Information Technology in Buildings

Ir. Dr. Sam C. M. Hui
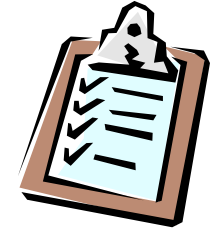Visiting Assistant Professor
Department of Mechanical Engineering
The University of Hong Kong
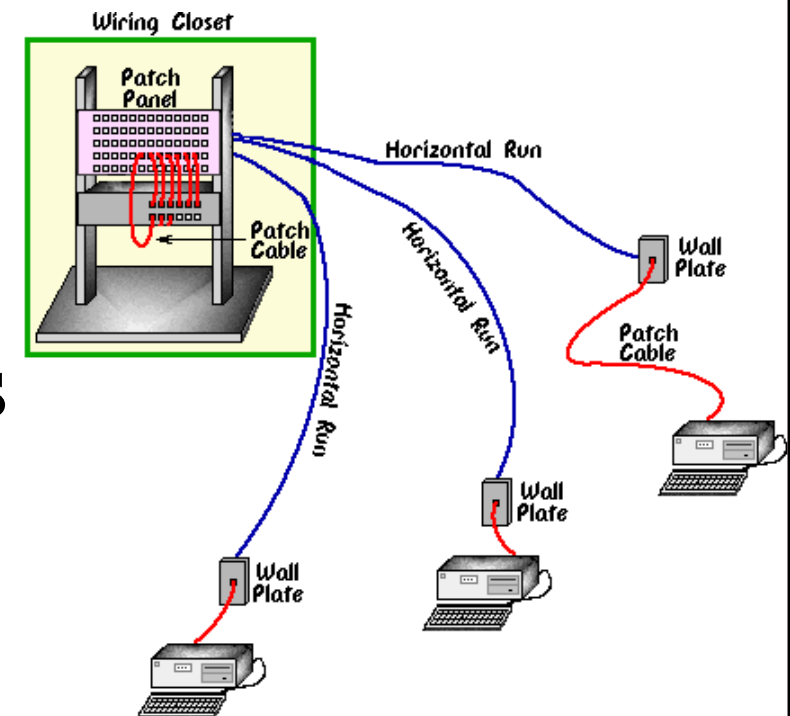E-mail: cmhui@hku.hk

Feb 2017

Contents

- 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)
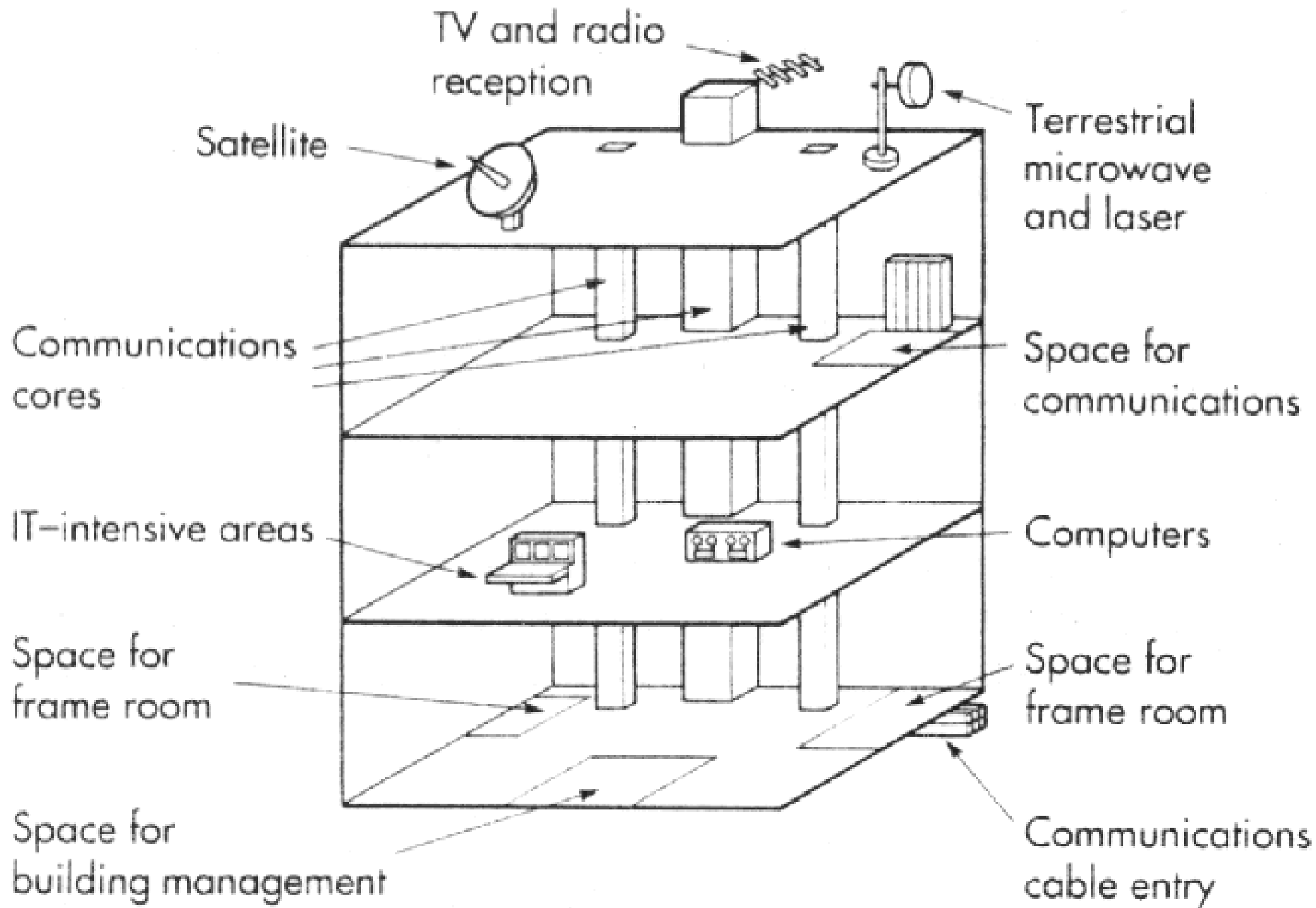 - 3. Miscellaneous (public address, CCTV, etc.)

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)

TV and radio reception

Satellite

Terrestrial microwave and laser

Communications cores

Space for communications

IT-intensive areas

Computers

Space for frame room

Space for frame room

Space for building management

Communications cable entry

(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
    - **<u>Building systems</u>** -- HVAC, lighting, daylighting control, energy monitoring, security access, and fire/smoke detection and alarm
    - **<u>Telecommunications</u>** -- 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)
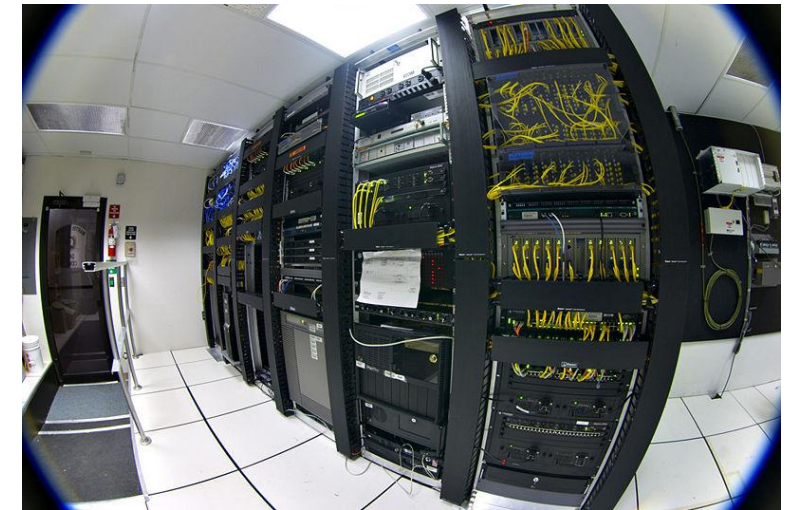   - [Environmental](#) requirements (e.g. temperature)

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)
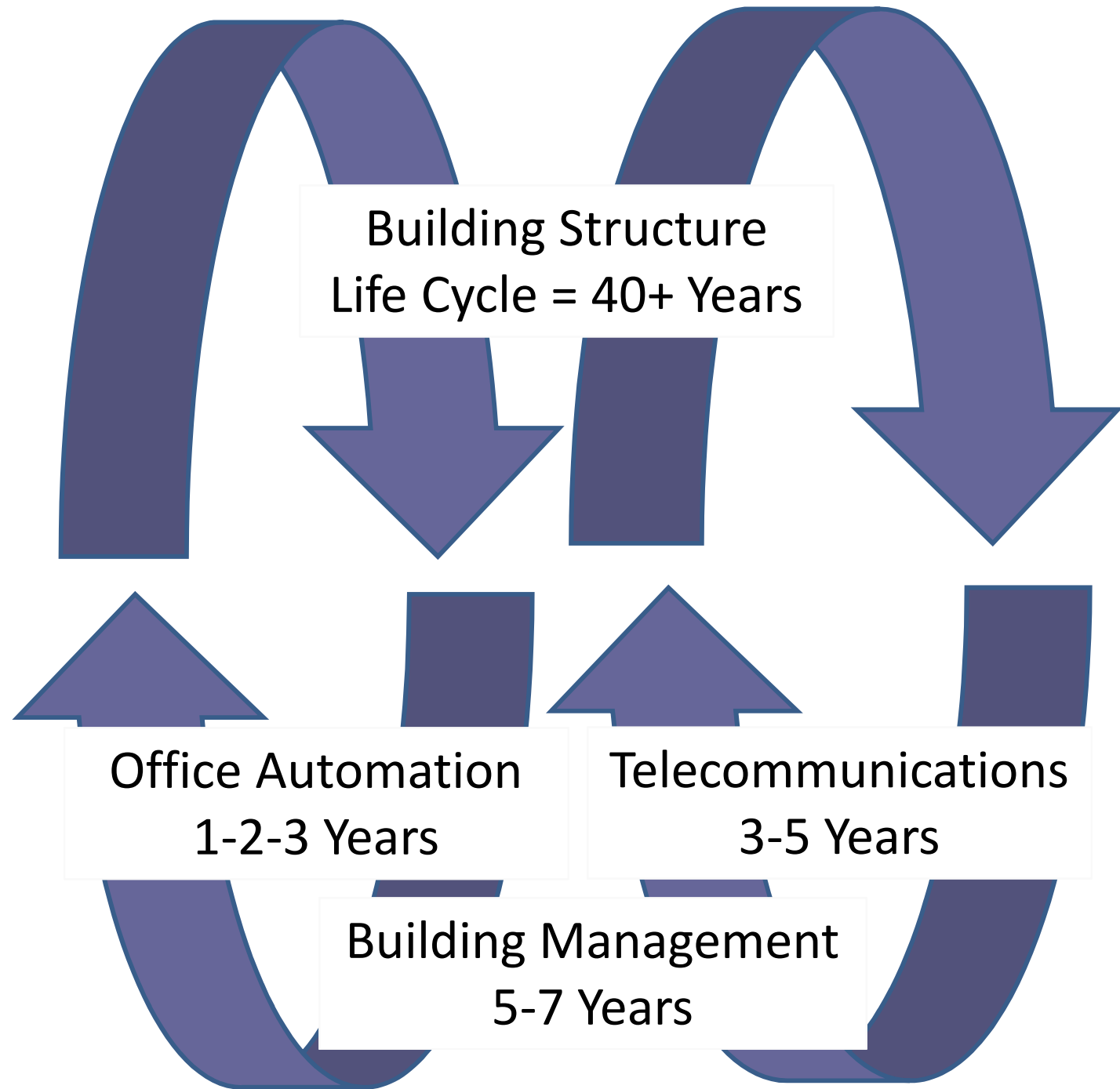
IT and Buildings

- 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

Building Structure
Life Cycle = 40+ Years

Office Automation
1-2-3 Years

Telecommunications
3-5 Years

Building Management
5-7 Years

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

(* See also: Information Technologies Engineering (WBDG) http://www.wbdg.org/design/dd_infotecheng.php)

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)†	**ICT systems†**	**Business systems‡**
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§	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

(Source: The Institution of Engineering and Technology)

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

- <u>Example</u>: 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
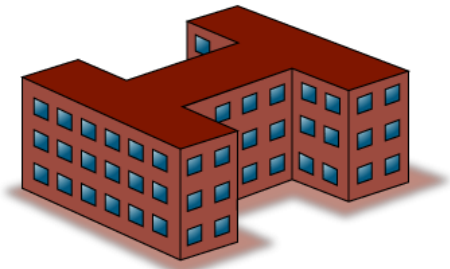
IT and Buildings

