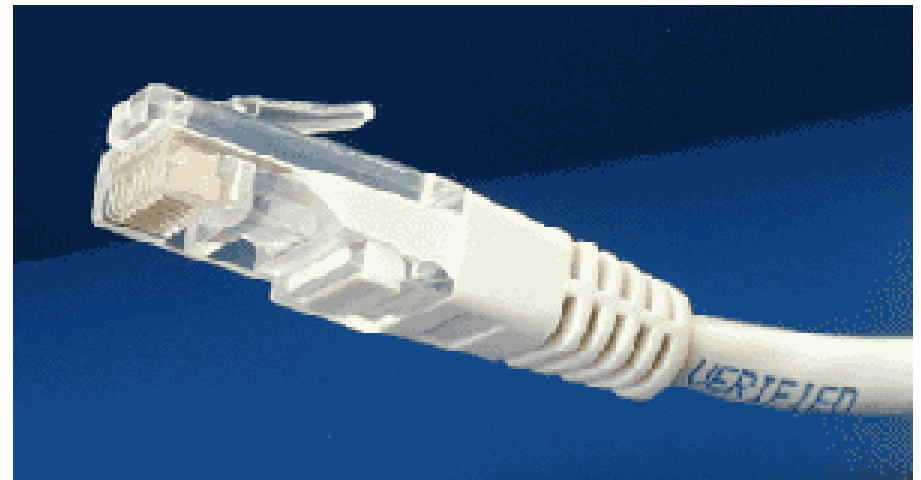
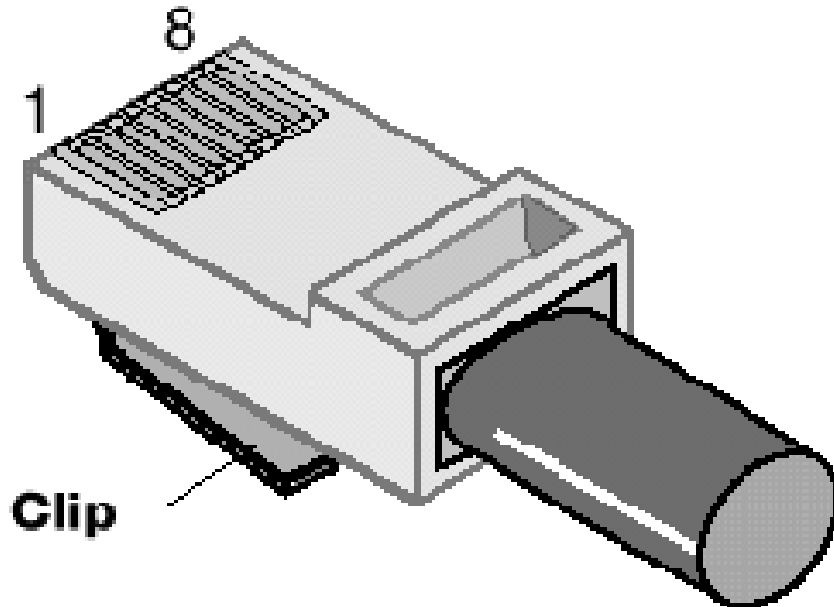
## Ethernet Port



“100 Base T” means:

- 100 Mbps
- Baseband signal
- Twisted pair

## RJ-45 Connector



RJ-45 = Registered Jack-45 (8-wire)  
(RJ-11: for telephone, 4- or 6-wire)

# Networking



- Network speed
  - How fast is fast? (time to transmit 10MB of data)
    - 28.8 kps modem: 5 minutes
    - 56 kps modem: 26 min. 20 sec.
    - 128 kps (ISDN): 10 minutes
    - 1.544 Mbps (T-1): 50 seconds
    - 10 Mbps (10BaseT): 8 seconds
    - 100 Mbps (100BaseT): 0.8 seconds
    - 1000 Mbps (1000BaseT): 0.08 seconds
    - 10 Gbps (10GBaseT): 0.008 seconds

The world is  
going Gigabit!

