

MECH3023: Building Energy Management & Control Systems

<http://www.hku.hk/bse/mech3023/>



Networking



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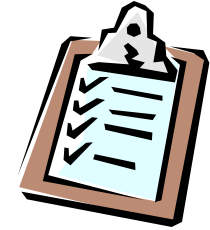
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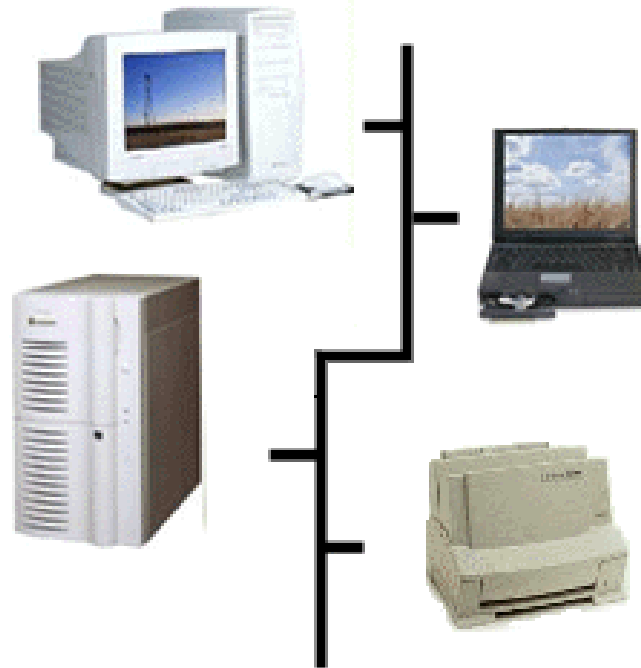


- Introduction
- Local Area Network
- Transmission Methods
- Emerging Trends

Introduction



- 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.



What network do you have at home?