- <u>Example</u>: 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)
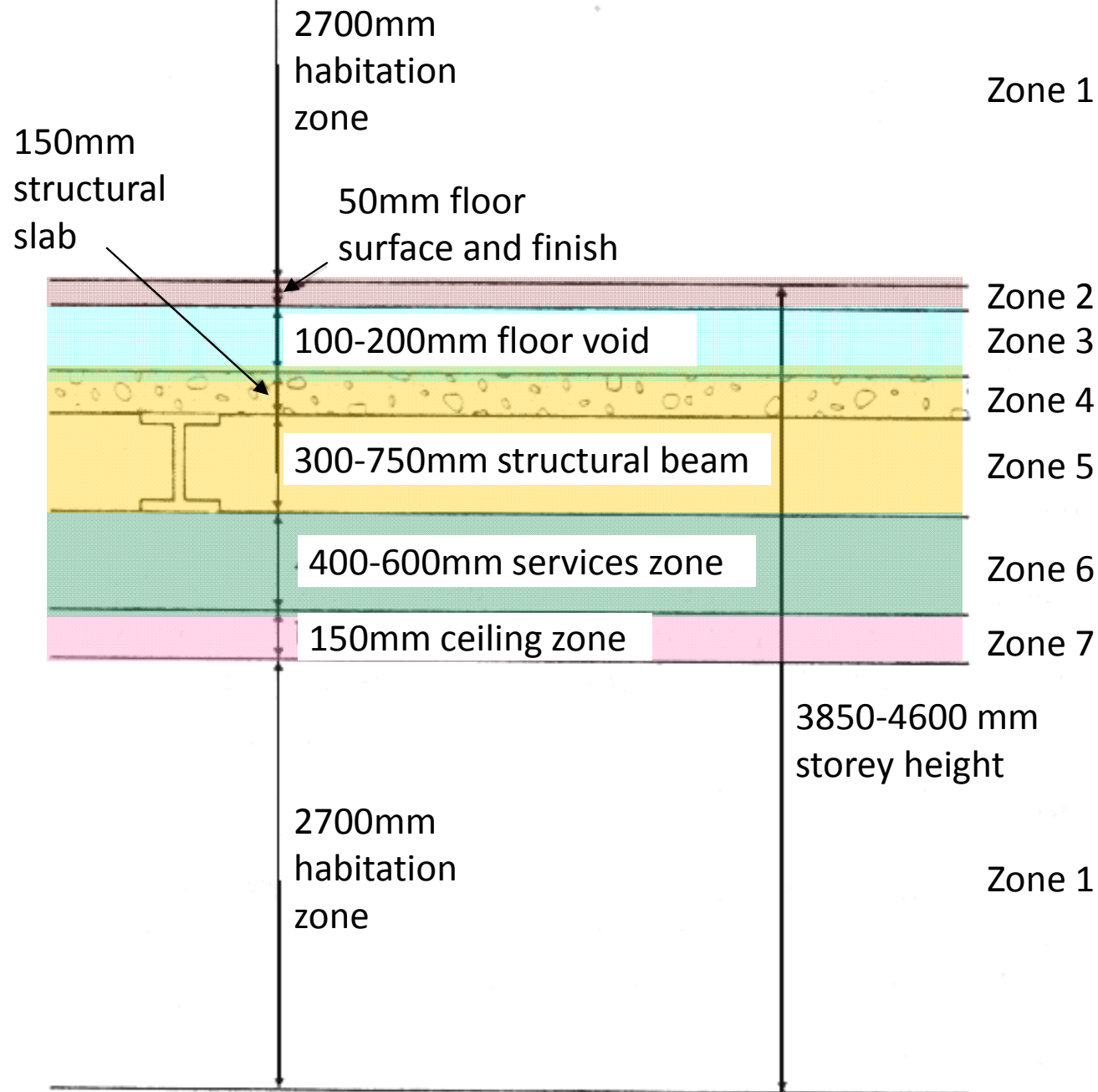   - Select a proper data center site

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
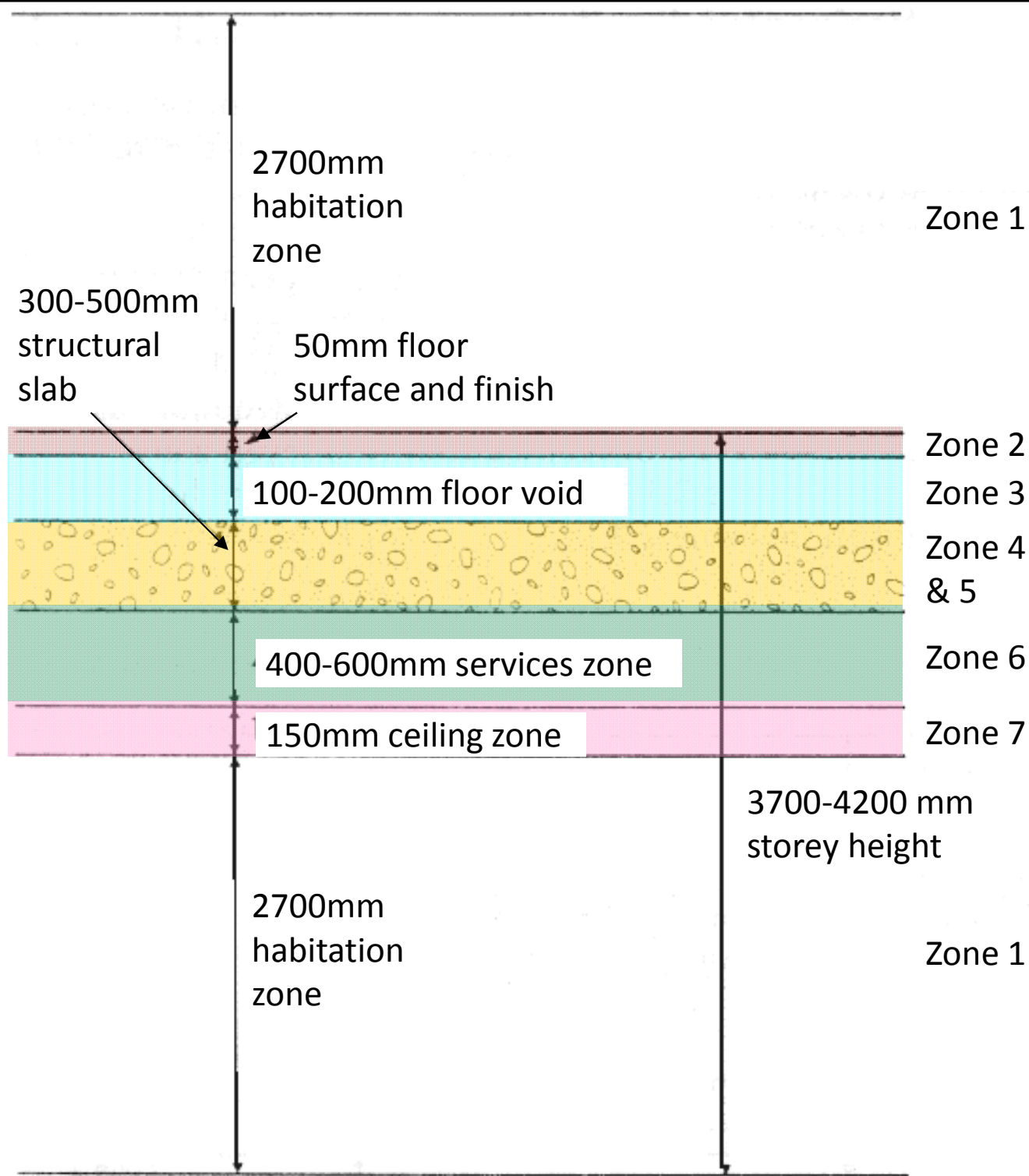
Space & Structural Req's

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

2700mm habitation zone

Zone 1

150mm structural slab

50mm floor surface and finish

Zone 2

100-200mm floor void

Zone 3

Zone 4

300-750mm structural beam

Zone 5

400-600mm services zone

Zone 6

150mm ceiling zone

Zone 7

3850-4600 mm storey height

2700mm habitation zone

Zone 1

Steel frame (3.85-4.6m storey height)

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

2700mm habitation zone   Zone 1

300-500mm structural slab

50mm floor surface and finish   Zone 2

100-200mm floor void   Zone 3

Zone 4 & 5

400-600mm services zone   Zone 6

150mm ceiling zone   Zone 7

3700-4200 mm storey height

2700mm habitation zone   Zone 1

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

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

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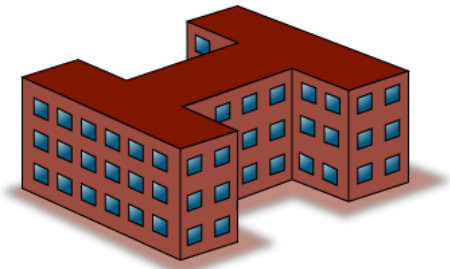
- [Floor loading](#)
  - Usually IT equipment will not exceed the floor loads, except where equipment densities are high
  - Where point loads are high, load spreading must be used, such as for power equipment
  - High volume of papers (very heavy!)
  - Loads of raised floors
  - Access areas
  - Weight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

Space & Structural Req's
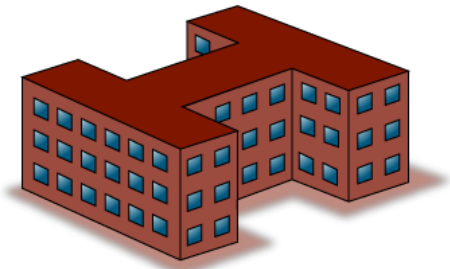
- [IT equipment rooms](#)
  - Project planning
    - Detailed knowledge of IT equipment often not known
   - May consult the public telephone/network operators & equipment suppliers
  - Design considerations
    - Voice and data services
    - Distributed equipment rooms
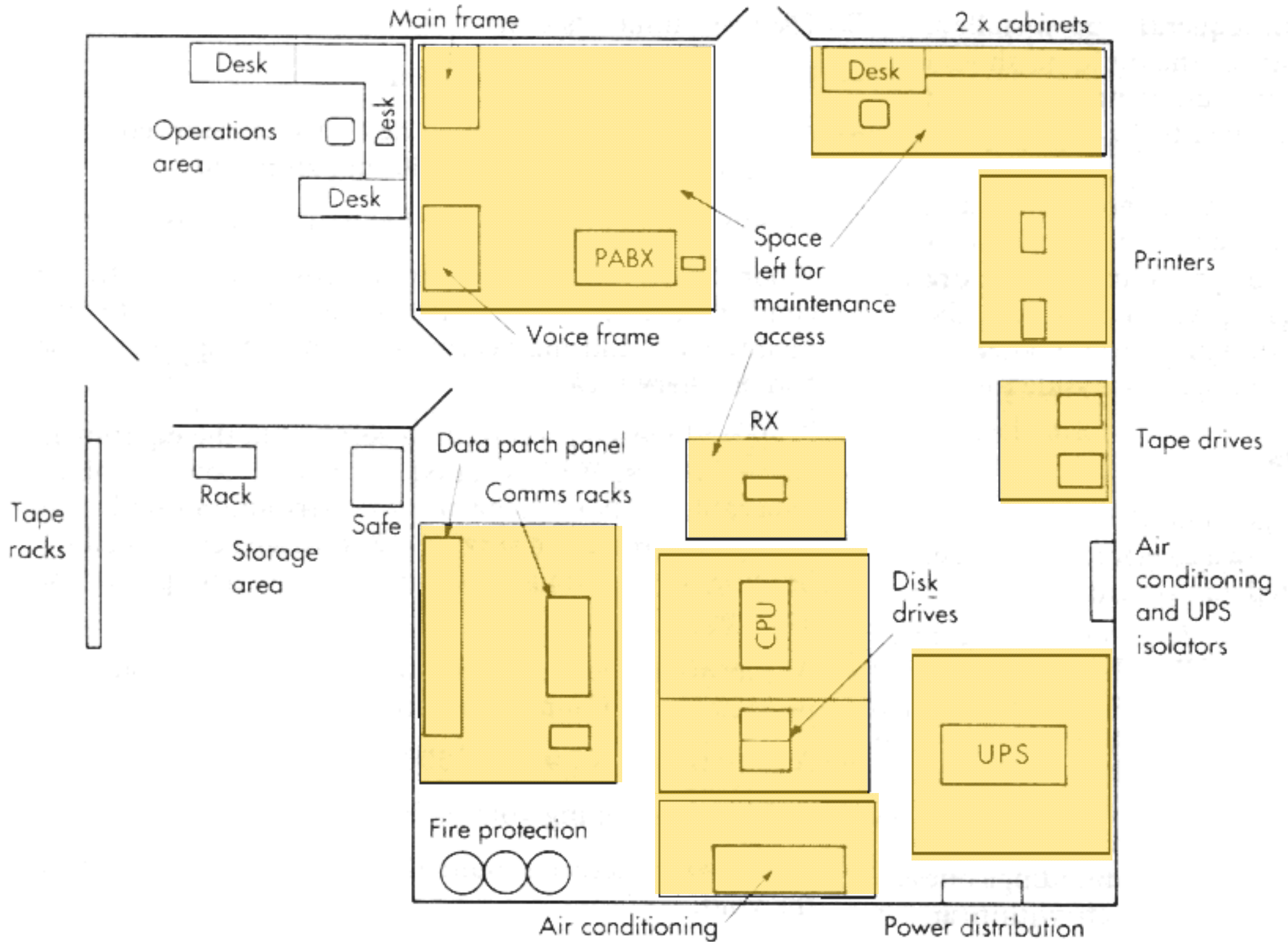   - Components of IT systems