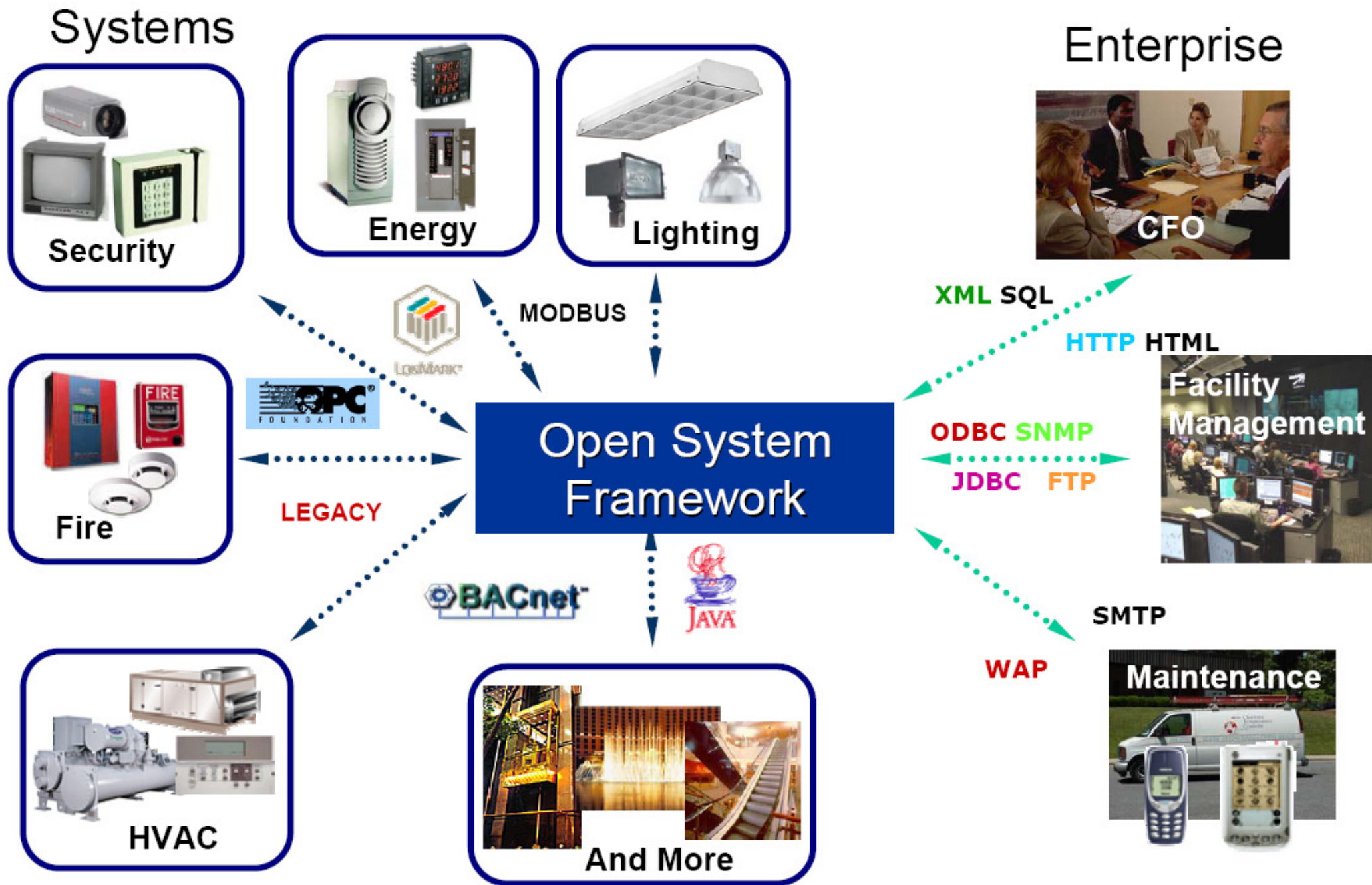
# Networking



- Leading official standards organisation
  - IEEE 802 LAN/MAN Standards Committee ([www.ieee802.org](http://www.ieee802.org)) and its working groups
    - 802.1: interface between OSI levels 1 & 2 with five higher level layers (OSI = Open Systems Interconnection)
    - 802.2: logical data link
    - 802.3: CSMA/CS (carrier sense multiple access with collision avoidance)
    - 802.4: Token bus
    - 802.5: Token ring



# Communication of building sub-systems using open system framework

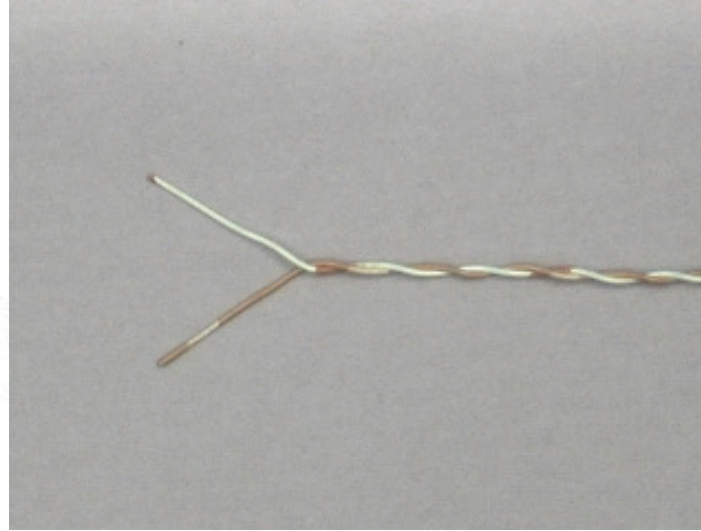
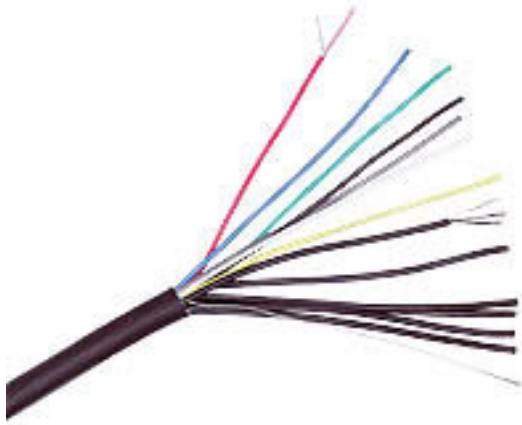




# Transmission Methods

- Media/transmission methods
  - Twisted pairs (TP)
    - Two insulated conductors twisted together to minimise interference by unwanted signals
      - Line bandwidth (300-3000 Hz)
      - Signal-to-noise ratio
      - Conditioning (of the line)
    - Conditioned line has speed up to 9600 bps
    - In most cases, 1200 bps is maximum
    - Unshielded twisted pairs (UTP)