Hub or Ethernet Switch or IP Sharing



Network Cable

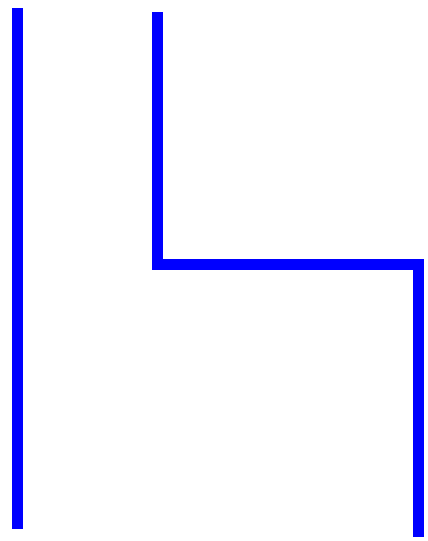


ADSL ATU-R

Splitter



Phone Line



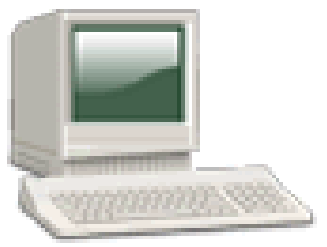
Telephone

Network Cable

Phone Line

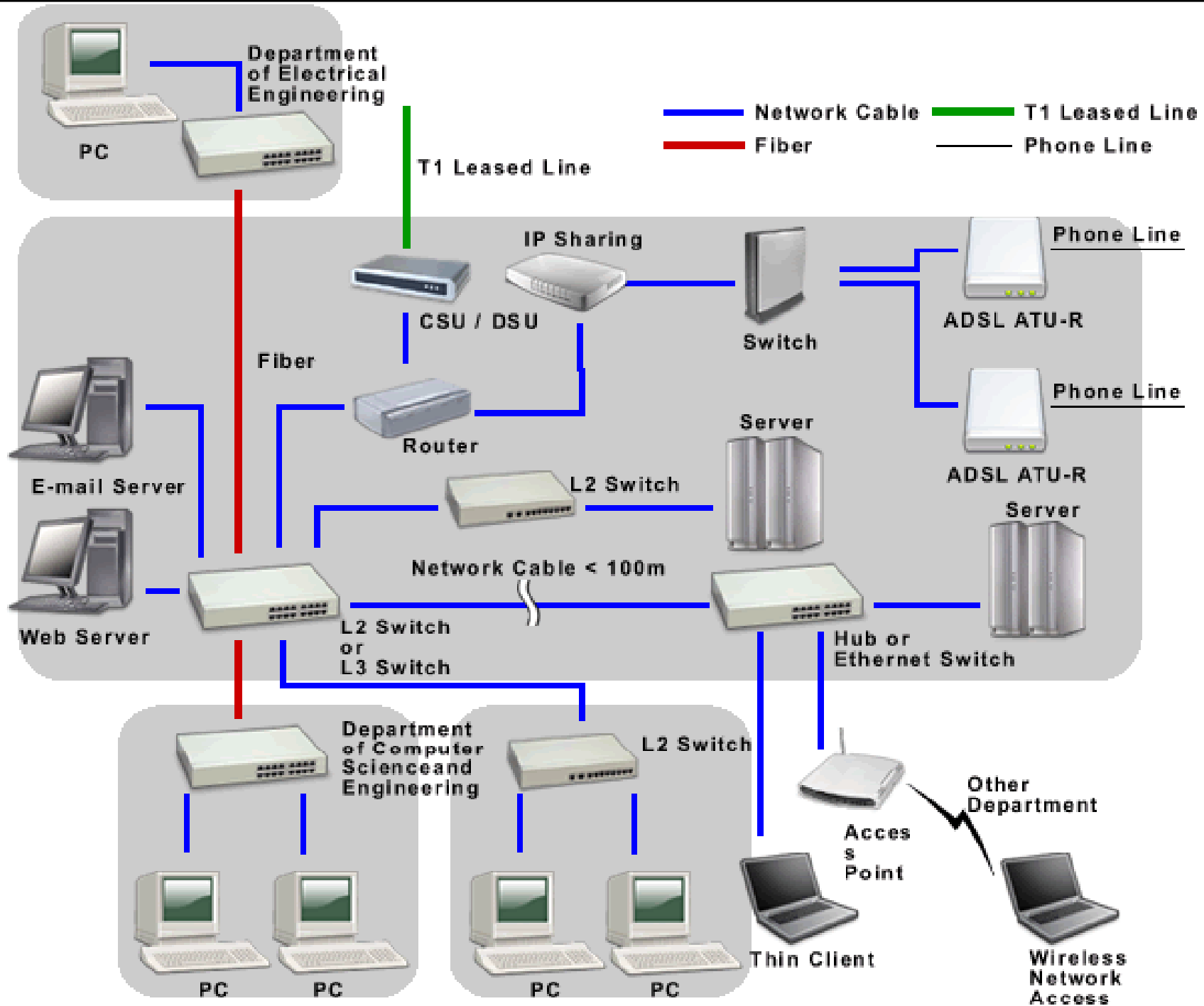


PC



PC

Home computer network



Office/Enterprise computer network

Introduction



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



Introduction

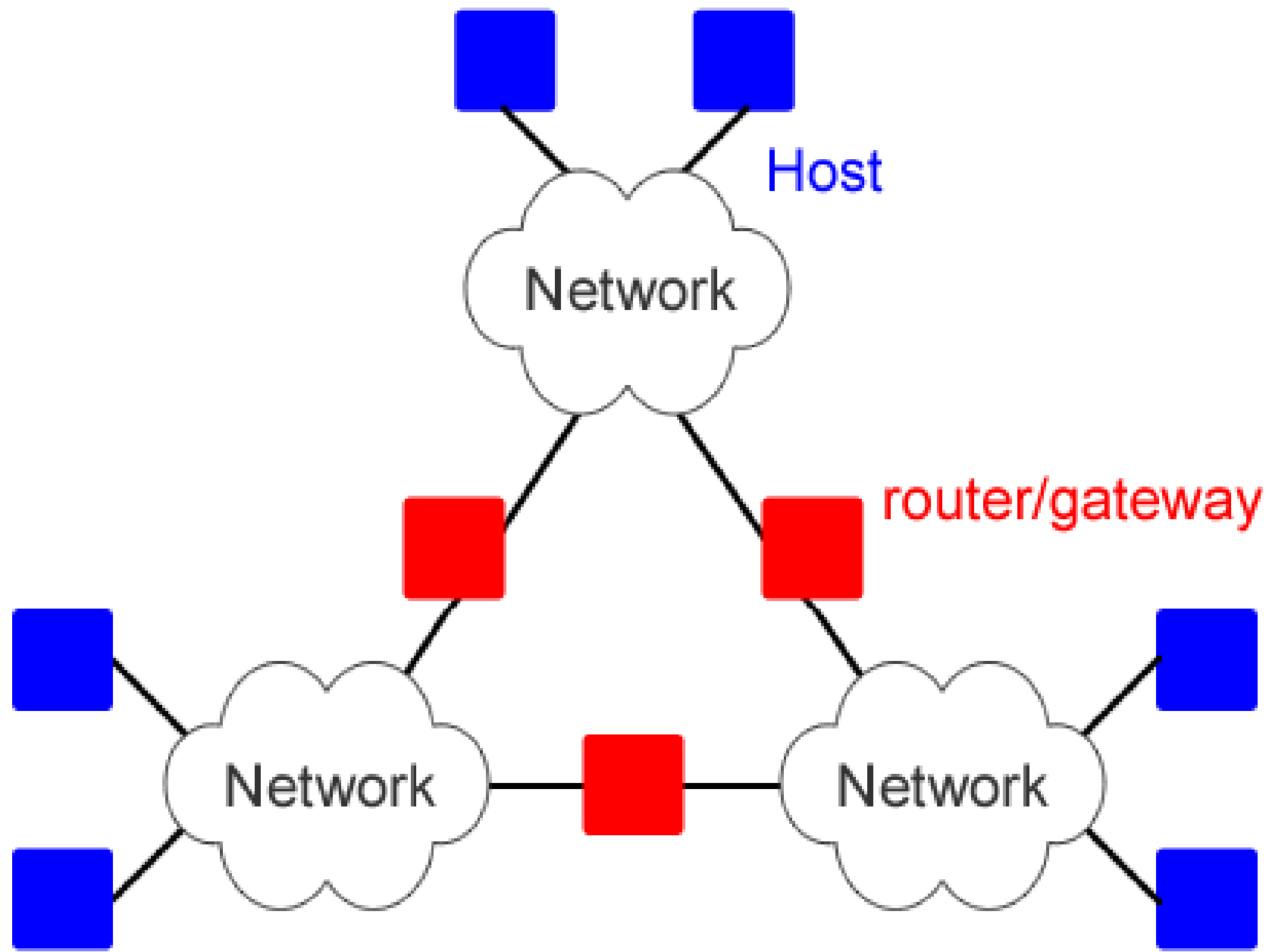


- Why networking is important for BEMCS?
 - From centralised systems to distributed networks
 - Centralised systems
 - One large central computer + remote terminals
 - Distributed processing
 - Multiple smaller computers, separated and connected through “networks”
- What are the advantages of distributed processing?

Local Area Network

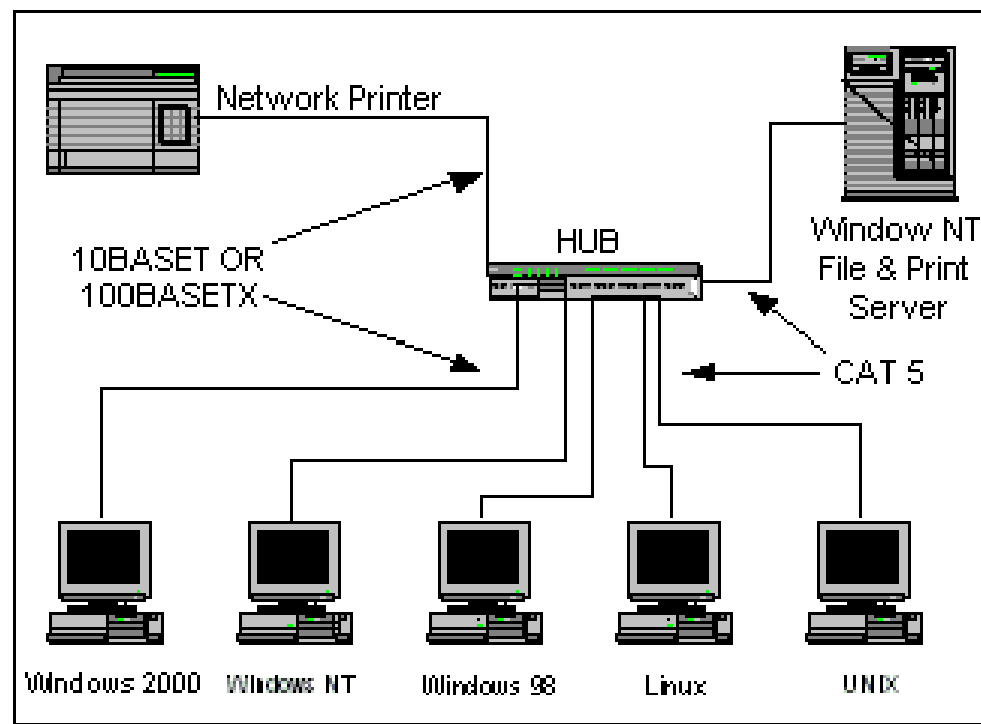


- Local area network (LAN)
 - A computer network that spans a relatively small area, and with high-speed switched connections
- Wide area network (WAN)
 - A system of LANs connected over any distance via telephone lines and radio waves
- Other types of network
 - Metropolitan area network (MAN)
 - Campus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