Components of IT systems

System	External service	Equipment	Internal distribution
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

(Source: CIBSE, 1992. Information Technology and Buildings)
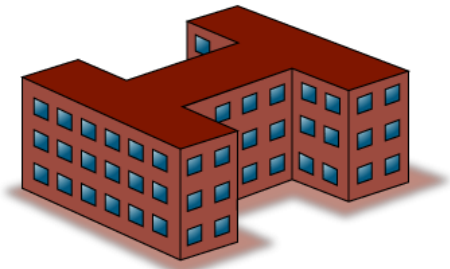
Space & Structural Req's
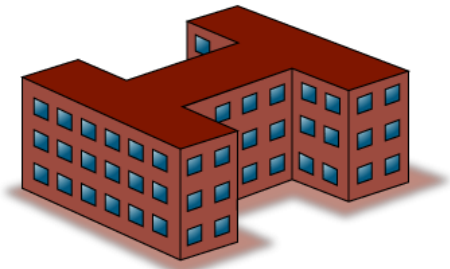
- <u>General equipment rooms</u>: design considerations
    - Minimum room height, floor void, ceiling void
    - Sufficient floor loadings
    - Access for installing, operating and maintenance of equipment
    - Environment suitable for operating the equipment
    - Room finishes easily cleaned
   - Floor areas allowed for all equipment, staff, services, storage, etc

Main frame

2 x cabinets

Desk

Operations area

Desk

Desk

Voice frame

PABX

Space left for maintenance access

Printers

RX

Tape drives

Data patch panel

Comms racks

Tape racks

Rack

Safe

Storage area

CPU

Disk drives

Air conditioning and UPS isolators

Fire protection

Air conditioning

UPS

Power distribution

(Source: CIBSE, 1992. Information Technology and Buildings)
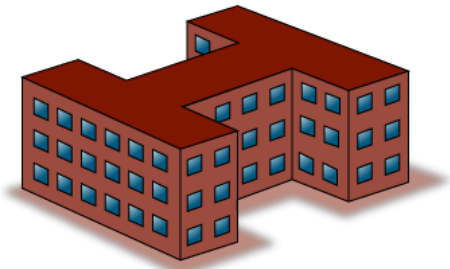
Space & Structural Req's

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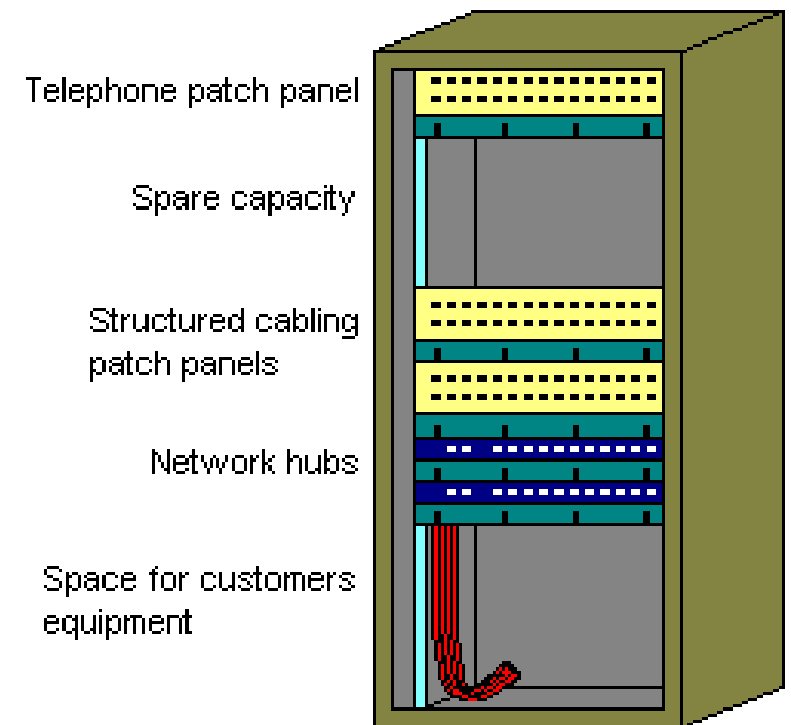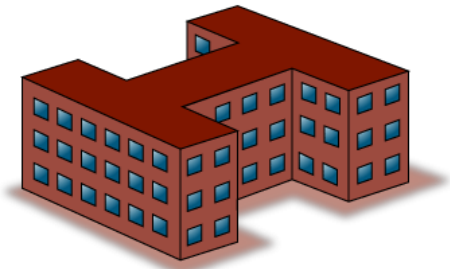
Space & Structural Req's
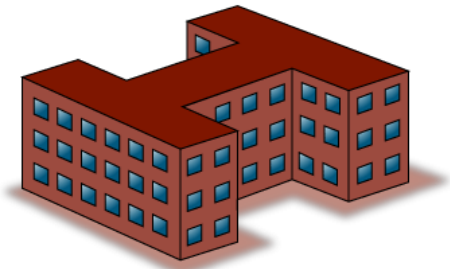
- Major sub-systems:
  - Lead-in or entrance facilities, including cable entry and cable entry chamber
  - Telecommunications and broadcasting equipment (TBE) room [*Equipment room*]
  - Secondary TBE room [*Telecomm room*]
  - Vertical riser (backbone)
  - Horizontal distribution facilities
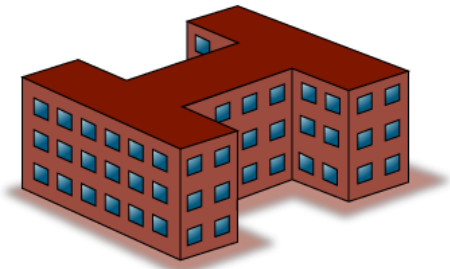
Space & Structural Req's

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

Telephone patch panel

Spare capacity

Structured cabling patch panels

Network hubs

Space for customers equipment

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

(* See also: Placing Electrical Systems and Communications Systems in Buildings [US GSA] http://www.gsa.gov/portal/content/101246)

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

- <u>Structured cabling system (SCS)</u>
  - 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

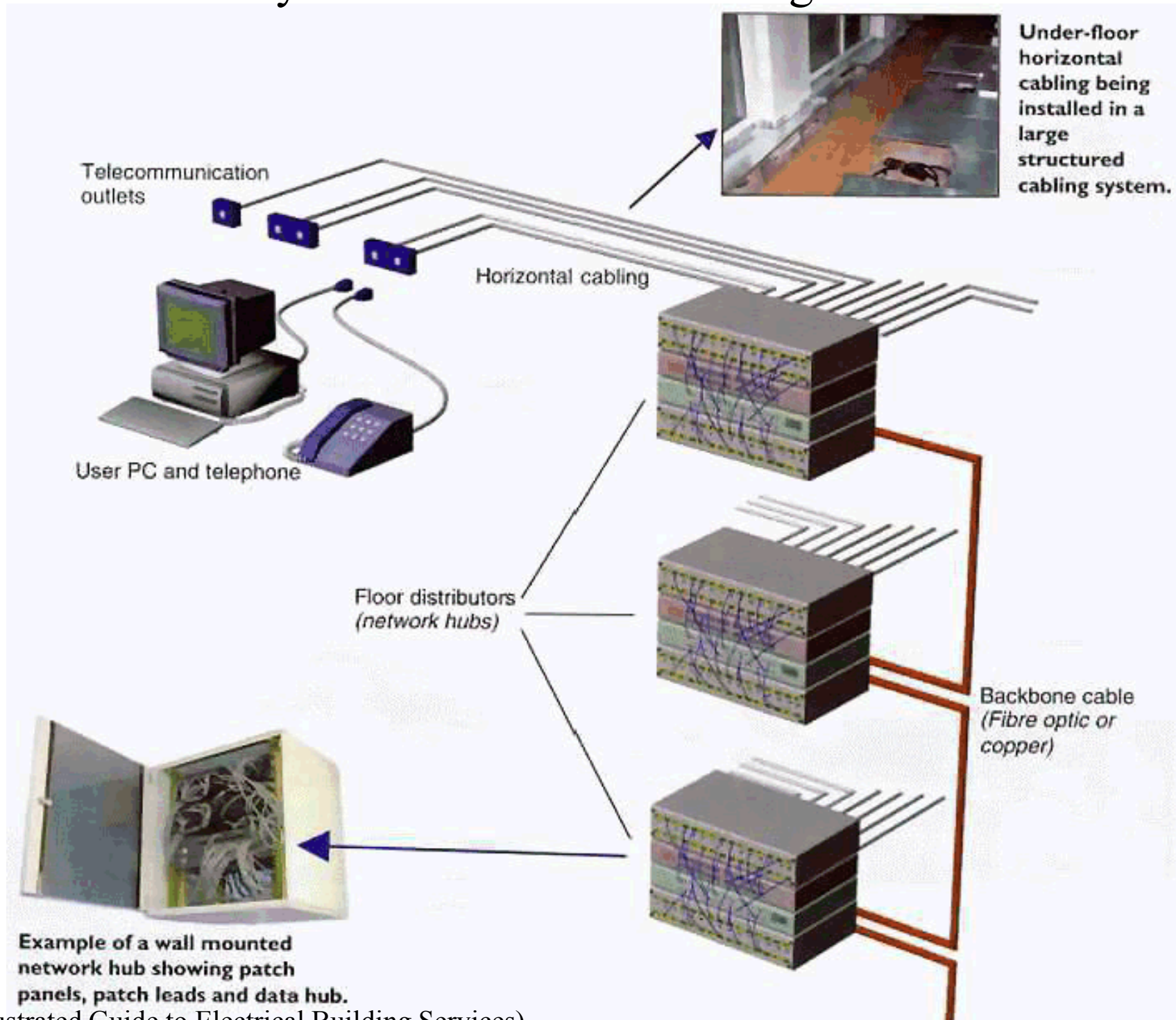Structured Cabling Subsystems
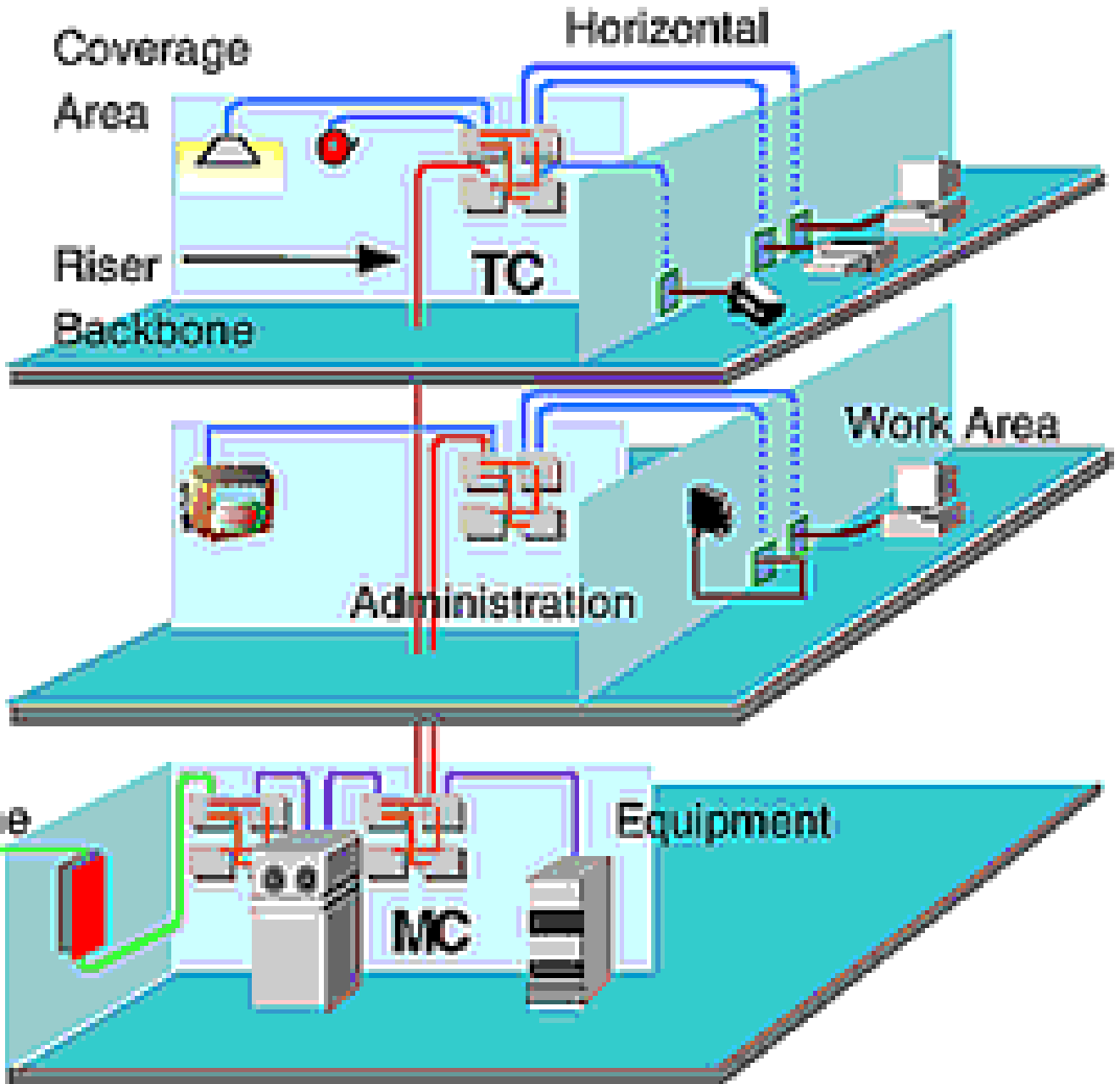
Cabling Management

- Industry <u>standards</u> 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

Under-floor horizontal cabling being installed in a large structured cabling system.