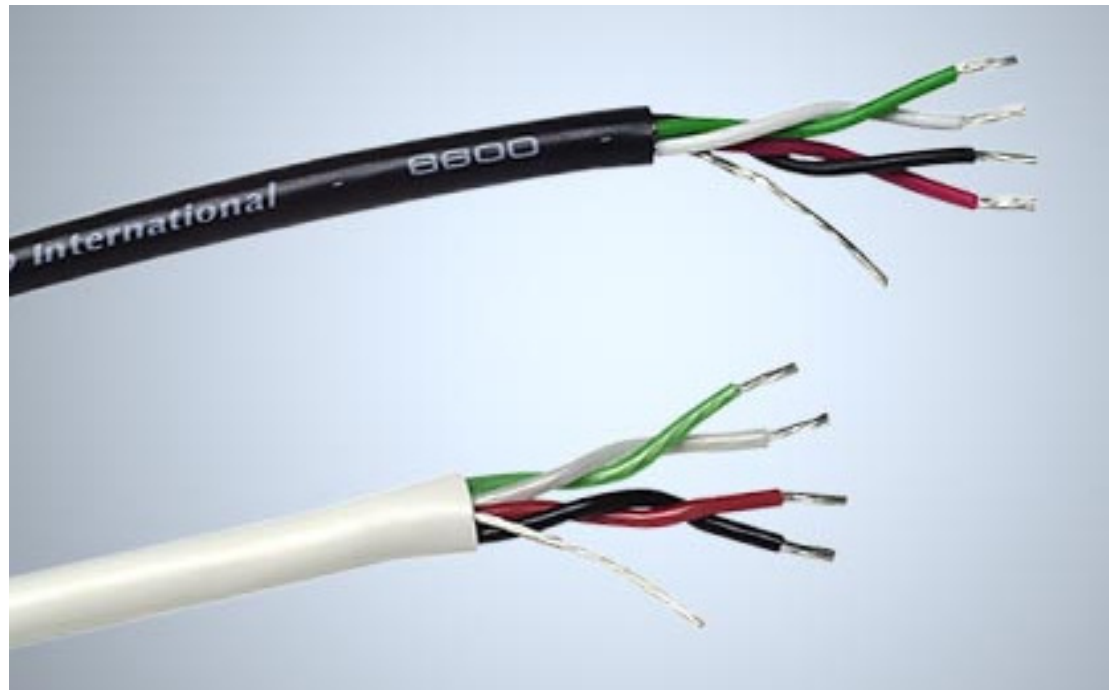
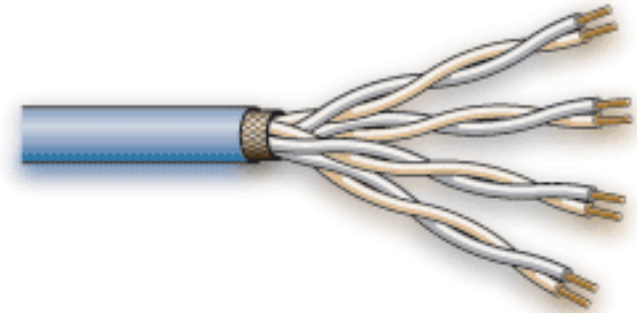
# Twisted pairs (TP)