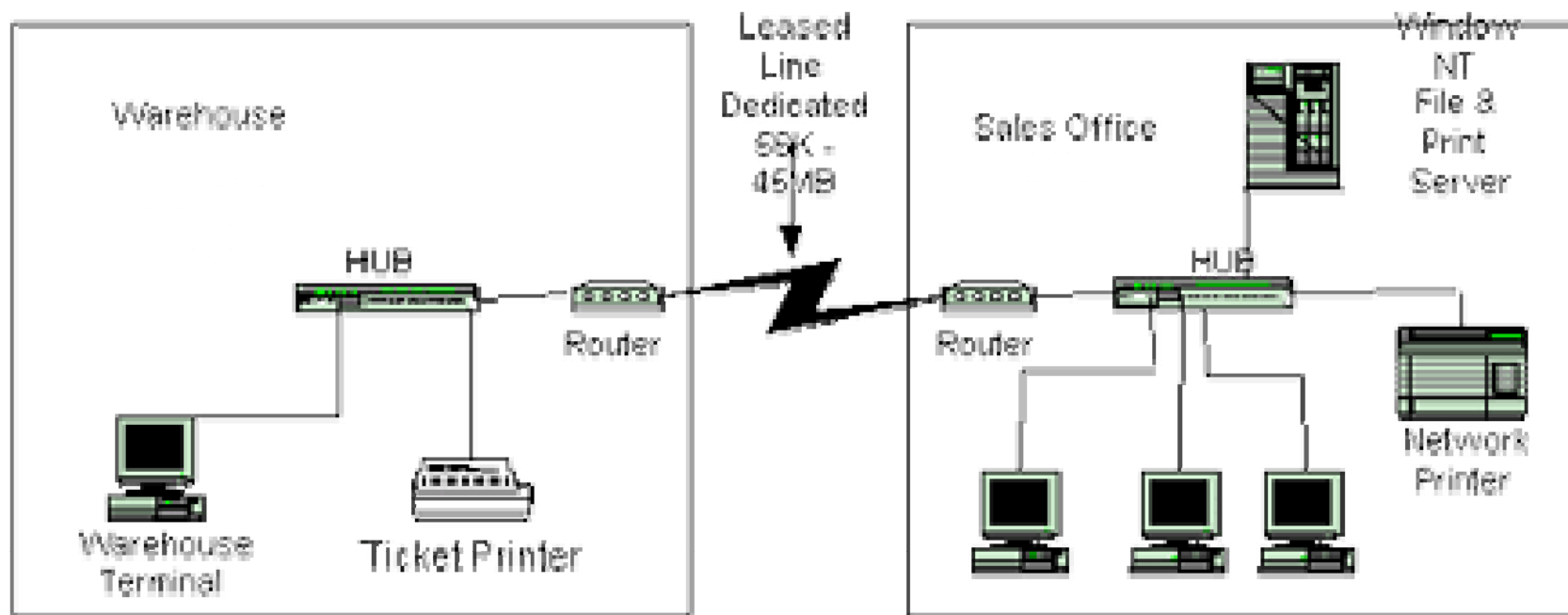


Internetworking

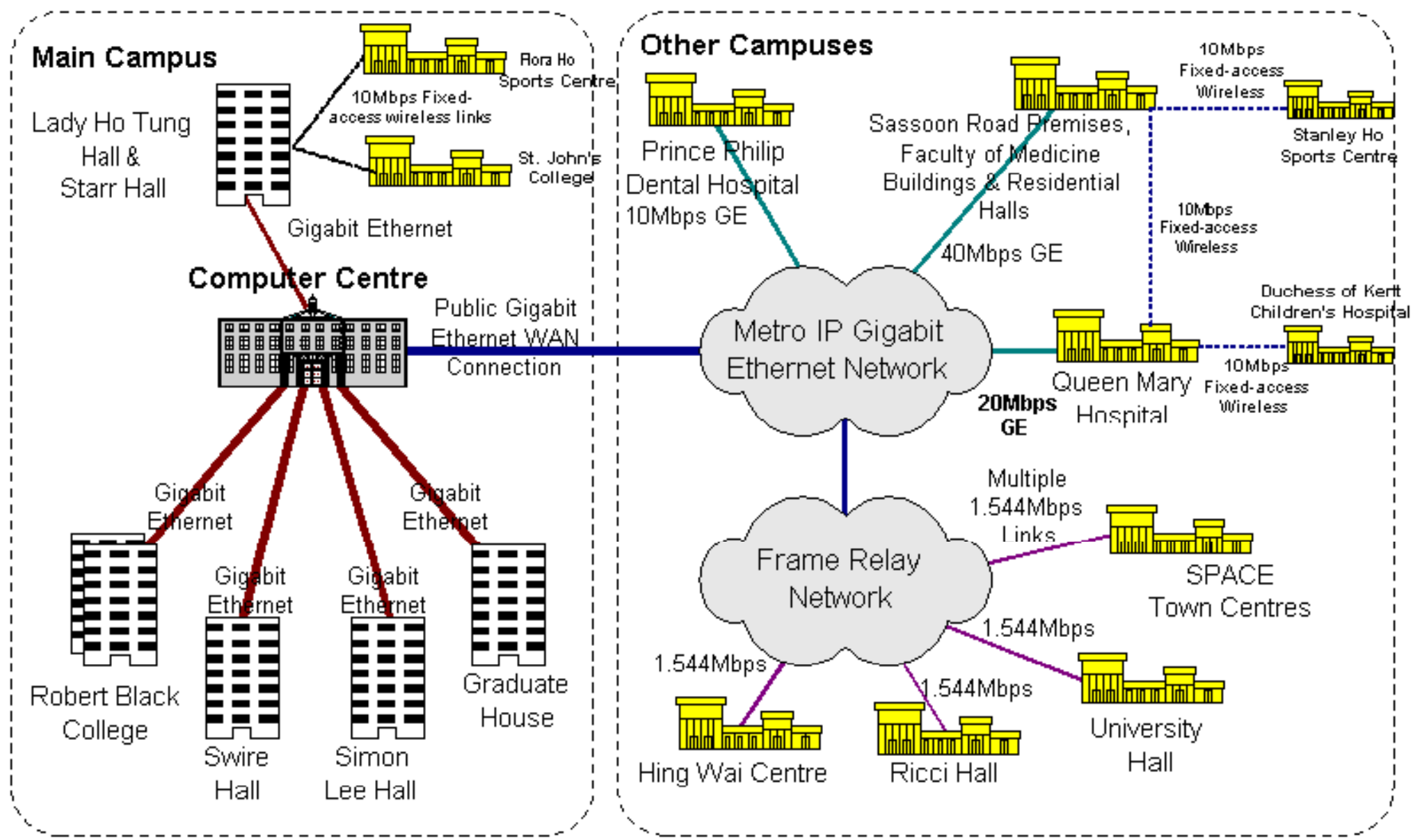
Local Area Network (LAN)



Local Area Network



Wide/Metropolitan Area Network (WAN/MAN)



Computer Network of HKU Remote Campuses and Residential Halls

Local Area Network

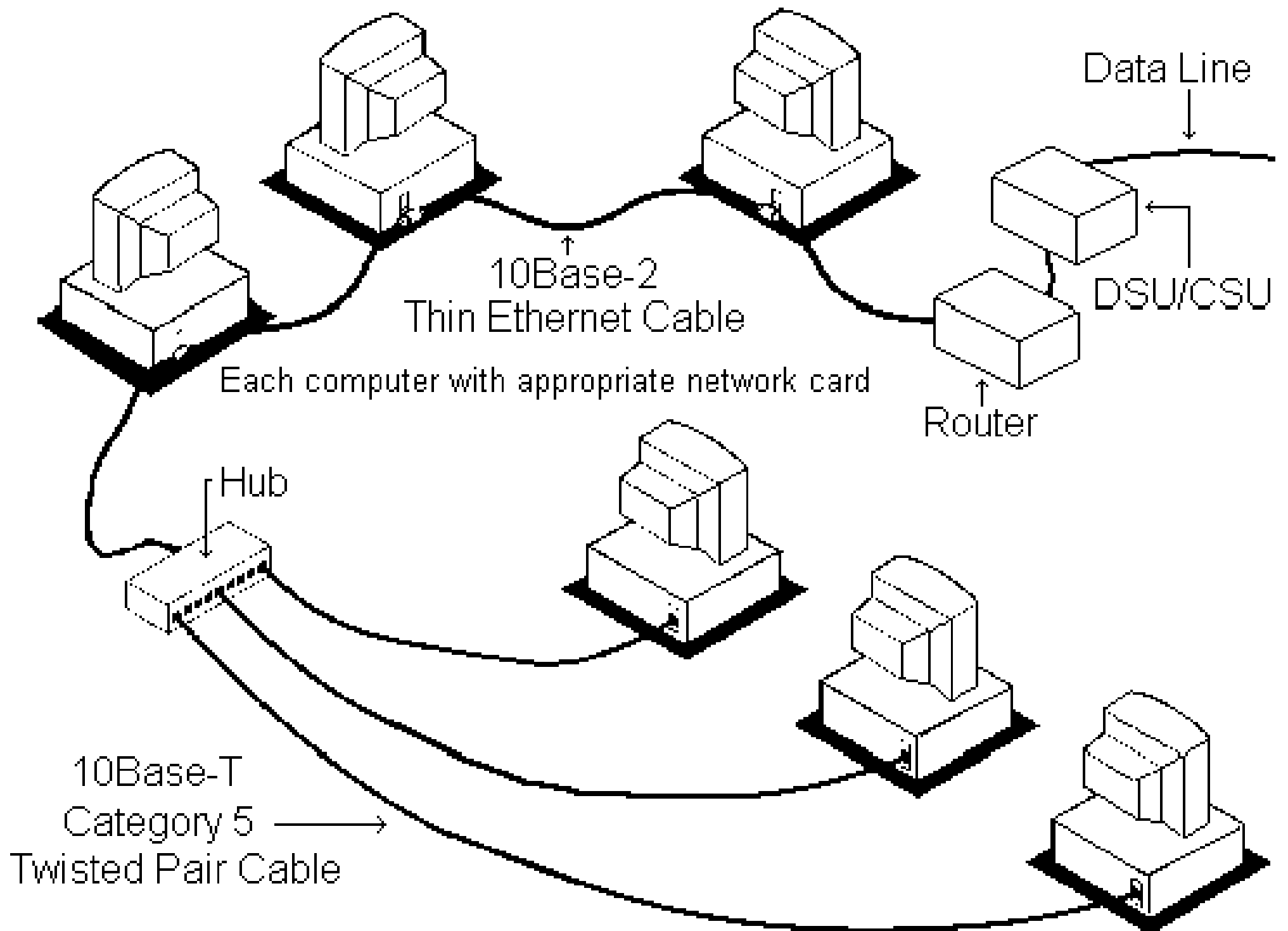


- Ideal LAN
 - As easy to use as an electrical distribution system
 - One-time installation (plugged in)
 - Widespread access (any device/component)
 - Application independence
 - Excess capacity, easy maintenance & administration
 - Current obstacles
 - No single standard
 - Diverse requirements
 -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