Telecommunication outlets

Horizontal cabling

User PC and telephone

Floor distributors (network hubs)

Backbone cable (Fibre optic or copper)

Example of a wall mounted network hub showing patch panels, patch leads and data hub.

(Source: Illustrated Guide to Electrical Building Services)
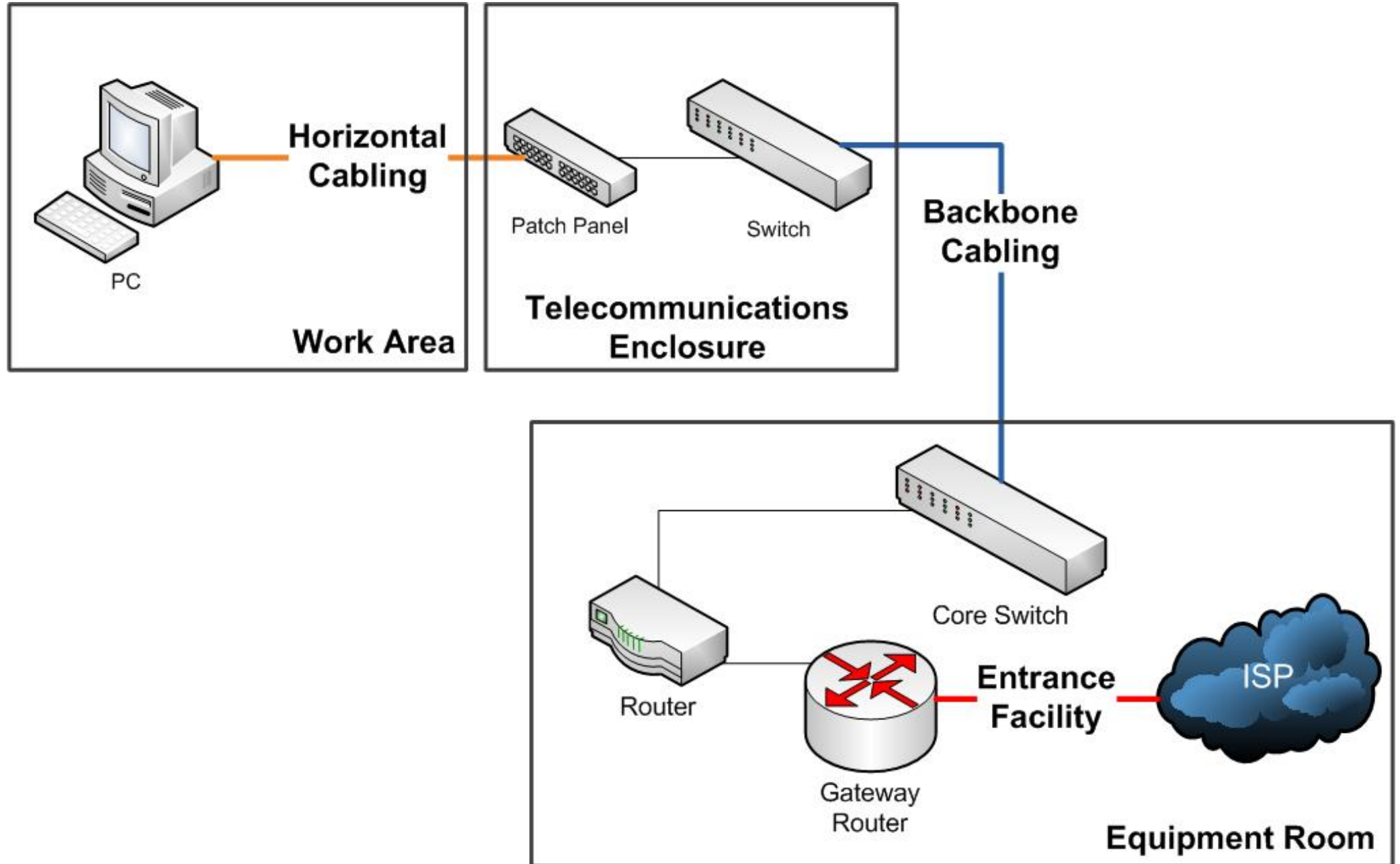
Cabling Management

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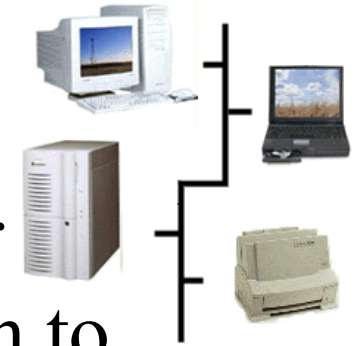
- Why Network?
  - Devices can be shared
  - Easier to manage
  - Easier to maintain
  - Less expensive for equipment & software

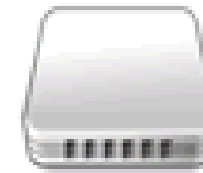# Home computer network

Hub or
Ethernet Switch or
IP Sharing

Splitter

Phone Line

Network Cable

ADSL ATU-R

Telphone

PC

PC

—— Network Cable

—— Phone Line

What network do you have at home?

Office/Enterprise computer network

Department of Electrical Engineering

PC

Network Cable — T1 Leased Line

Fiber — Phone Line

T1 Leased Line

Fiber

IP Sharing

CSU / DSU

Switch

Phone Line

ADSL ATU-R

Phone Line

ADSL ATU-R

E-mail Server

Router

L2 Switch

Server

Server

Web Server

L2 Switch
or
L3 Switch

Network Cable < 100m

Hub or
Ethernet Switch

Department
of Computer
Scienceand
Engineering

L2 Switch

Access
Point

Other
Department

Thin Client

Wireless
Network
Access

PC   PC   PC   PC

Networking

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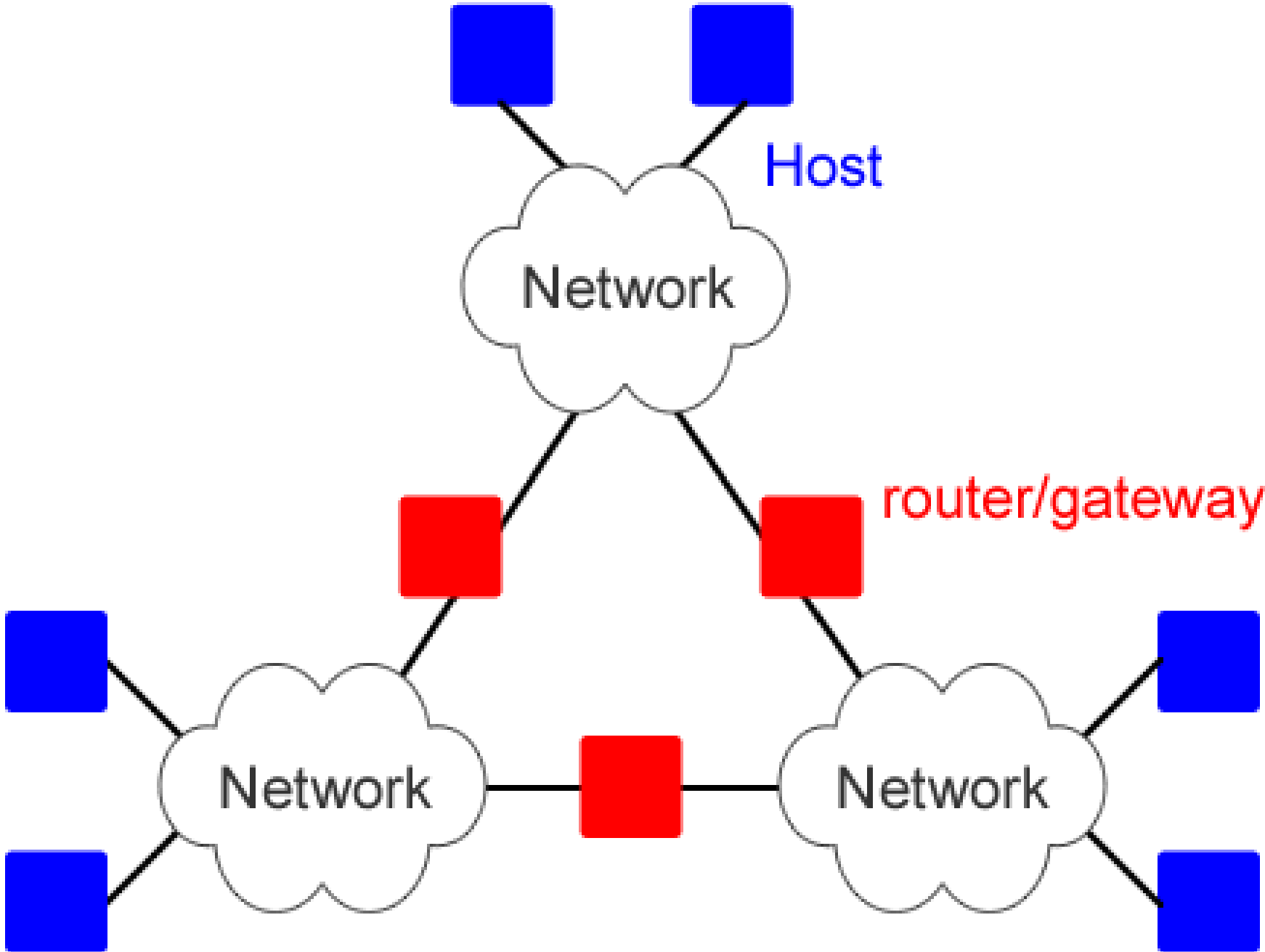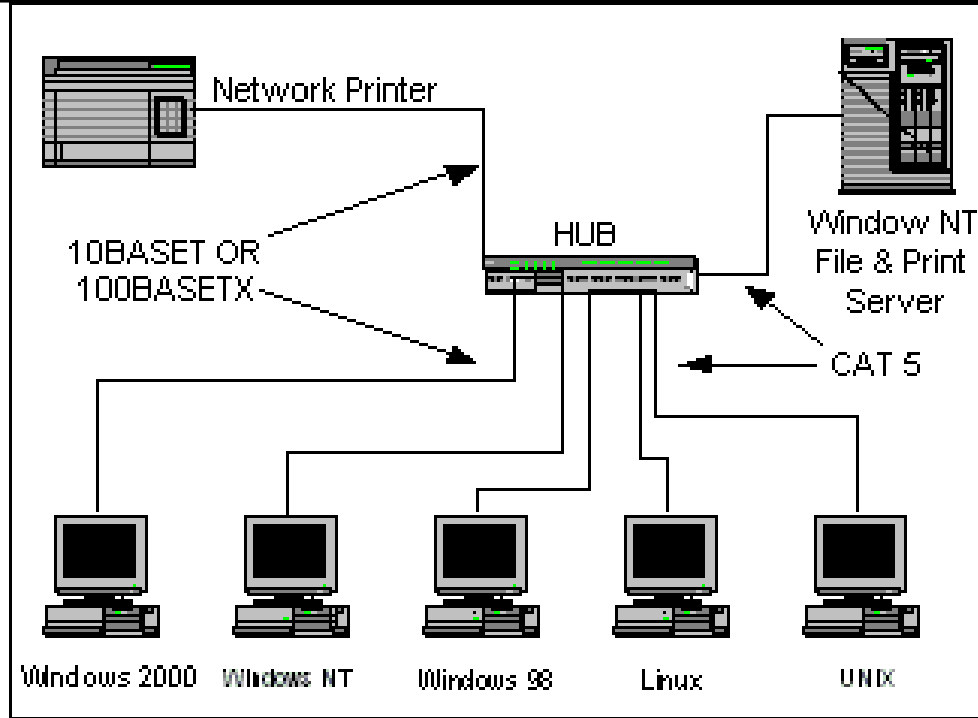- Wide area network (WAN)
  - A system of LANs connected over any distance via telephone lines and radio waves
- Other types of network
  - Metropolitan area network (MAN)
  - Campus area network (CAN)
  - Home area network (HAN)

Internetworking concept

Local Area Network (LAN)