**Unshielded twisted-pair**



**Foiled twisted-pair**



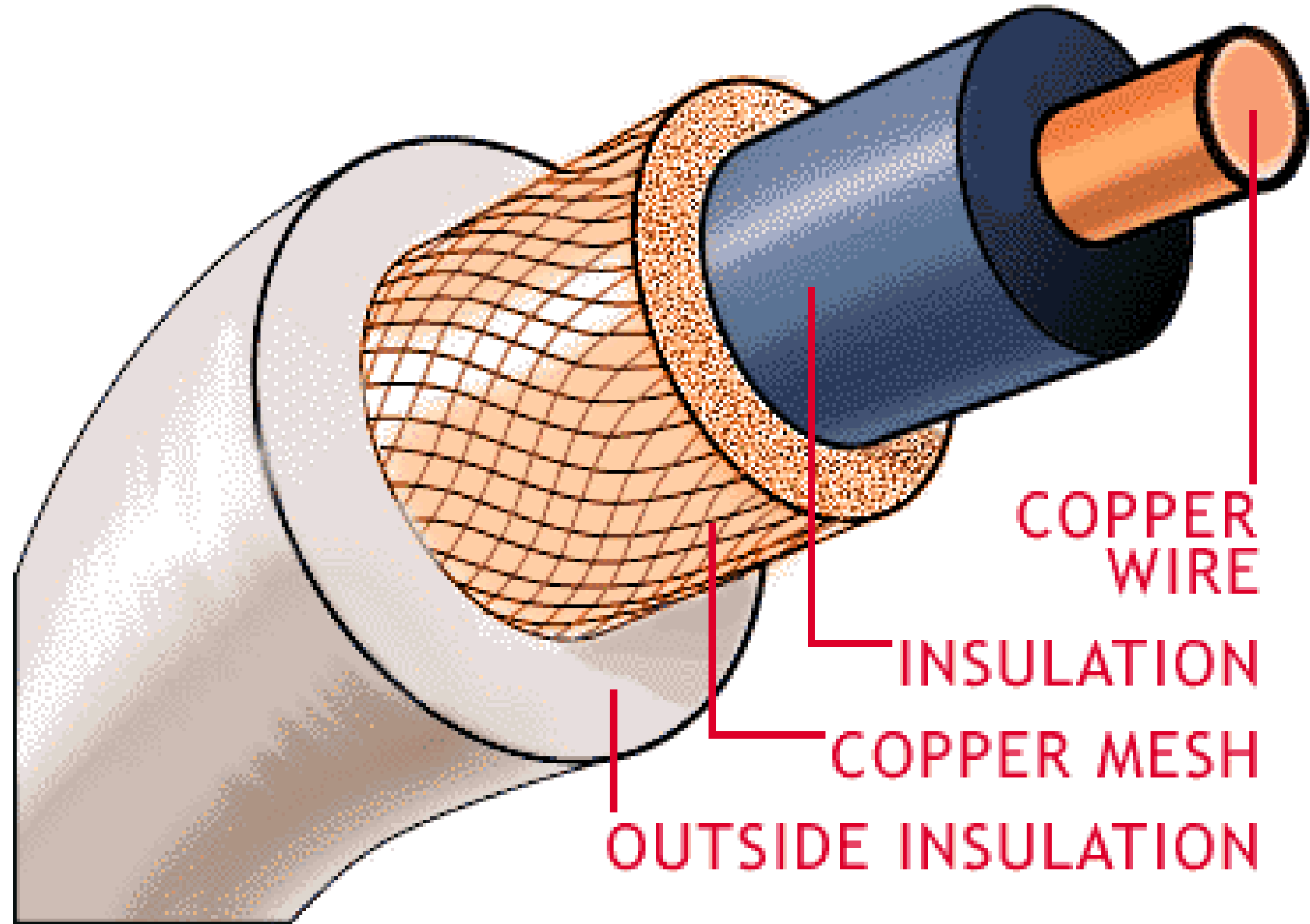




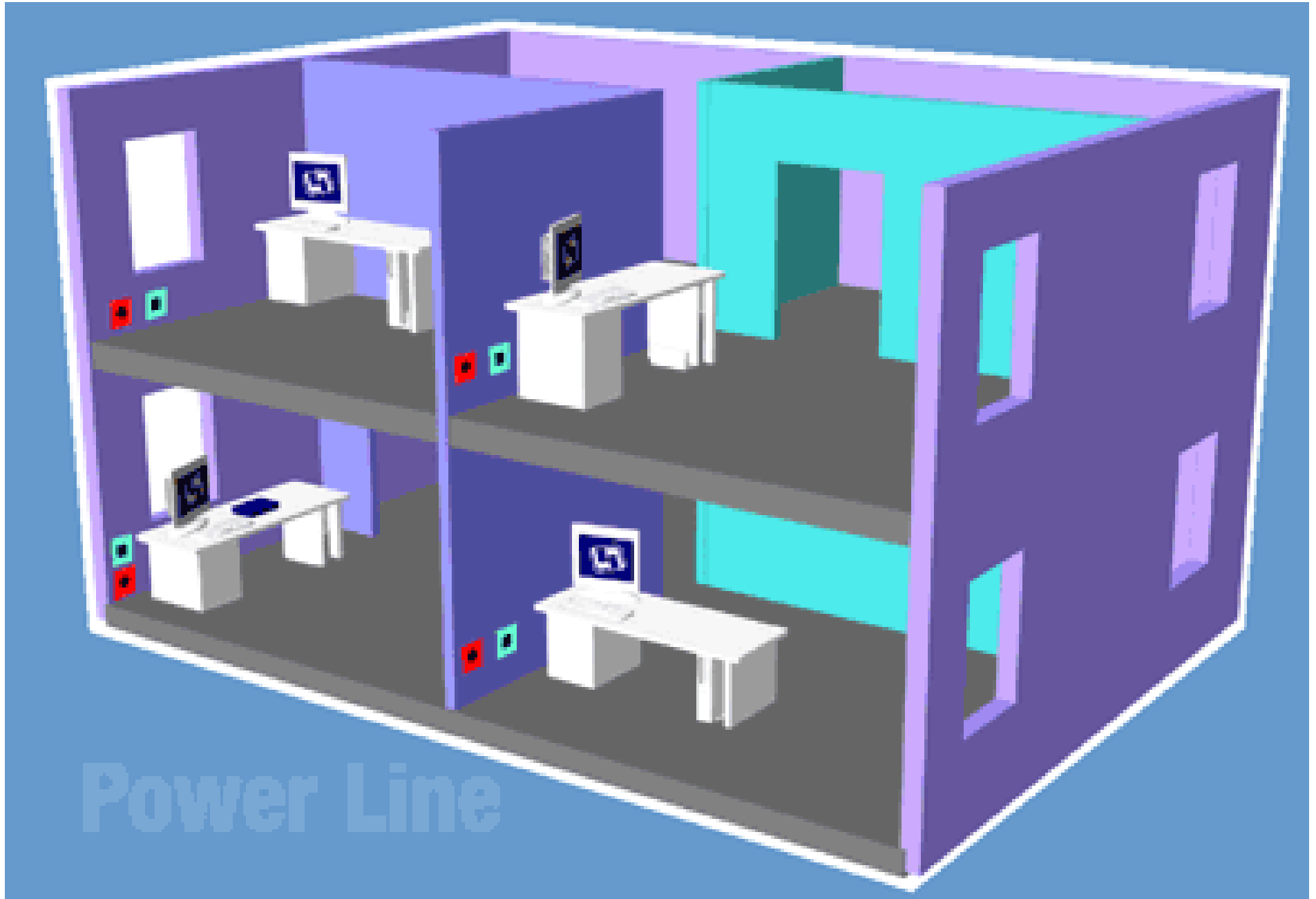
# Transmission Methods

- Media/transmission methods (cont'd)
  - Voice grade lines
    - Type 3002 in in the Bell Telephone Company's standard BSP41004
  - Coaxial cable
    - Centre conductor surrounded by a shield
      - Electromagnetic interference
  - Power lines
    - Using carrier current transmission that superimposes a low RF signal (100 kHz) onto the 50/60 Hz power distribution system

# Coaxial cable



# Power line transmission and communication



(\* Video: Powerline Home Networking (2:10) <http://www.youtube.com/watch?v=yud7wfWgTBk>)