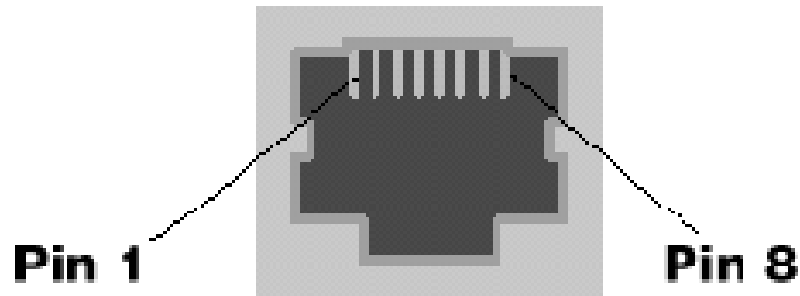
Local Area Network



- 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



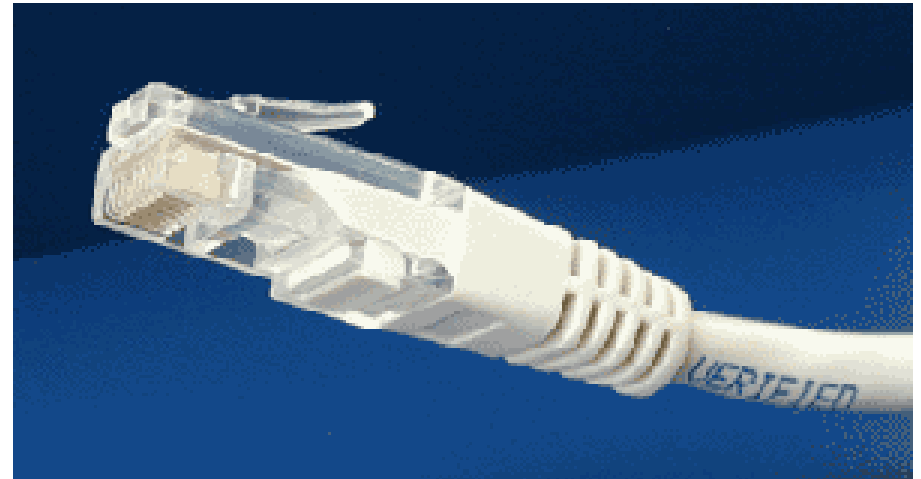
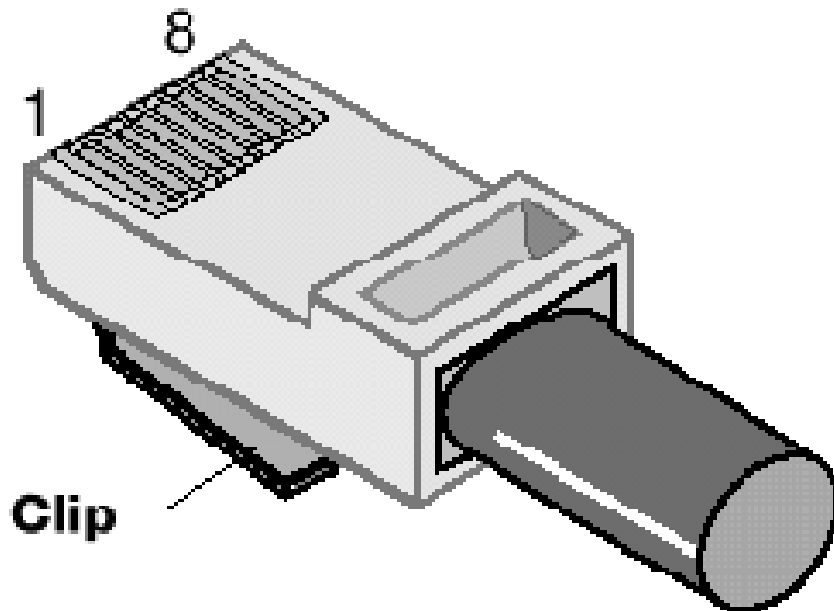
Ethernet Port



“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)

Local Area Network



- Network speed
 - How fast is fast? (time to transmit 1MB of data)
 - 28.8 kps modem: 5 minutes
 - 56 kps modem: 2 min. 38 sec.
 - 128 kps (ISDN): 1 minutes
 - 1.544 Mbps (T-1): 5 seconds
 - 10 Mbps (10BaseT): 0.8 seconds
 - 100 Mbps (100BaseTX): 0.08 seconds

Local Area Network



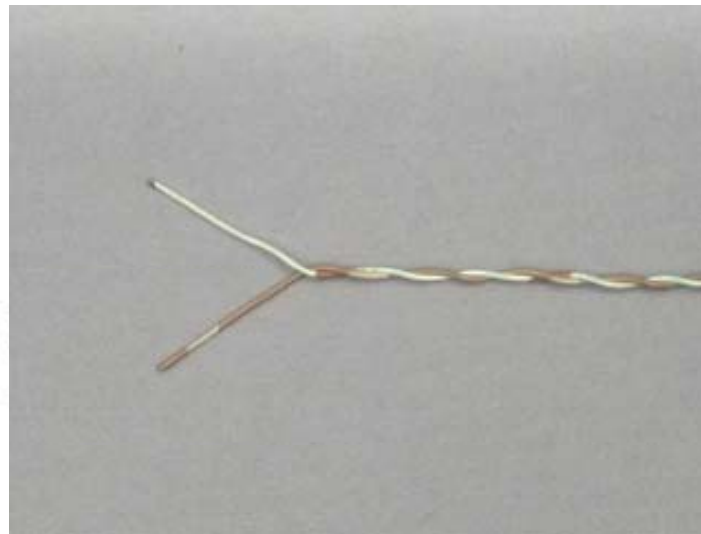
- Leading official standards organisation
 - IEEE 802 LAN/MAN Standards Committee (www.ieee802.org) and its working groups
 - 802.1: interface between OSI levels 1 & 2 with five higher level layers
 - 802.2: logical data link
 - 802.3: CSMA/CS
 - 802.4: Token bus
 - 802.5: Token ring





Transmission Methods

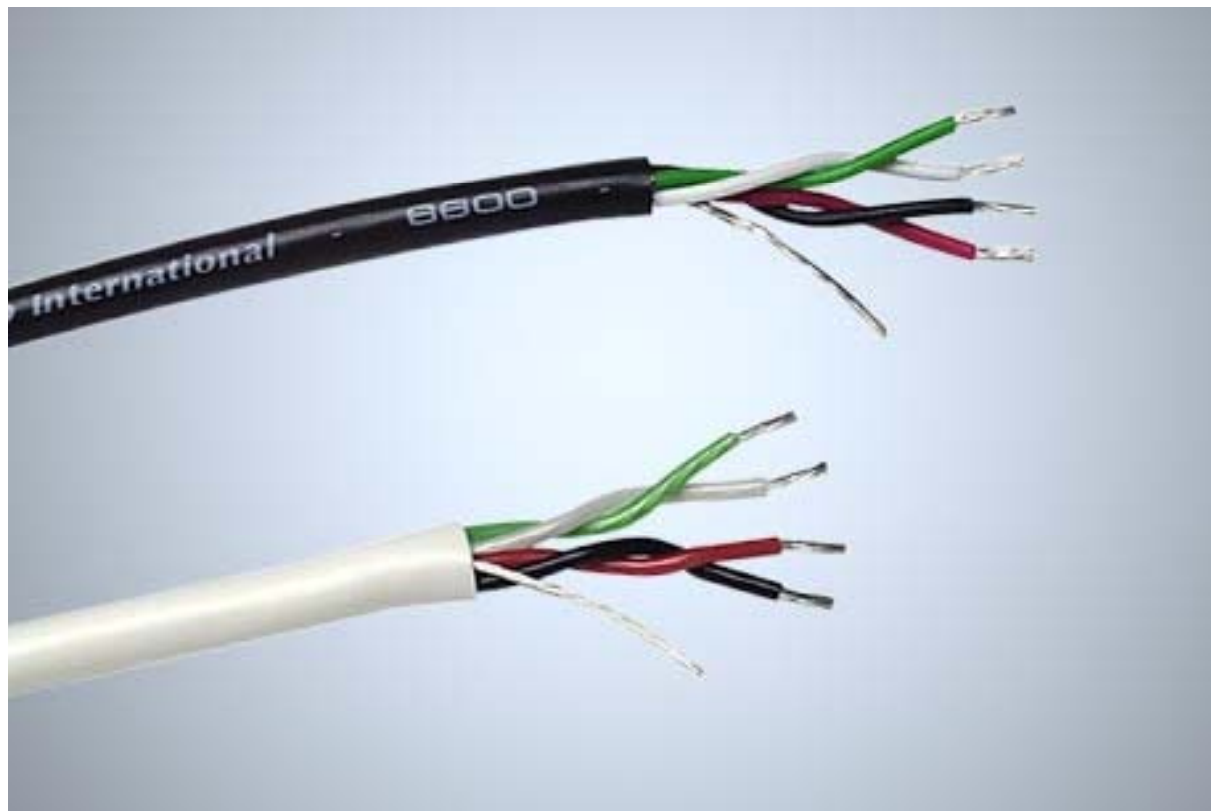
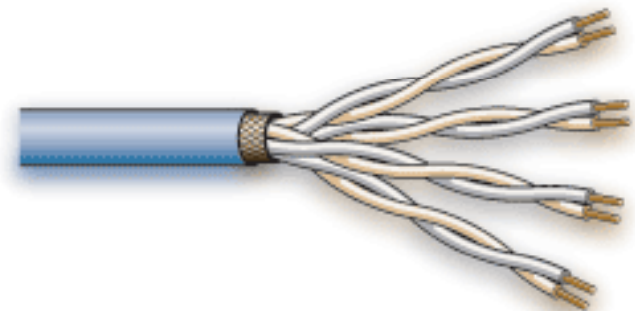
- Media/transmission methods
 - Twisted pairs (TP)
 - Two insulated conductors twisted together to minimise interference by unwanted signals
 - Line bandwidth (300-3000 Hz)
 - Signal-to-noise ratio
 - Conditioning (of the line)
 - Conditioned line has speed up to 9600 bps
 - In most cases, 1200 bps is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