Network Printer

10BASET OR 100BASETX

HUB

Window NT File & Print Server

CAT 5

Windows 2000   Windows NT   Windows 98   Linux   UNIX

Local Area Network

Leased Line Dedicated 56K - 45MB

Warehouse

HUB

Router

Warehouse Terminal

Ticket Printer

Sales Office

Window NT File & Print Server

HUB

Router

Network Printer

Wide/Metropolitan Area Network
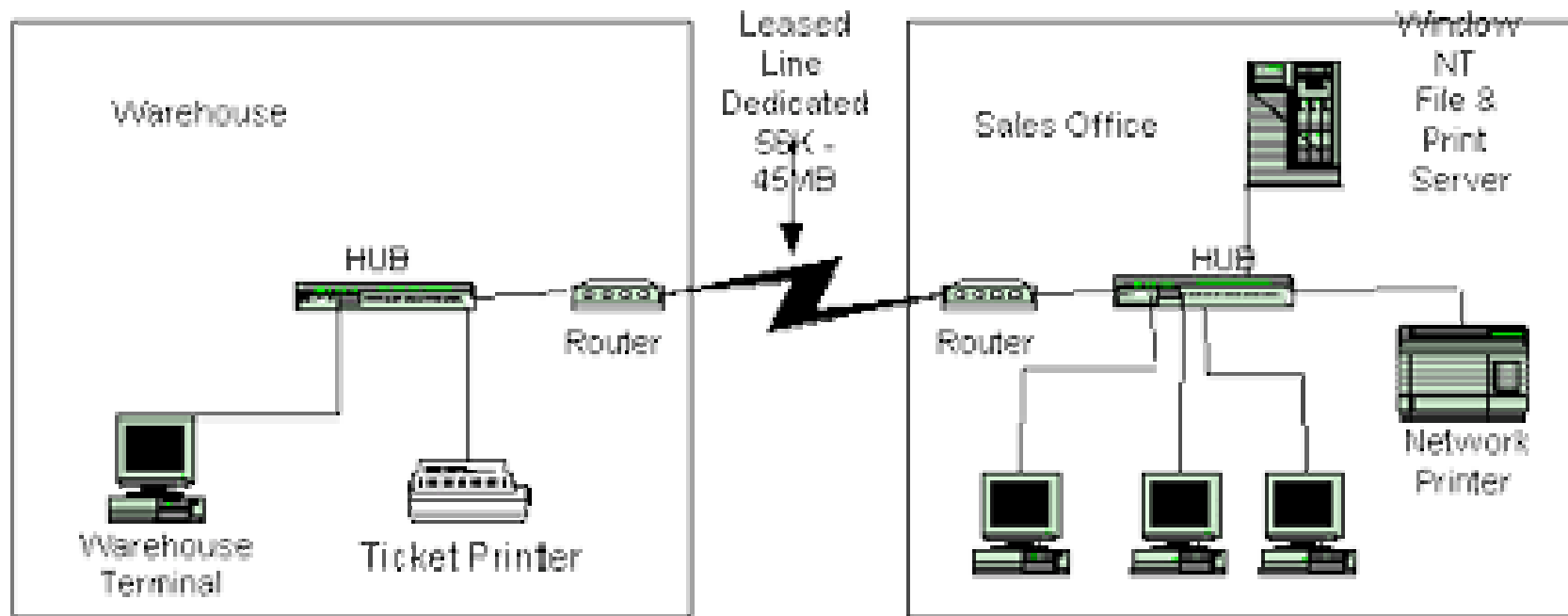
Wide/Metropolitan Area Network (WAN/MAN)

Example of network infrastructure -- HKU

Main Campus

Lady Ho Tung Hall, Starr Hall & Ricci Hall

St. John's College, Morrison Hall, Lee Shau Kee Hall, Suen Chi Sun Hall, Pokfield Road Residence

Gigabit Ethernet

Gigabit Ethernet

ITS Data Centre

Gigabit Ethernet

Gigabit Ethernet

Gigabit Ethernet

Gigabit Ethernet

Gigabit Ethernet

Robert Black College

Swire Hall

Simon Lee Hall

Graduate House

Other Campuses

Cyberport

Dual Gigabit Ethernet Connections

CWDM Optical Network

Dual Gigabit Ethernet Connections

CWDM Optical Network

Public Gigabit Ethernet WAN Connections

Kennedy Town Centre

Prince Philip Dental Hospital

University Hall

Sassoon Road Premises, Faculty of Medicine Buildings & Residential Halls

54Mbps Fixed-access Wireless

Stanley Ho Sports Centre

Duchess of Kent Children's Hospital

Optical Fibre

54Mbps Fixed-access Wireless

Queen Mary Hospital

100Mbps

Metro-Ethernet

100Mbps

100Mbps

100Mbps

100Mbps

Hing Wai Centre

Sch. Of Business

Tsang Yuk Hospital

Family Medicine Unit

Computer Network of HKU Remote Campuses and Residential Halls
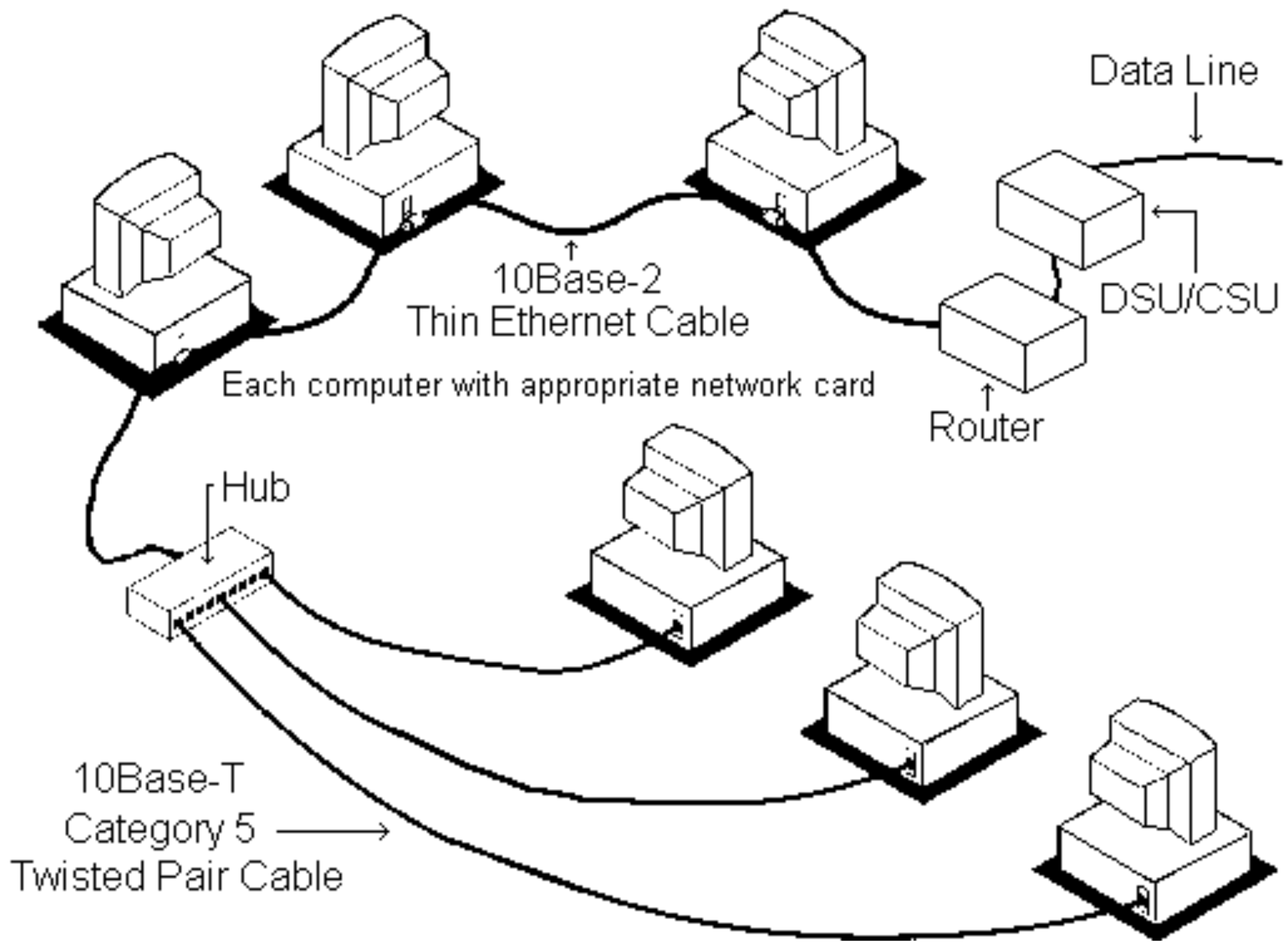
Networking

- 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
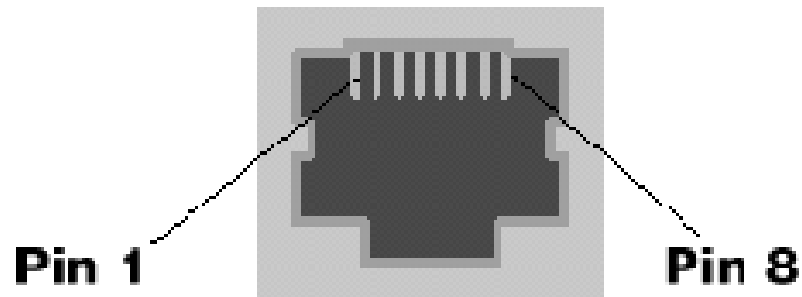   - Sophisticated functional requirements

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

Data Line

10Base-2
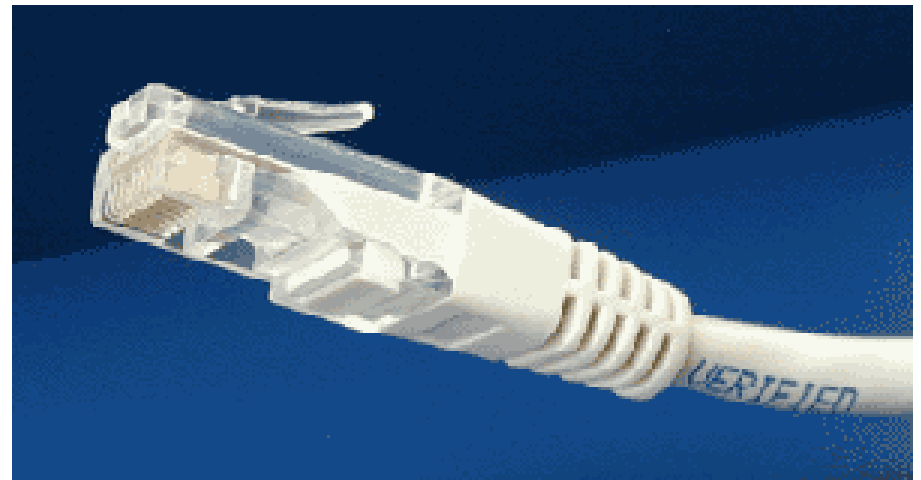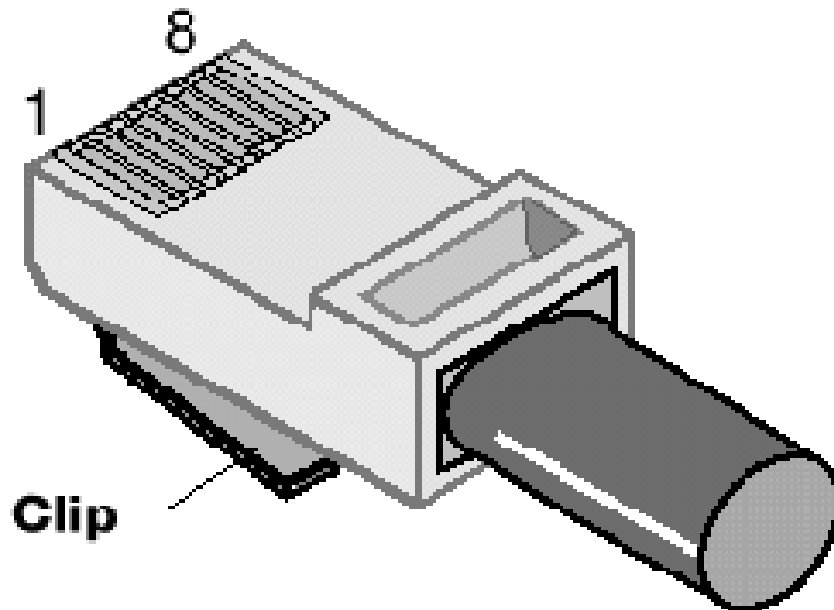Thin Ethernet Cable