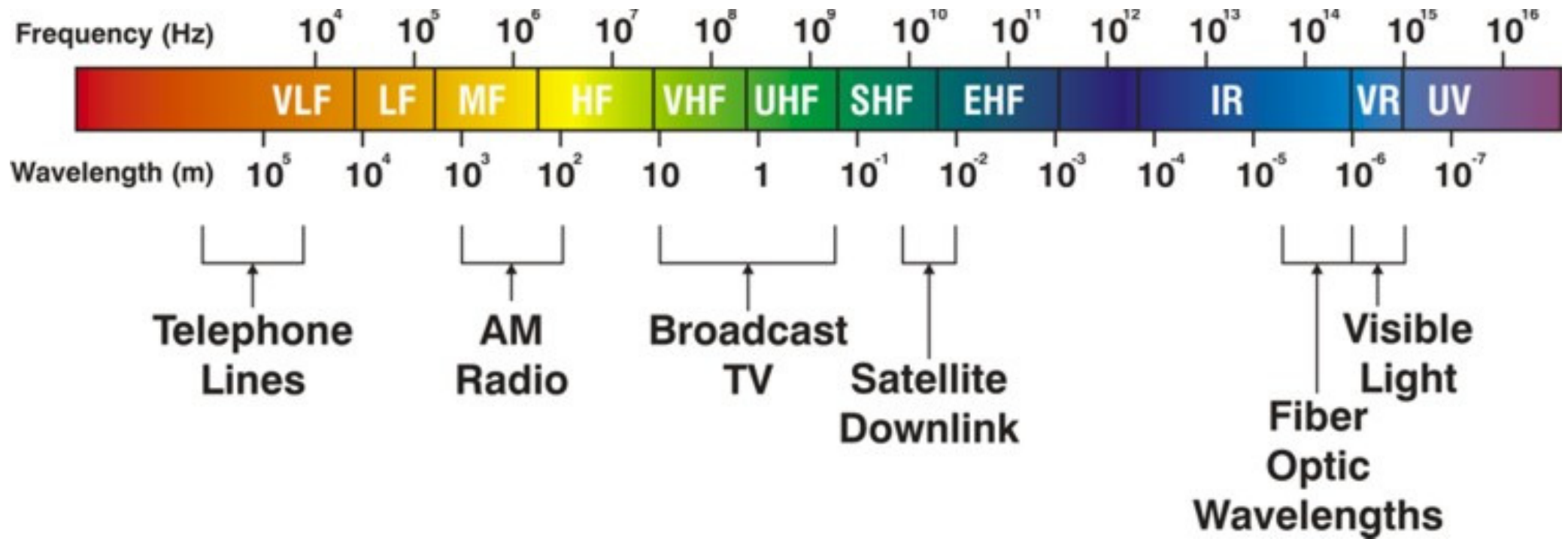
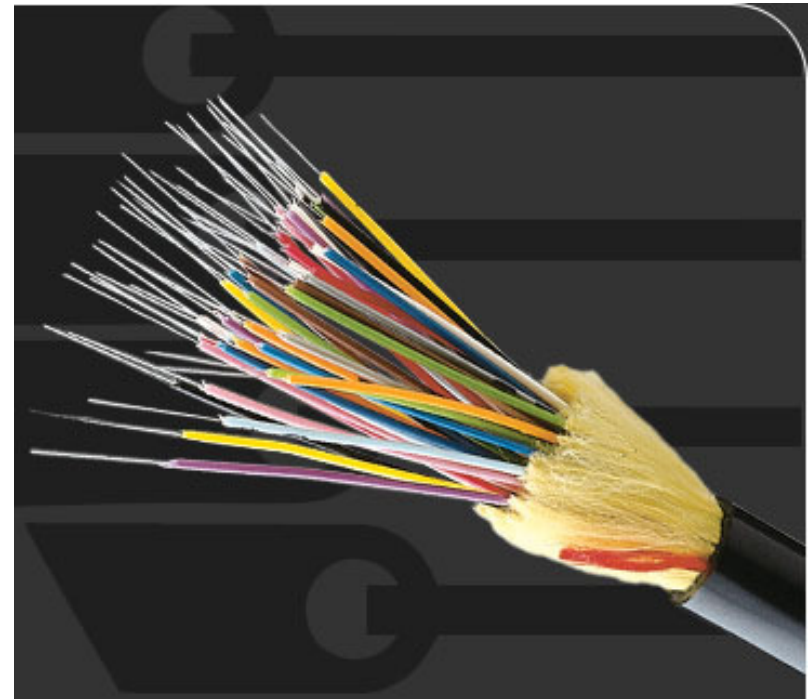
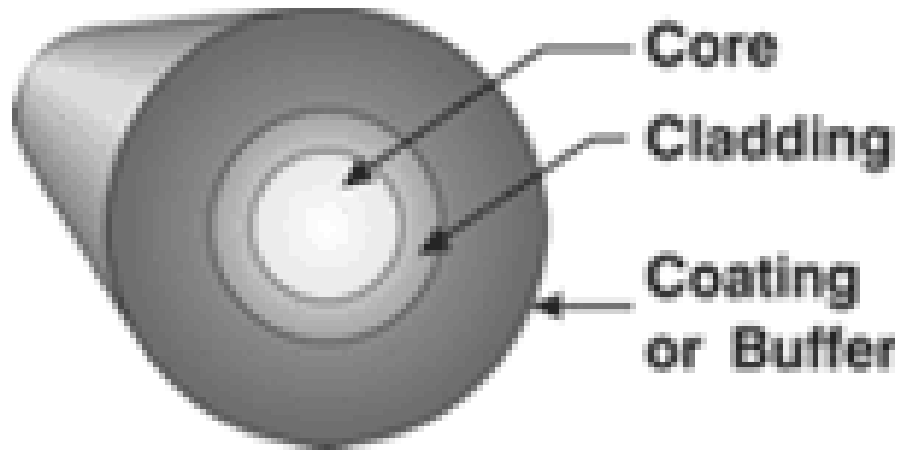
(Source: [www.linksys.com](http://www.linksys.com))



# Transmission Methods

- Media/transmission methods (cont'd)
  - Radio frequency (RF)
    - Modulated RF, with radio receivers and transmitters
  - Microwave
    - Used by TV stations, very high cost
  - Fibre optics
    - Infrared light travelling through transparent fibres
    - Best suited for point-to-point high speed transmission
    - Bandwidth virtually unlimited

# Fibre optics transmission



# Comparison of transmission methods

Method	First cost	Scan rates	Reliability	Maint. Effort	Expandability	Compatibility
Coaxial	High	Fast	Excellent	Min.	Unlimited	Unlimited
Twisted pair	High	Medium	Very good	Min.	Unlimited	Limited
Radio frequency	Medium	Fast but limited	Low	High	Very limited	Very limited
Microwave	Very high	Very fast	Excellent	High	Unlimited	Unlimited
Telephone	Very low	Slow	Low to high	Min.	Limited	Limited
Fibre optics	High	Very fast	Excellent	Min.	Unlimited	Unlimited