Unshielded twisted-pair



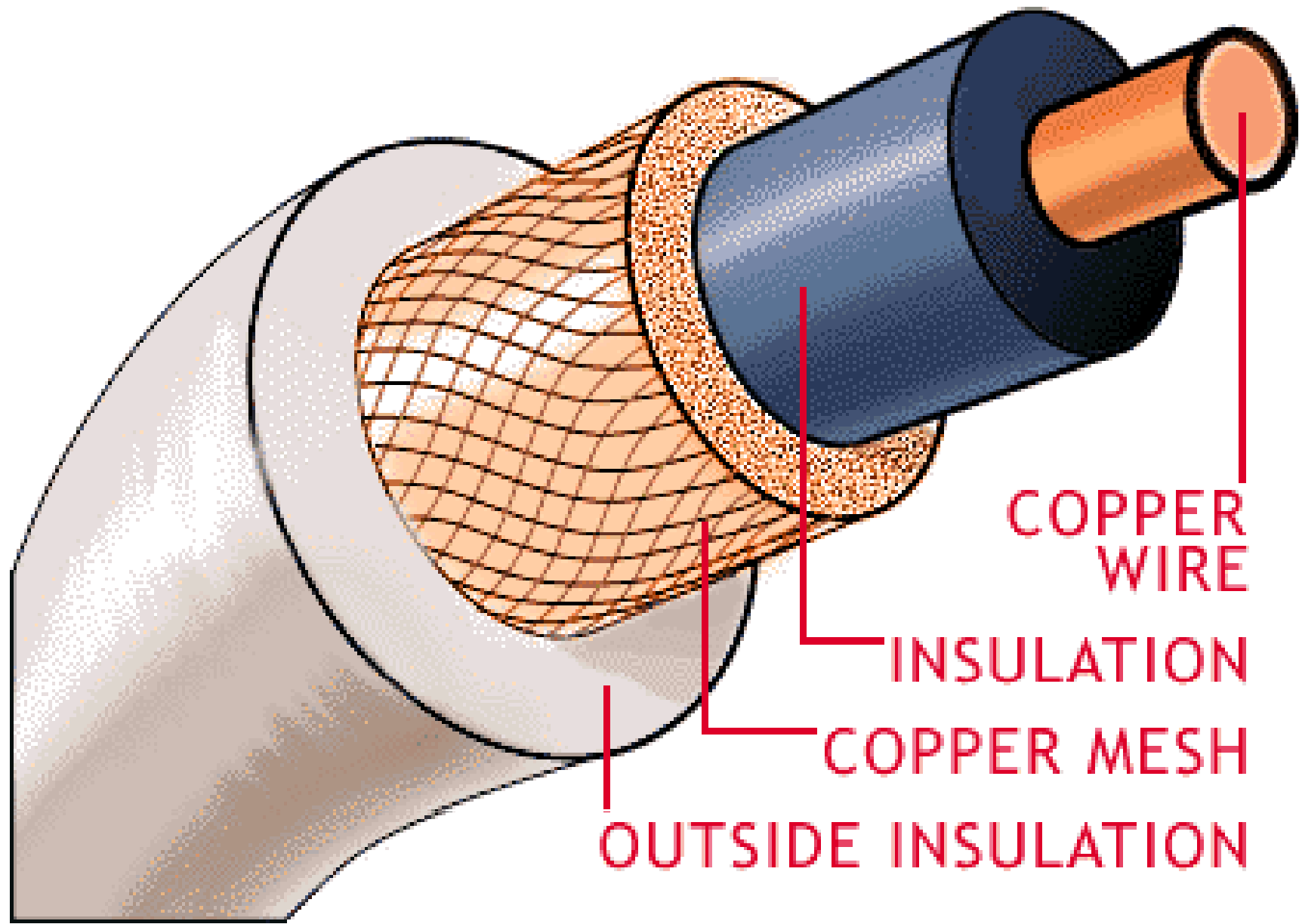
Foiled twisted-pair





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



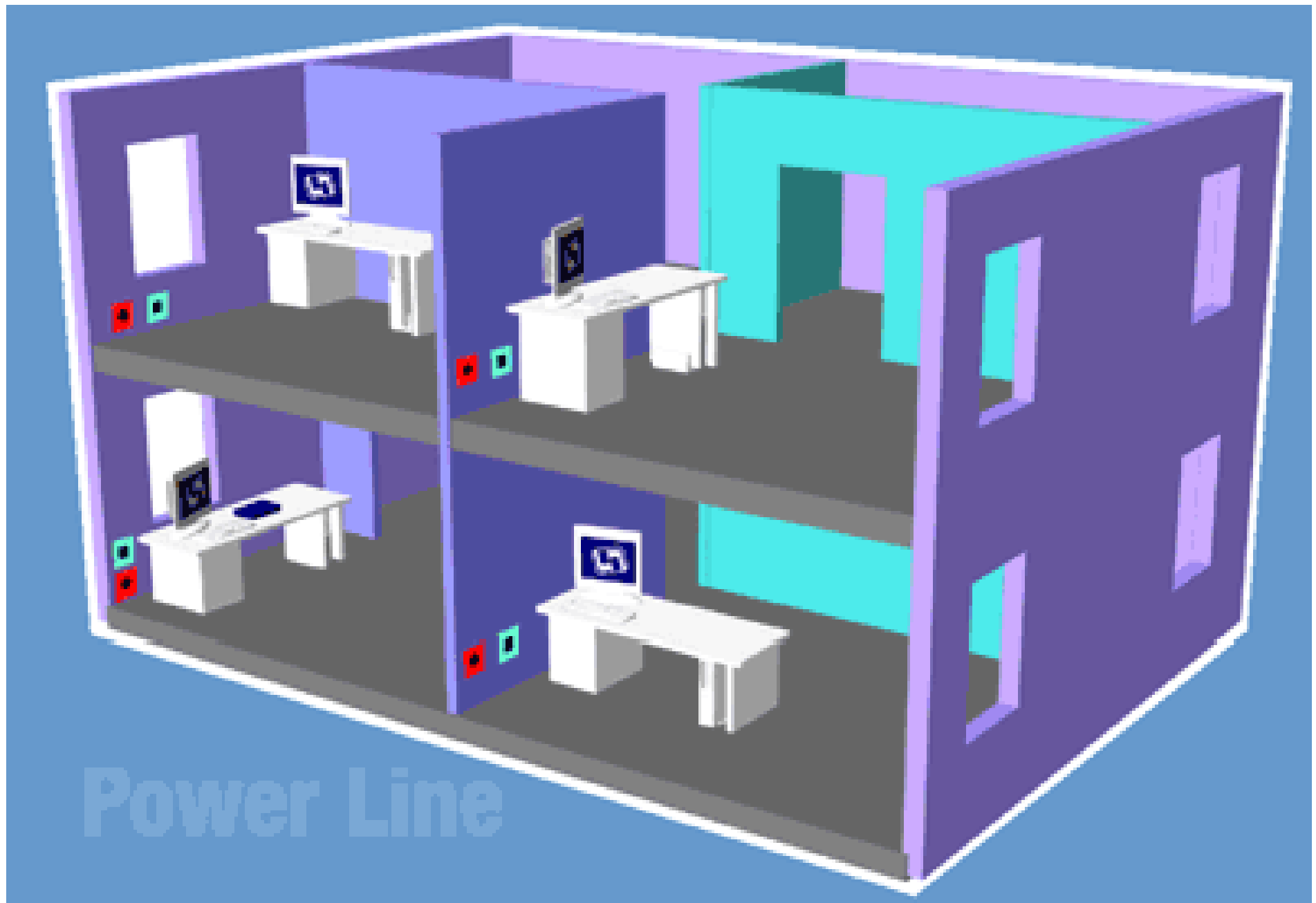
COPPER
WIRE

INSULATION

COPPER MESH

OUTSIDE INSULATION

Coaxial cable

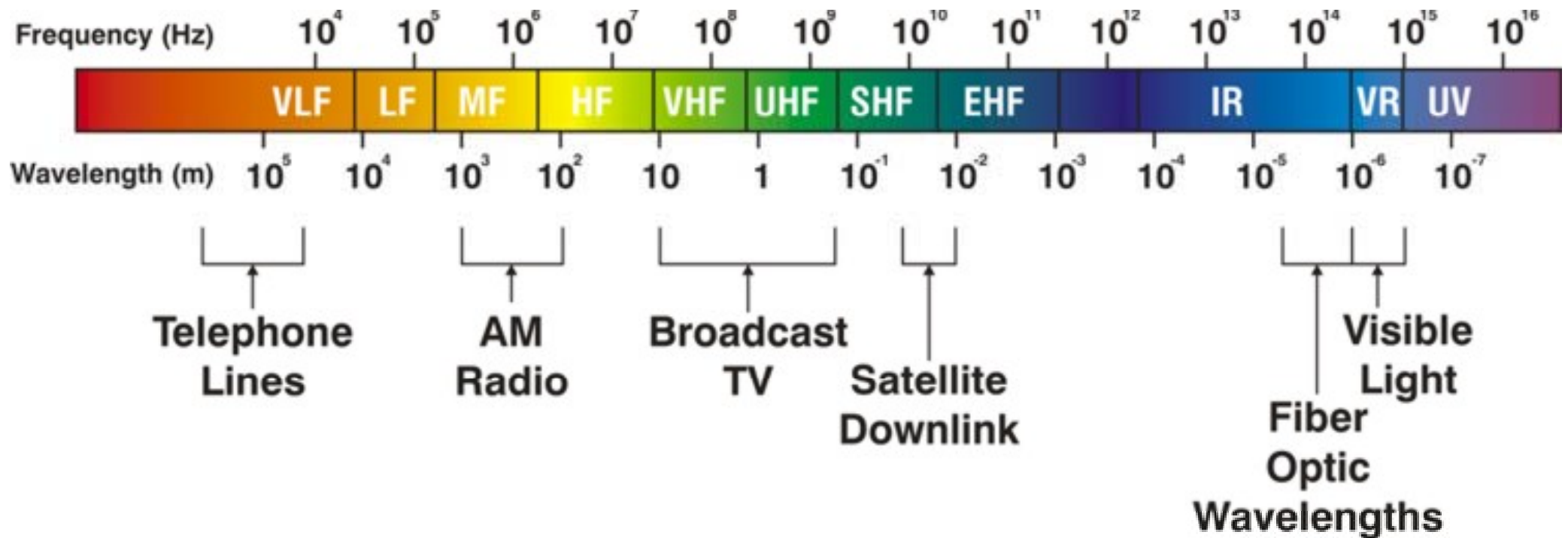
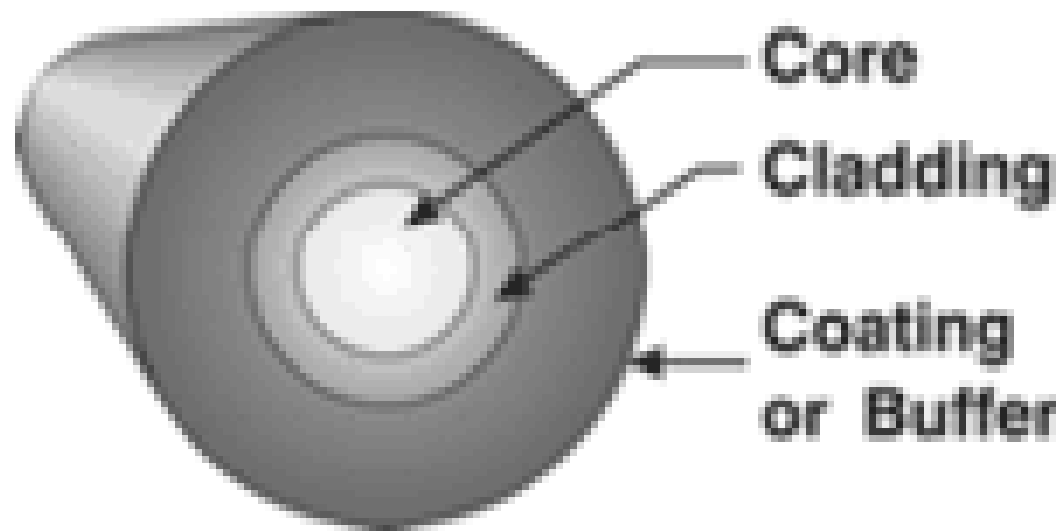


(Source: www.linksys.com)



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



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

- MODEM = modulator/demodulator
 - Communicate between field panels & controllers
 - Impose info in binary form onto carrier waves
 - Have you heard the “sound” of a modem before?
 - Two classifications:
 - Baseband
 - Using differential current pulses for transmission
 - Short range: 2-3 miles
 - Broadband
 - Frequency, amplitude, or phase characteristics are modulated



Transmission Methods

- Telecommunication services and systems in HK (HK: the Facts – telecommunications
<http://www.gov.hk/en/about/abouthk/factsheets/docs/telecommunications.pdf>)
 - Local Fixed Telecommunications Network Services (FTNS)
 - International Telecommunications Services (via satellite and submarine cable systems)
 - Public Mobile Radiotelephone Services