DSU/CSU

Each computer with appropriate network card

Router

Hub

10Base-T
Category 5 →
Twisted Pair Cable

Ethernet port and connector

Ethernet Port

Pin 1   Pin 8

RJ-45 Connector

8

1

Clip

"100 Base T" means:
- 100 Mbps
- Baseband signal
- Twisted pair

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
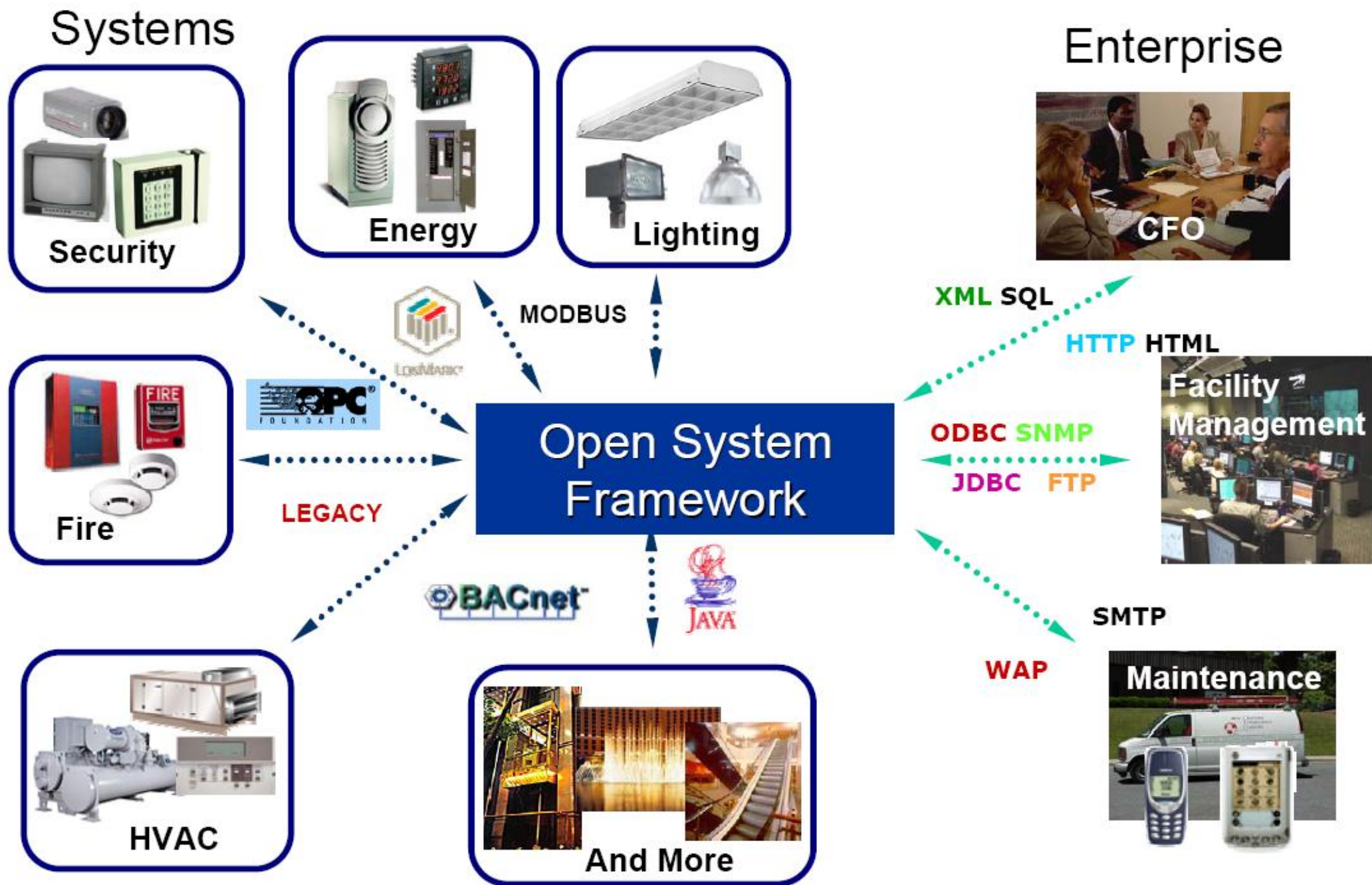
The world is going Gigabit!

Networking

- Leading official standards organisation
  - IEEE 802 LAN/MAN Standards Committee (www.ieee802.org) 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

Systems

Security

Energy

Lighting

Fire

HVAC

And More

Enterprise

CFO

Facility Management

Maintenance

MODBUS

LEGACY

XML SQL

HTTP HTML

ODBC SNMP

JDBC FTP

SMTP

WAP

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
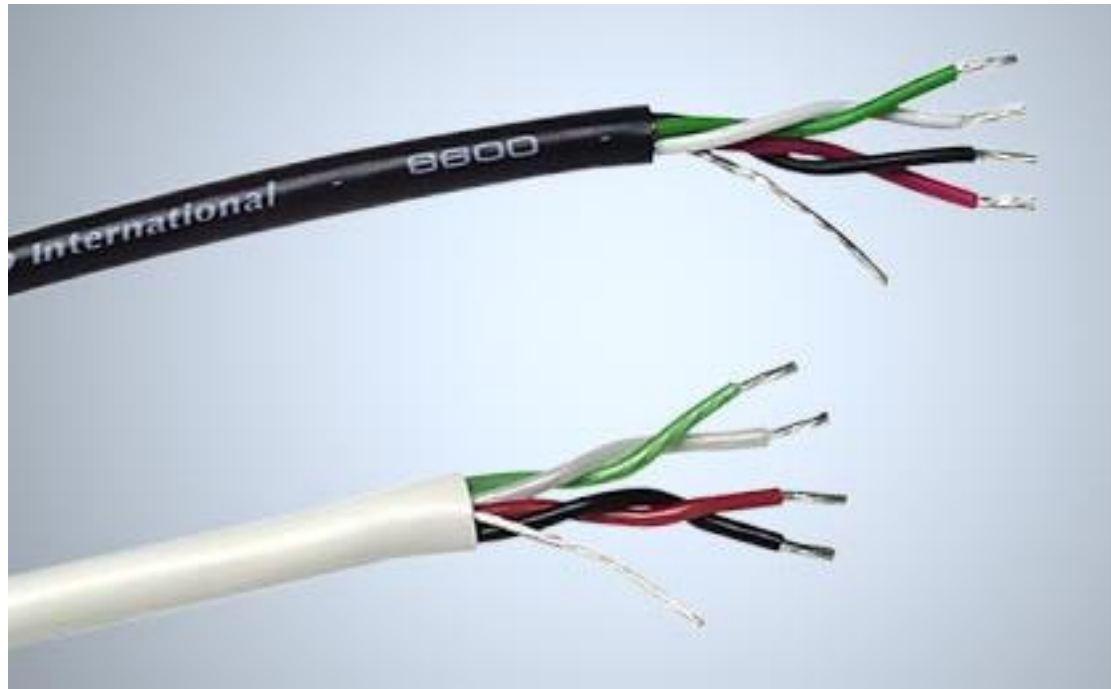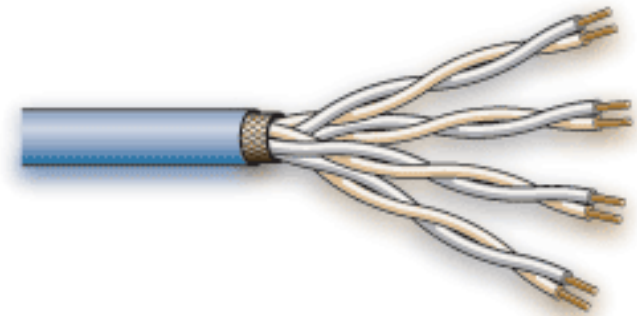   - In most cases, 1200 bps is maximum
    - Unshielded twisted pairs (UTP)

Twisted pairs (TP)
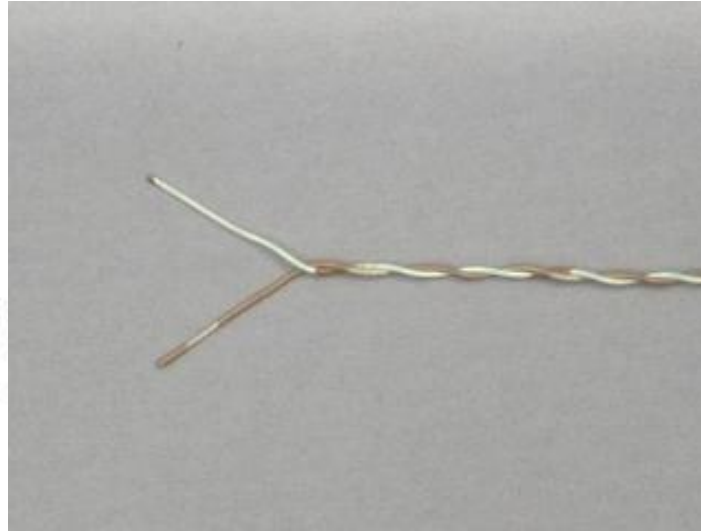
Unshielded twisted-pair

Foiled twisted-pair

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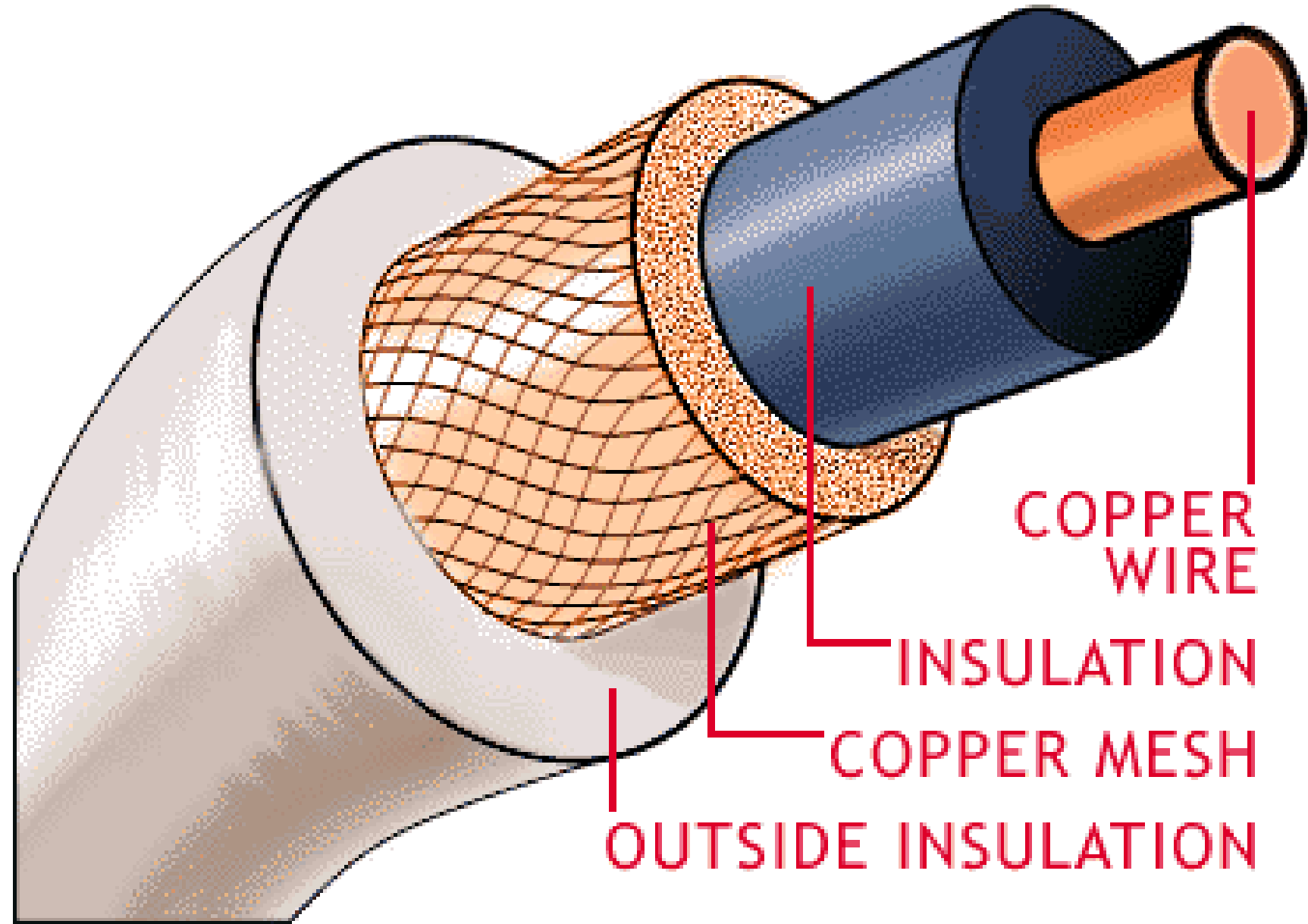
- Media/transmission methods (cont'd)
  - [Voice grade lines](#)
    - Type 3002 in in the Bell Telephone Company's standard BSP41004
  - [Coaxial cable](#)
    - Centre conductor surrounded by a shield
      - Electromagnetic interference
  - [Power lines](#)
    - Using carrier current transmission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