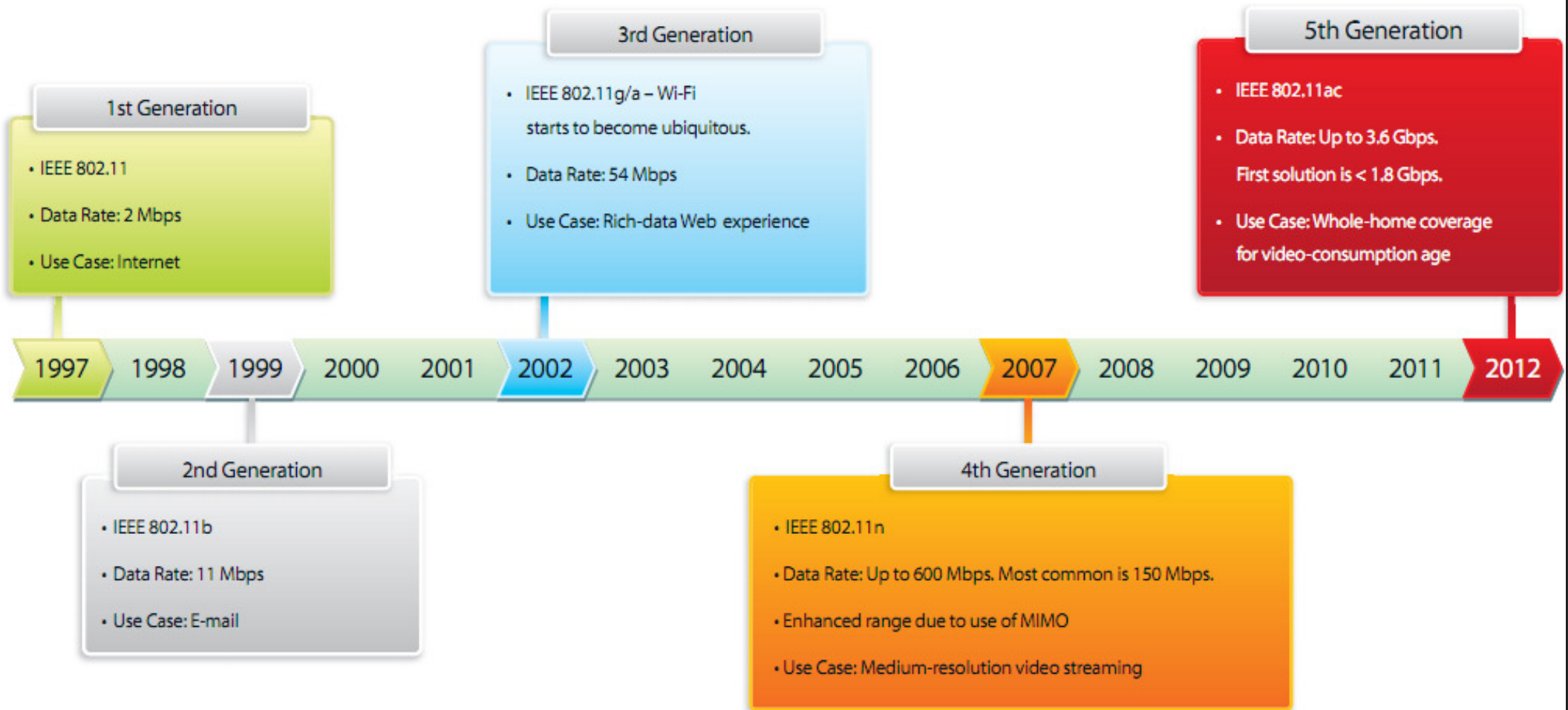


# Transmission Methods

- **Wireless communication**
  - Transfer of information between two or more points that are not connected by an electrical conductor, such as radio & infrared controller
- **Modern wireless technologies**
  - Digital devices that communicate without wires
    - Such as mobile phones and wireless networking
  - 4G LTE (long-term evolution), LTE-Advanced
  - Wi-Fi (wireless LAN), Bluetooth