 - Third Generation (3G) Mobile Services
 - International Value Added Network Services (IVANS), including Internet Service Providers (ISP)

Key Telecommunications Statistics (Hong Kong)

Telecommunications Services	Quantity
Mobile network operators (Jan 2010)	5
Wireline-based local fixed telecom. network services (FTNS) operators (Jan 2010)	10
Wireless-based local FTNS operators (Jan 2010)	1
FTNS operators for distribution of domestic free TV programme service (Jan 2010)	2
Satellite-based external FTNS operators (Jan 2010)	5
Cable-based external FTNS operators (Jan 2010)	29
External telecommunications services operators (Jan 2010)	262
Household fixed line penetration rate (Nov 2009)	101.4%
Mobile subscriber penetration rate (Nov 2009)	171.6%
Mobile subscribers (Nov 2009)	12,057,735
2.5G and 3G mobile subscribers (Nov 2009)	4,947,009
Internet Services	Quantity
Internet service providers (Jan 2010)	168
Registered customer accounts with dial-up access (estimated) (Nov 2009)	962,584
Registered customer accounts with broadband access (estimated) (Nov 2009)	2,023,107
Household broadband penetration rate (Nov 2009)	80.0%
Public Wi-Fi access points (Jan 2010)	8,8266

(Source: Office of the Telecommunications Authority, www.ofta.gov.hk)