Coaxial cable

COPPER WIRE

INSULATION

COPPER MESH

OUTSIDE INSULATION

Power line transmission and communication
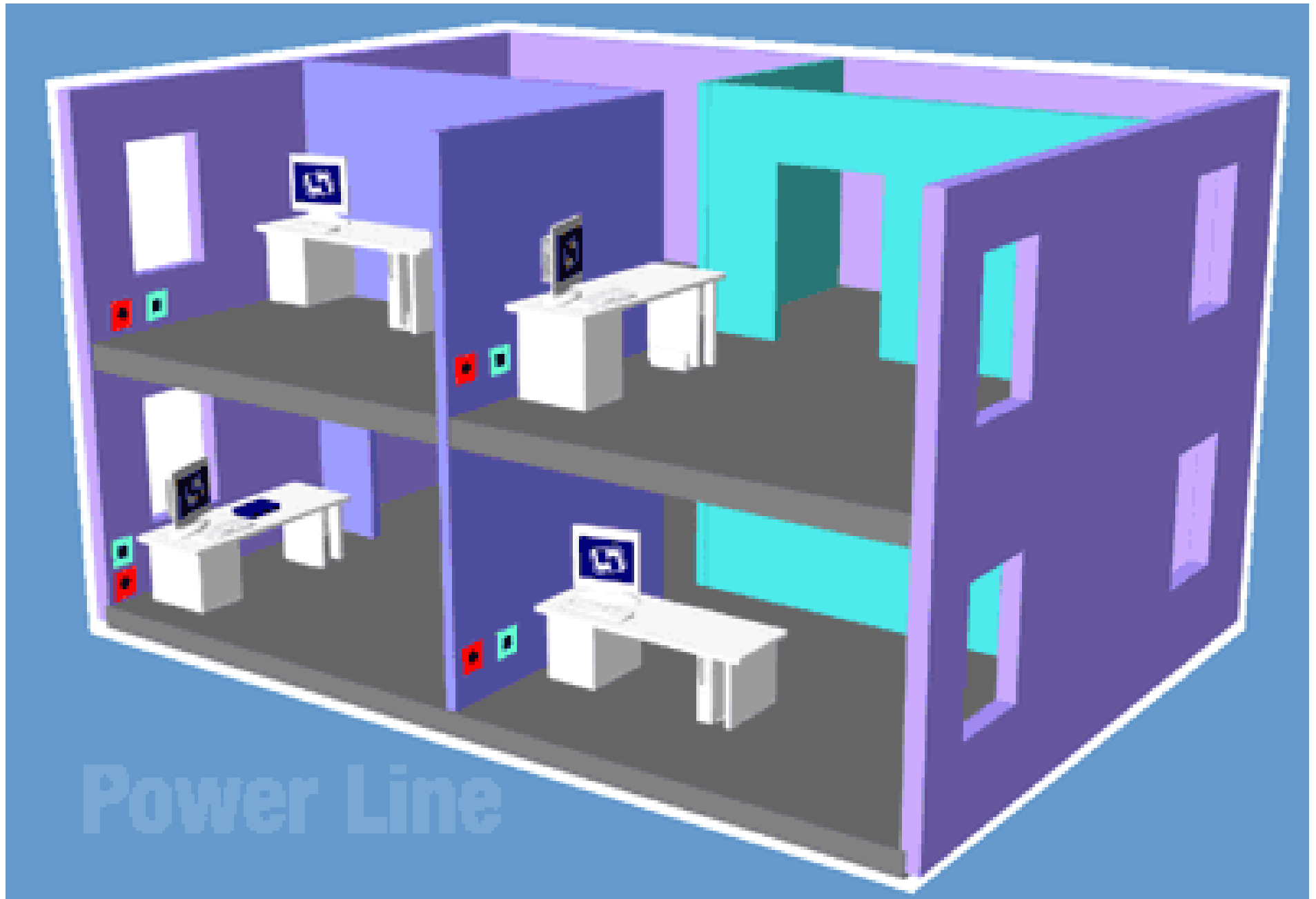
(* Video: Powerline Home Networking (2:10) http://www.youtube.com/watch?v=yud7wfWgTBk)

(Source: www.linksys.com)
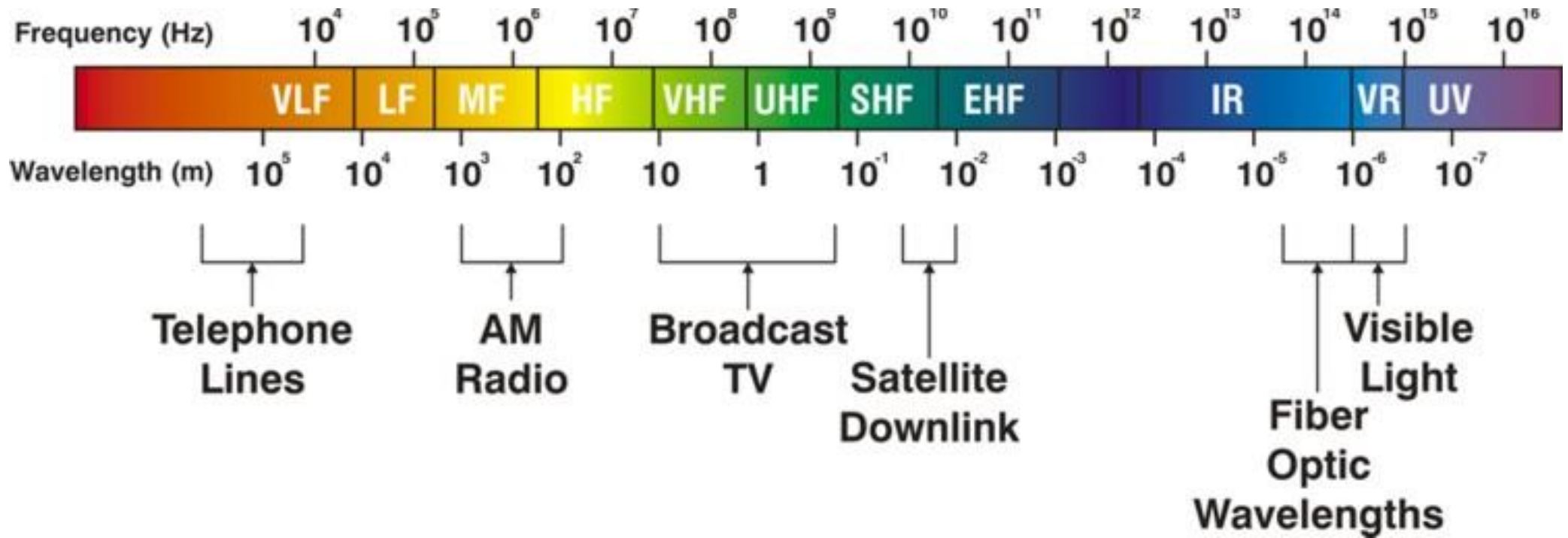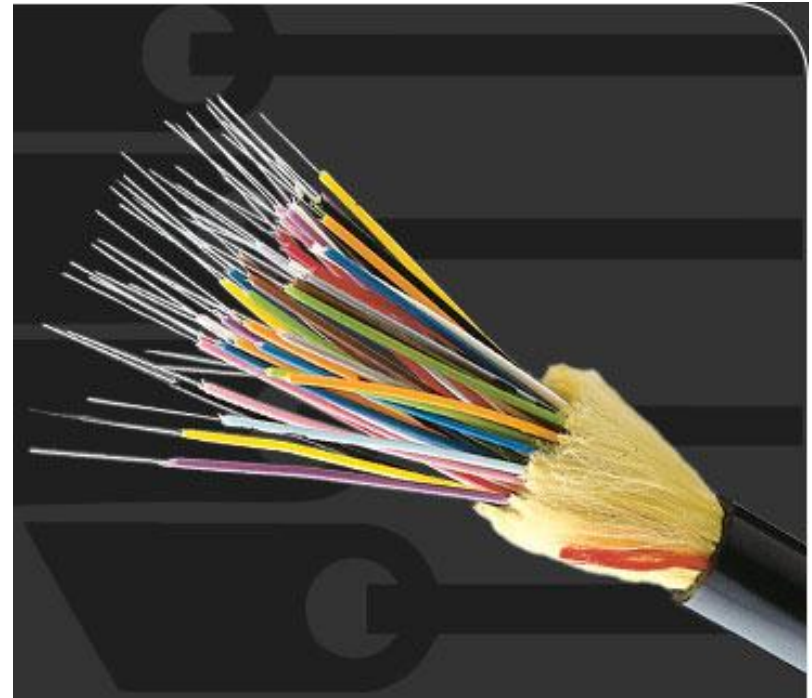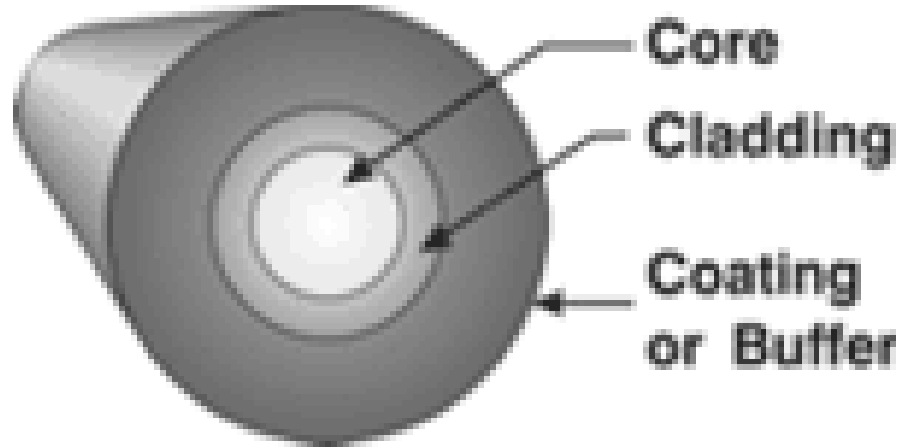
Transmission Methods

- 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

Core
Cladding
Coating or Buffer

Frequency (Hz)	10^4	10^5	10^6	10^7	10^8	10^9	10^{10}	10^{11}	10^{12}	10^{13}	10^{14}	10^{15}	10^{16}

VLF | LF | MF | HF | VHF | UHF | SHF | EHF | IR | VR | UV

Wavelength (m)	10^5	10^4	10^3	10^2	10	1	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}