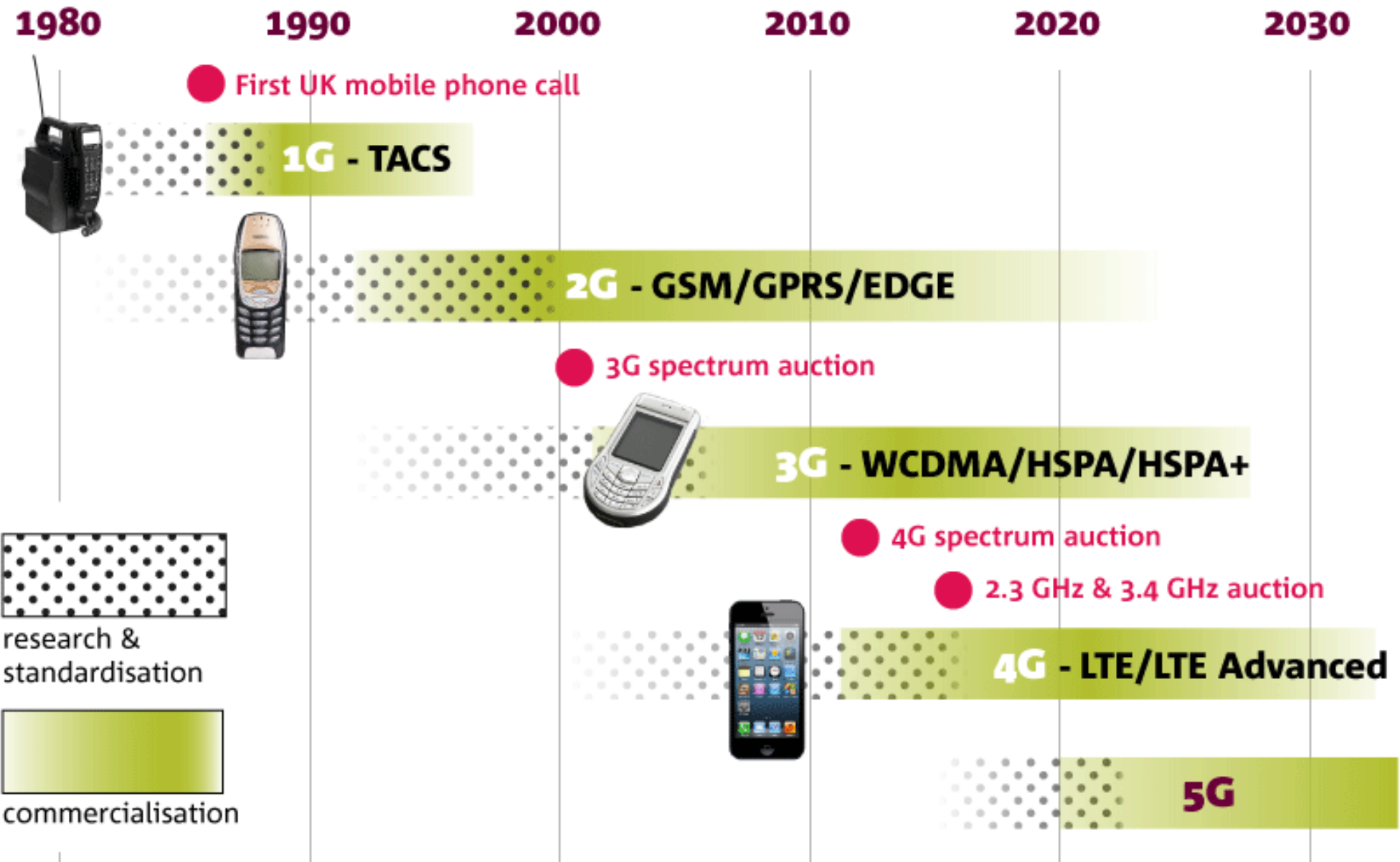


# Evolution of Wi-Fi technology





# Evolution of mobile phone communications



# In-Building Wireless Systems



- Mobility of people and business
  - Mobile devices become a must
    - “One person one number” + Voice to data
  - 70%+ of mobile traffic occurs inside buildings
  - Full in-building coverage is essential (e.g. lift cars)
- Indoor systems should be pre installed, like other utilities in the building
  - Covering areas of high user density
  - Keep the building users “Happy”



# In-Building Wireless Systems



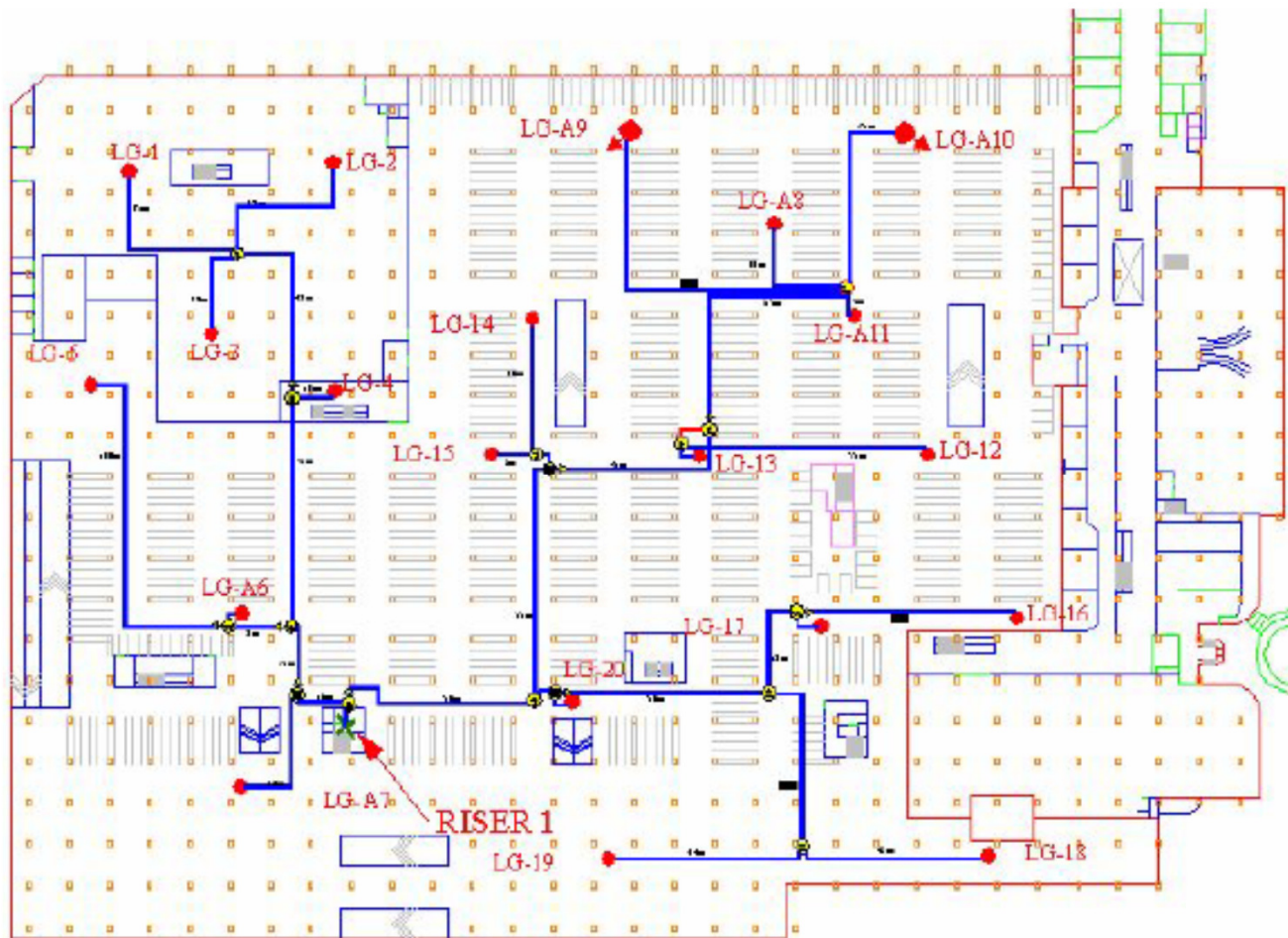
- System design options:
  - RF (radio frequency) source
    - Antenna/Repeater – brings in RF from the outdoor cellular network
    - Carrier installed base transceiver station provides dedicated RF
  - Passive distributed antenna systems
    - RF is distributed over coax cables to each antenna from an RF source (repeater or base station)
    - Coax cable losses limit their effectiveness in large buildings for higher frequency transmissions