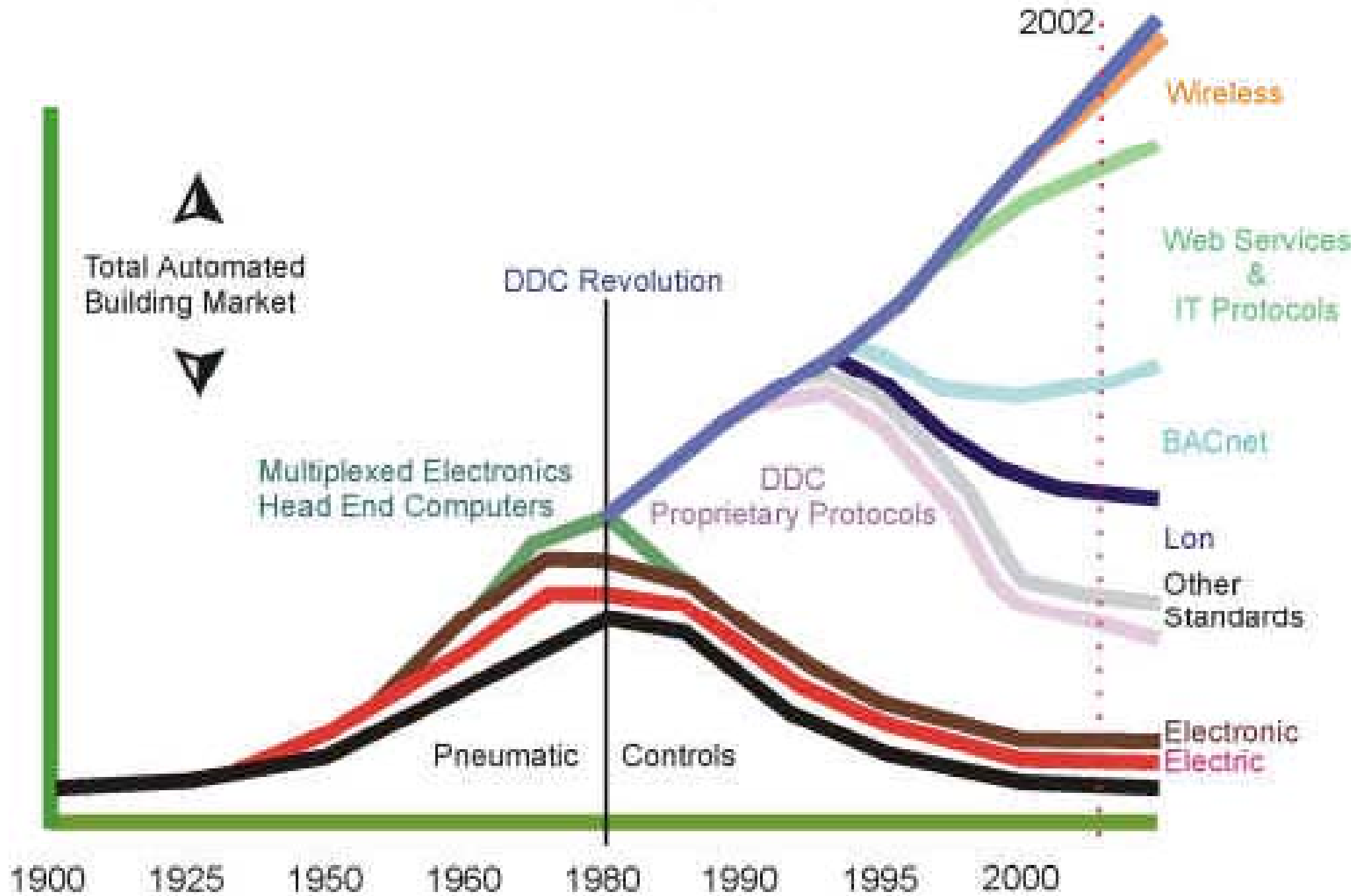
Emerging Trends

O = Open

I = Integrated

W = Wireless

Automated Buildings Evolution



Networking



[Journal Articles]:

- Hartman, T., 2001. Whole building networks - beyond HVAC, *Network Controls*, May 2001, pp. 36-43.
- Doherty, P., 2002. The future of controls is wireless and small, *Network Controls*, July 2002, pp. 40-45.



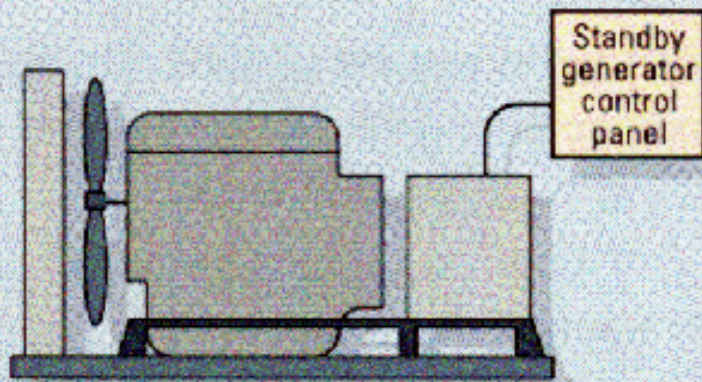
Whole Building Network

- Advantages of network-based systems
 - Easier & more convenient monitoring
 - Improved energy efficiency
 - Simplified system maintenance
 - Self-balancing & self-setup
- Integrated facility networks (IFNs)
 - To streamline building O&M activities
 - To monitor & control the systems/equipments

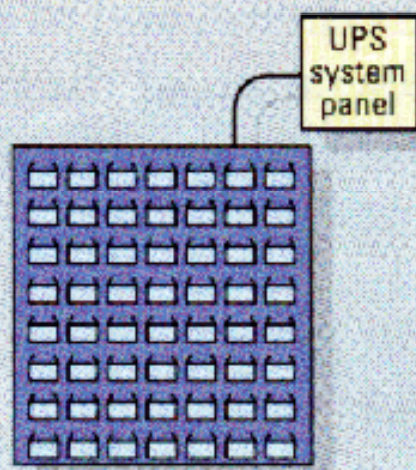


Whole Building Network

- What can be integrated?
 - HVAC
 - Lighting
 - Security
 - Fire (alarm & control)
 - Emergency generator
 - Uninterruptable power supply (UPS)
 - Lifts & escalators
 -