Telephone Lines

AM Radio

Broadcast TV

Satellite Downlink

Fiber Optic Wavelengths

Visible Light

Comparison of transmission methods

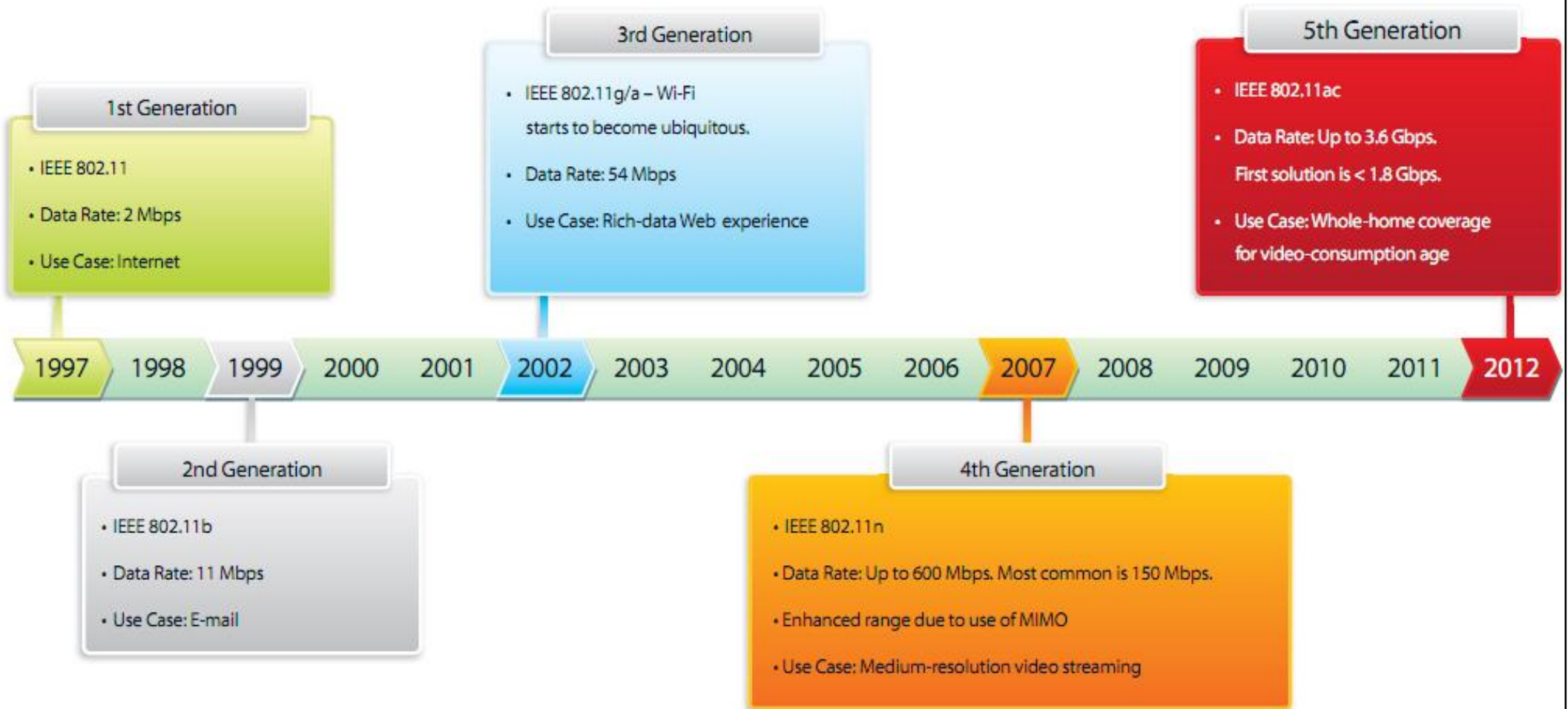| Method	First cost	Scan rates	Reliability	Maint. Effort	Expand-ability	Compati-bility
Coaxial	High	Fast	Excellent	Min.	Unlimited	Unlimited
Twisted pair	High	Medium	Very good	Min.	Unlimited	Limited
Radio frequency	Medium	Fast but limited	Low	High	Very limited	Very limited
Microwave	Very high	Very fast	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
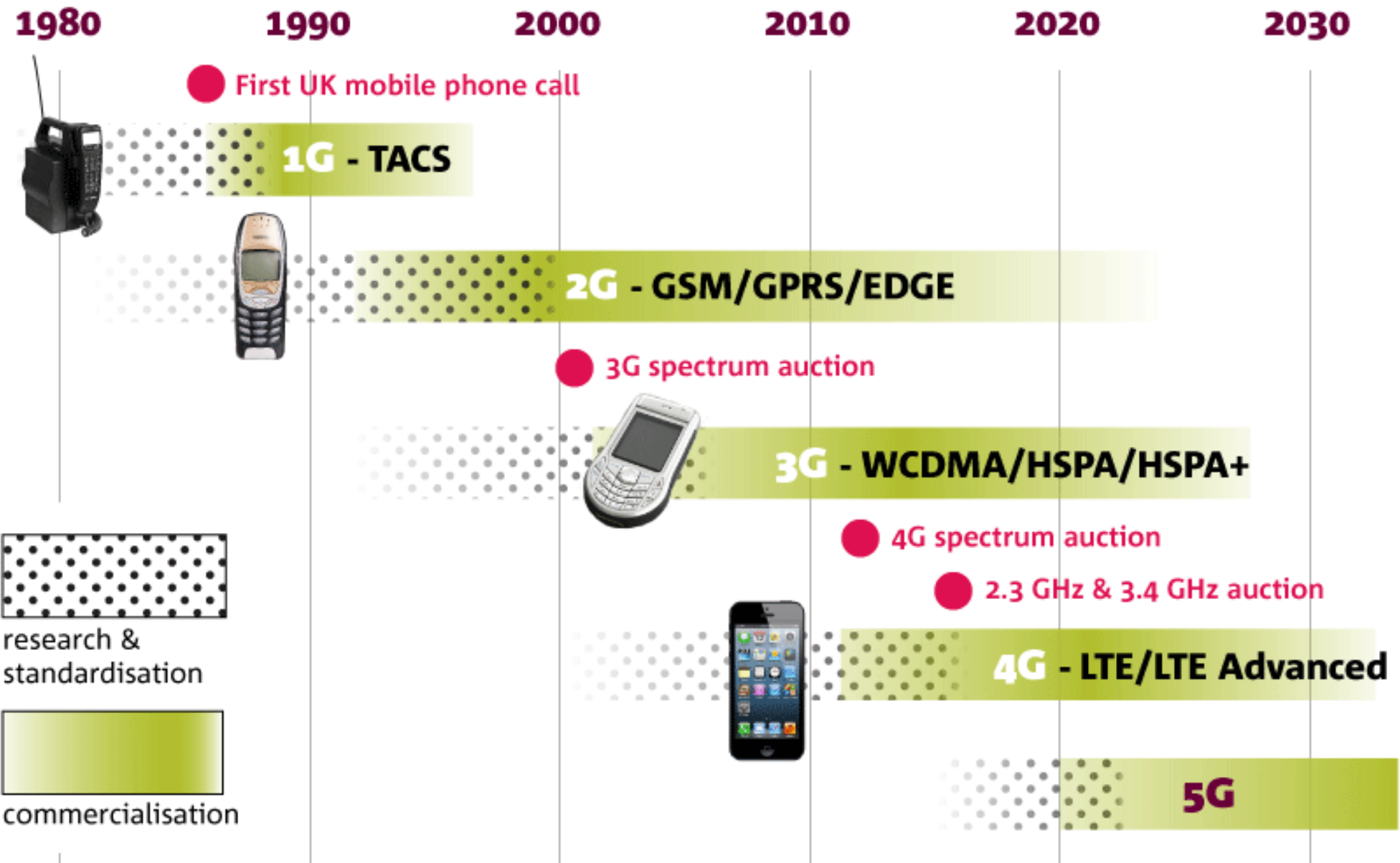
- ## Wireless communication

  - 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

1st Generation
- IEEE 802.11
- Data Rate: 2 Mbps
- Use Case: Internet

2nd Generation
- IEEE 802.11b
- Data Rate: 11 Mbps
- Use Case: E-mail

3rd Generation
- IEEE 802.11g/a – Wi-Fi starts to become ubiquitous.
- Data Rate: 54 Mbps
- Use Case: Rich-data Web experience

4th Generation
- IEEE 802.11n
- Data Rate: Up to 600 Mbps. Most common is 150 Mbps.
- Enhanced range due to use of MIMO
- Use Case: Medium-resolution video streaming

5th Generation
- IEEE 802.11ac
- Data Rate: Up to 3.6 Gbps. First solution is < 1.8 Gbps.
- Use Case: Whole-home coverage for video-consumption age

Timeline: 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012

Evolution of mobile phone communications

(Source: http://tutorvoice.com/index.php/2015/10/11/generations-of-wireless-communication-technology/)

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)
  - <u>Active distributed antenna systems</u>
    - 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)
  - <u>Distributed radios</u>
    - 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
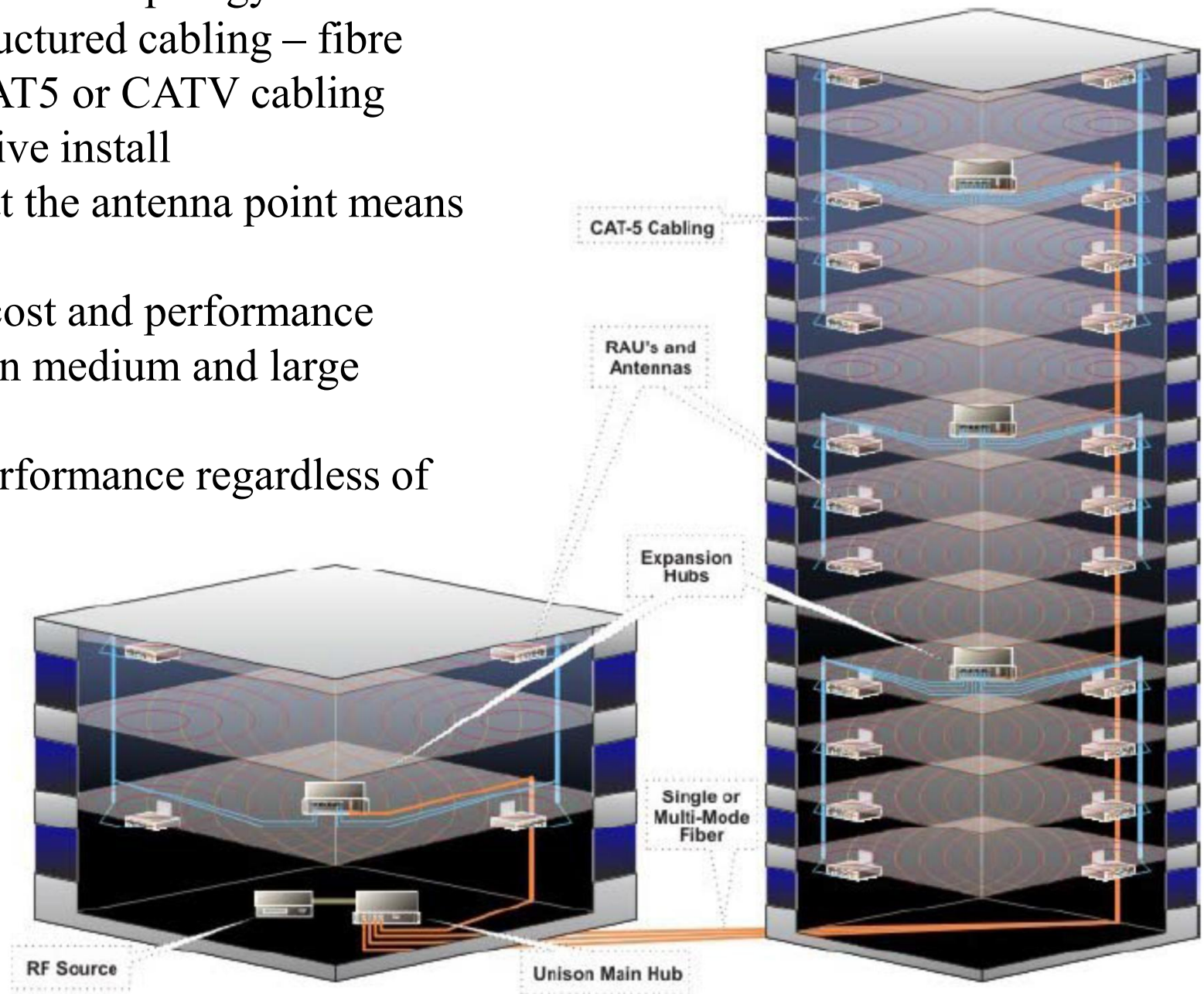
Example of passive distributed antenna system
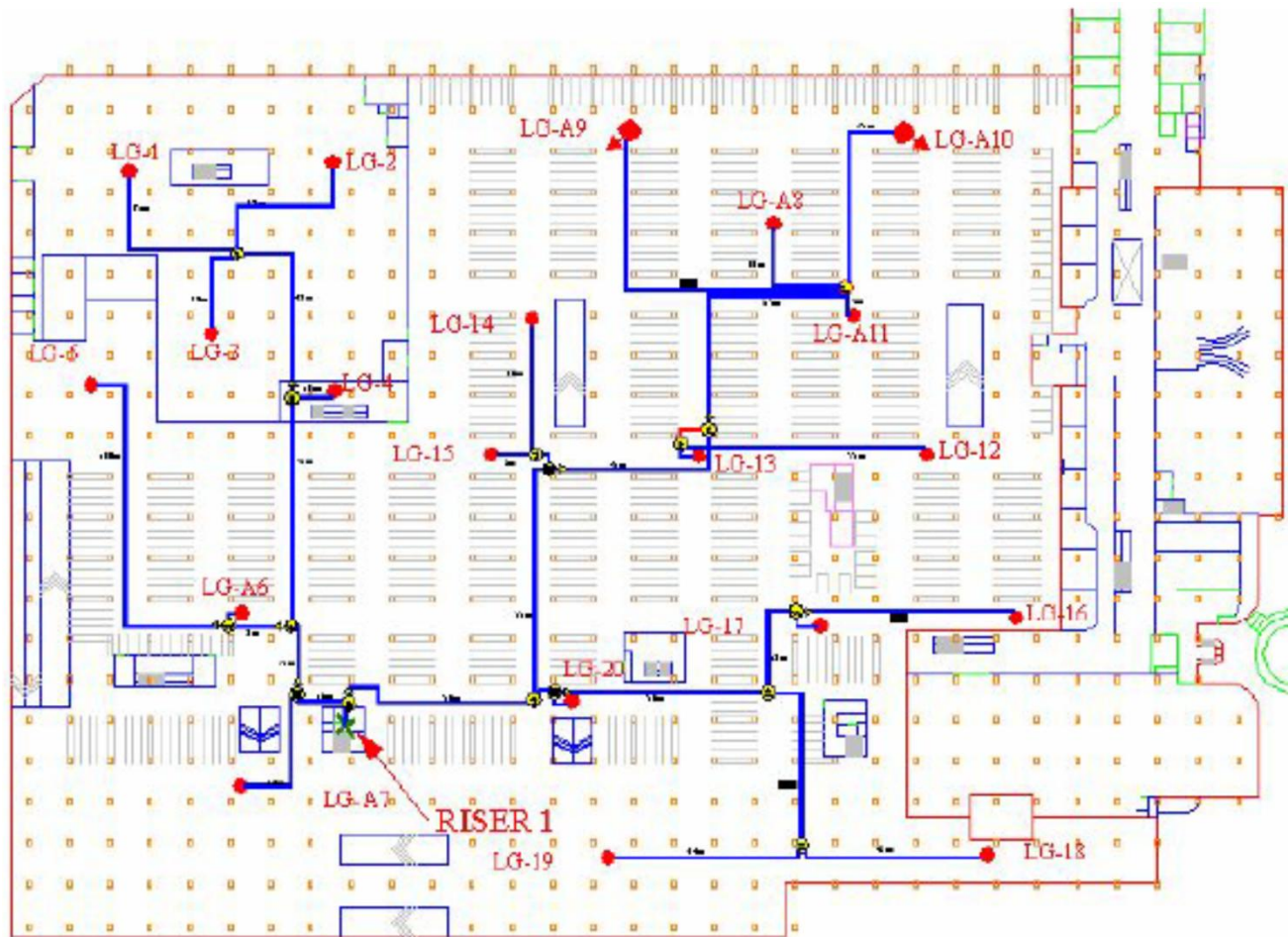
- Essentially a "sprinkler system" for cell phone signals
- Distribution via large coaxial cables
- Losses through the cable limit the size
- New, higher frequency bands have high loss

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

CAT-5 Cabling

RAU's and Antennas

Expansion Hubs

Single or Multi-Mode Fiber

RF Source

Unison Main Hub

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

- 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]