# In-Building Wireless Systems



- System design options: (cont'd)
  - Active distributed antenna systems
    - Fiber-optic cabling backbone overcomes the transmission losses that occur w/ coax-based system
    - Electric components convert and amplify signals to RF by the antenna (preferred for medium to large buildings)
  - Distributed radios
    - Consist of small cellular radios, called picocells and femtocells to create an internal cellular network
    - Do not rely on the macro network for switching and hand-offs; only wireless carriers can provide this

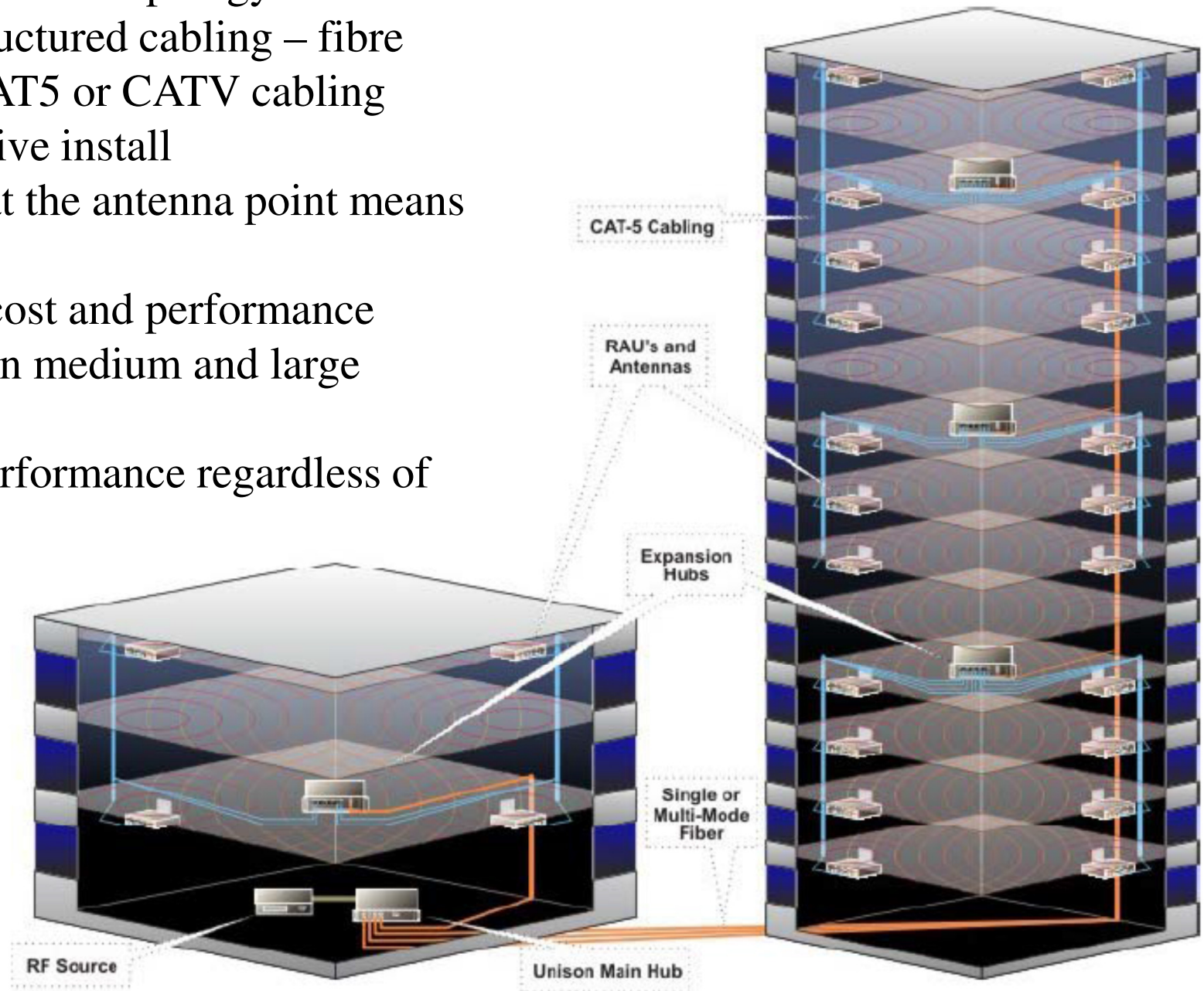
# Example of passive distributed antenna system



- Essentially a “sprinkler system” for cell phone signals
- Distribution via large coaxial cables
- Losses through the cable limit the size
- New, higher frequency bands have high loss

# Example of active distributed antenna system

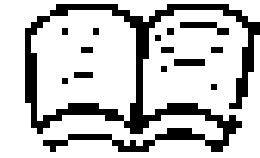
- LAN/WLAN-like topology
- Standard structured cabling – fibre optic and CAT5 or CATV cabling
- Less disruptive install
- Amplifiers at the antenna point means zero “loss”
- Significant cost and performance advantages in medium and large buildings
- Excellent performance regardless of frequency



# In-Building Wireless Systems



- In-building wireless implementation steps
  - Budgetary design – usually based on floor plans
    - Determine which areas of the building require coverage (entire building, public areas, parking levels, etc.)
    - Determine the building's construction materials
    - Determine capacity requirements
  - Site survey
    - Confirm RF propagation, determine locations for equipment, confirm antenna locations, measure interference thresholds, confirm cable routes and lengths, power, security



# Further Reading

- Information Technologies Engineering (WBDG)  
[http://www.wbdg.org/design/dd\\_infotecheng.php](http://www.wbdg.org/design/dd_infotecheng.php)
- Placing Electrical Systems and Communications Systems in Buildings [US GSA]  
<http://www.gsa.gov/portal/content/101246>
- Black Box Guide to Structured Cabling [[PDF](#)]
- Introduction to structured cabling [[PDF](#)]