Standby generator control panel



UPS system panel

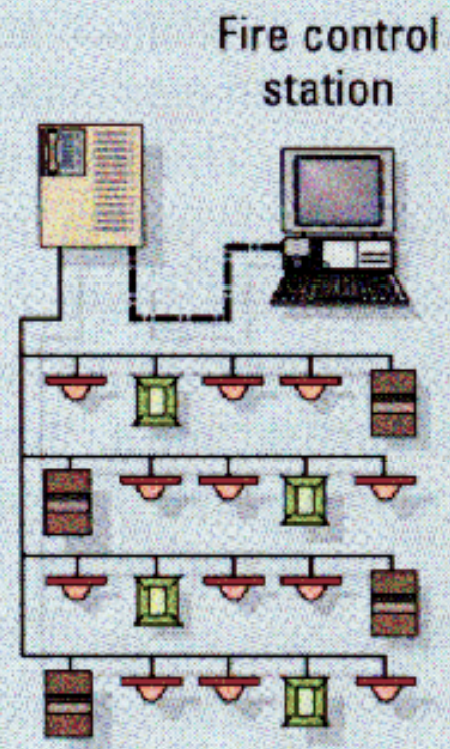
Uninterruptible power system

Computer room environmental control panel

Critical System 1 monitor/controller

Computer room environmental control panel

Critical System 2 monitor/controller



Fire control station

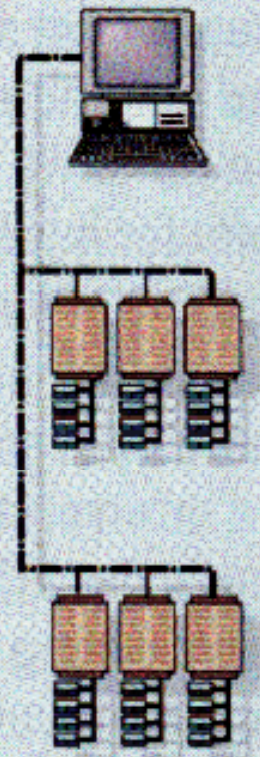
Fire alarm system

Security console

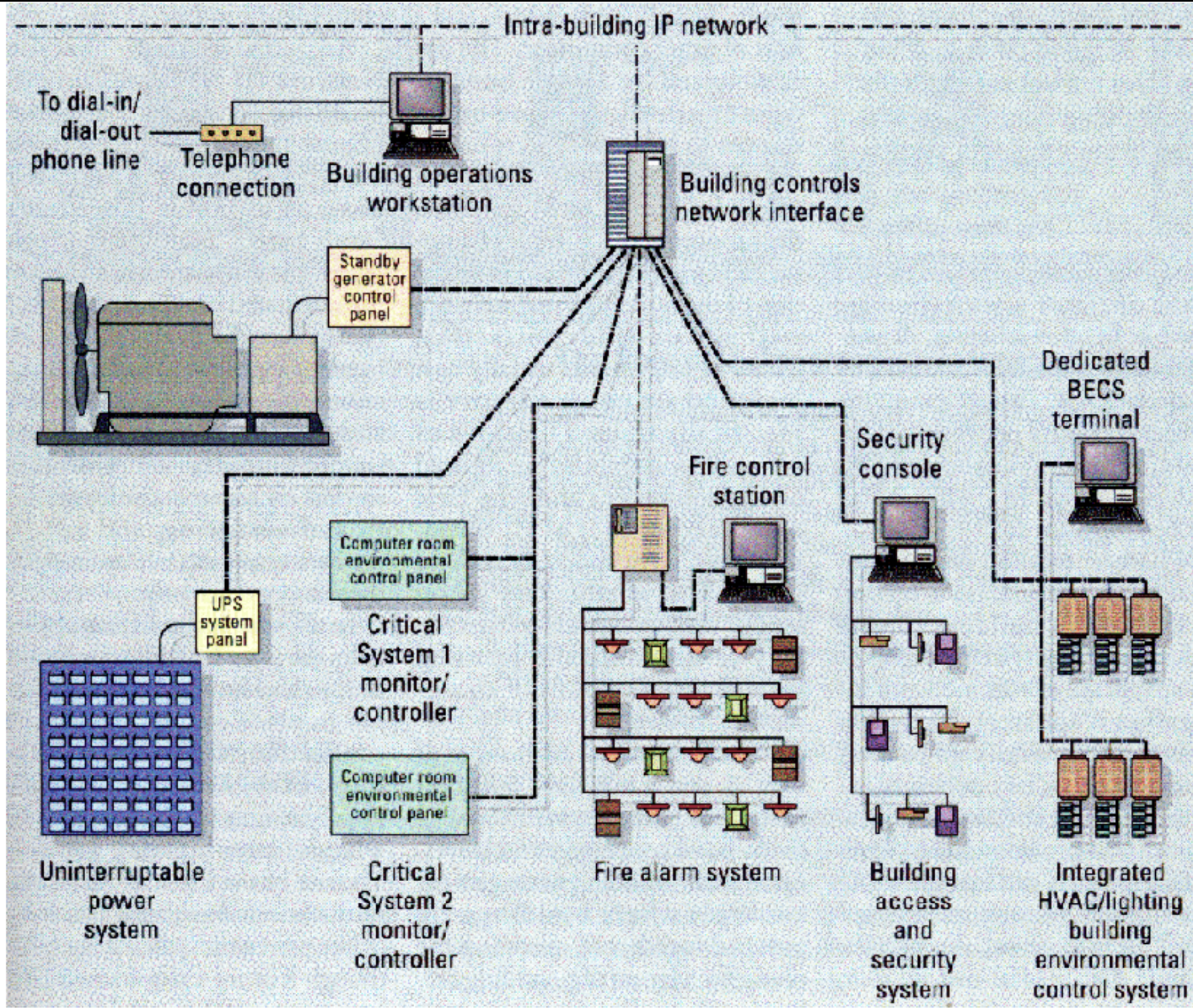


Building access and security system

Dedicated BECS terminal



Integrated HVAC/lighting building environmental control system





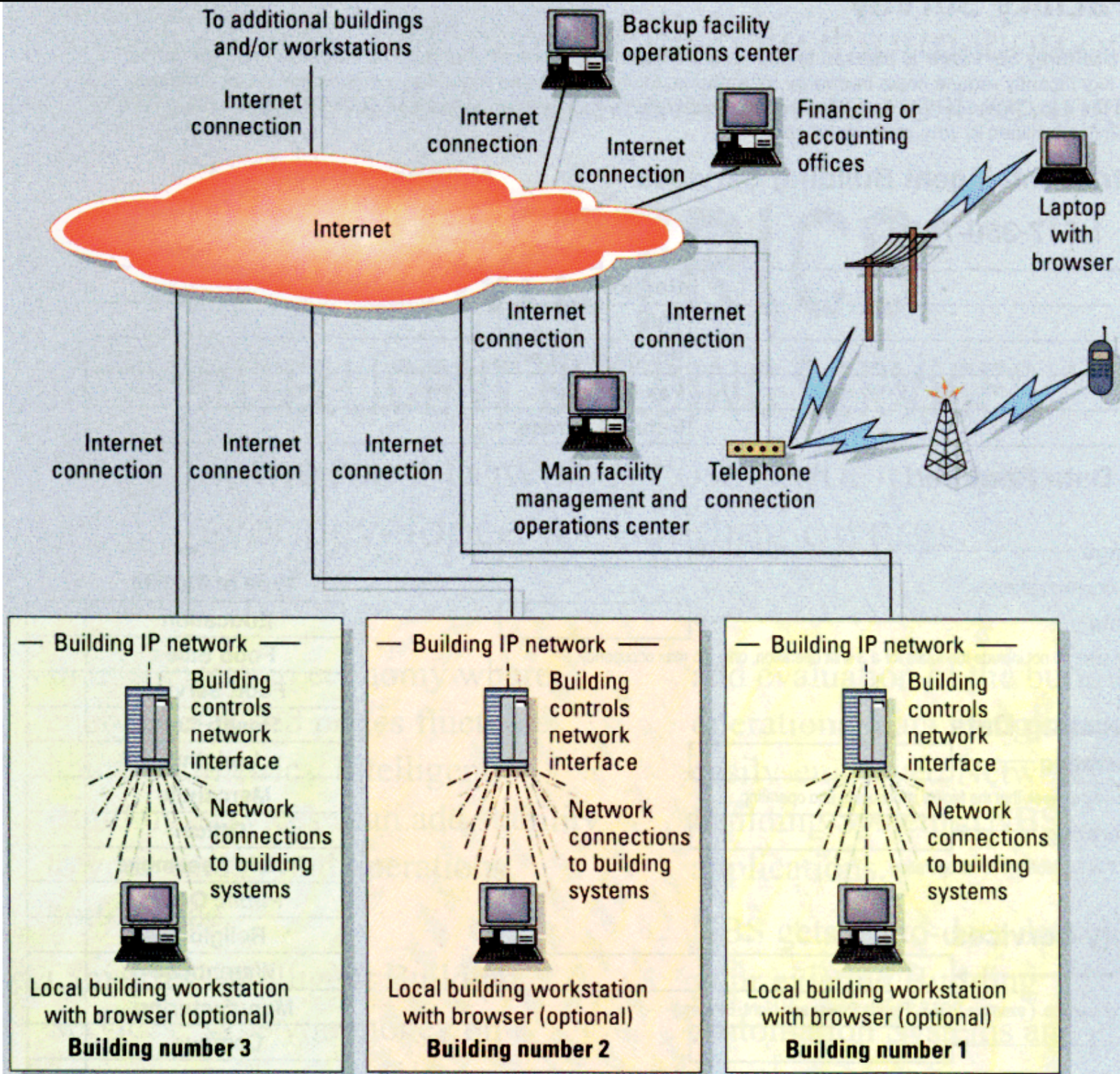
Whole Building Network

- A single communication is not yet there
 - Interfacing equipment is needed
 - Network interface or ‘gateway’
- Advantages of network integration
 - Everything can be checked at one location
 - Improved reliability on critical systems
 - Only one single modem is needed
 - Benefits of interoperability (e.g. minimise disruption & operation costs)



Whole Building Network

- Multi-building management
 - Benefit: shared O&M resources & expertise
 - Can reduce maintenance costs
 - Internet:- inter-building communication backbone
 - Web browser
 - Less dependent on vendors
- What type(s) of buildings are most suitable?



To additional buildings and/or workstations

Backup facility operations center

Internet connection

Internet connection

Internet connection

Financing or accounting offices

Internet

Laptop with browser

Internet connection

Internet connection

Internet connection

Internet connection

Internet connection

Main facility management and operations center

Telephone connection

— Building IP network —

Building controls network interface

Network connections to building systems

Local building workstation with browser (optional)

Building number 3

— Building IP network —

Building controls network interface

Network connections to building systems

Local building workstation with browser (optional)

Building number 2

— Building IP network —

Building controls network interface

Network connections to building systems

Local building workstation with browser (optional)

Building number 1

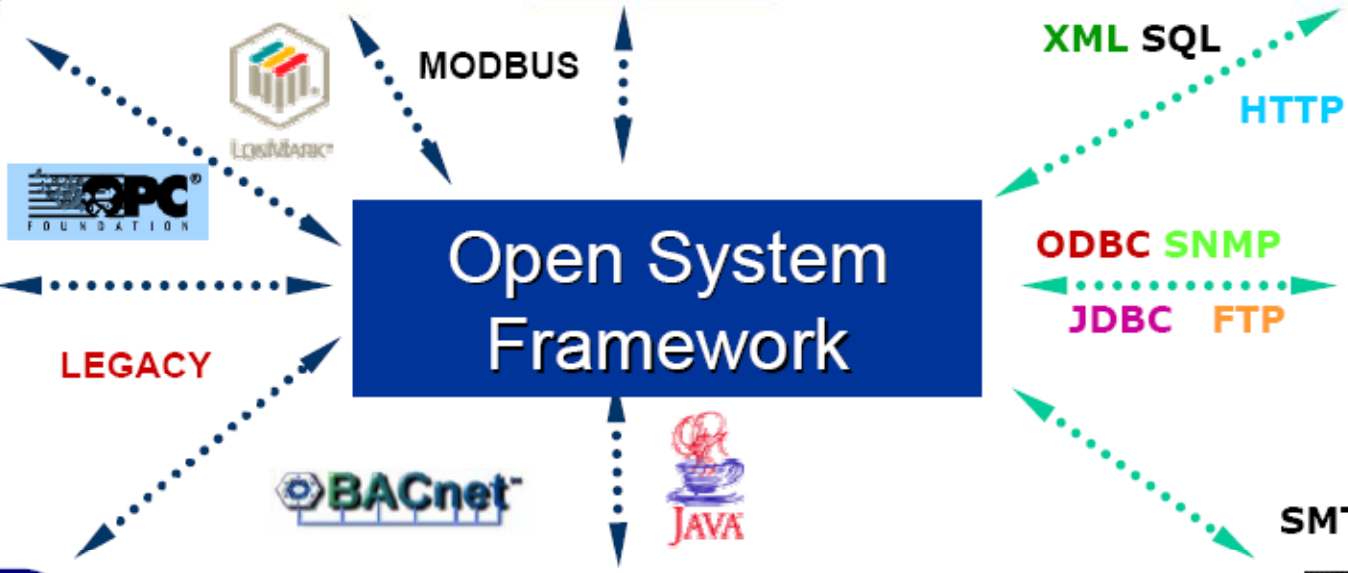
Systems

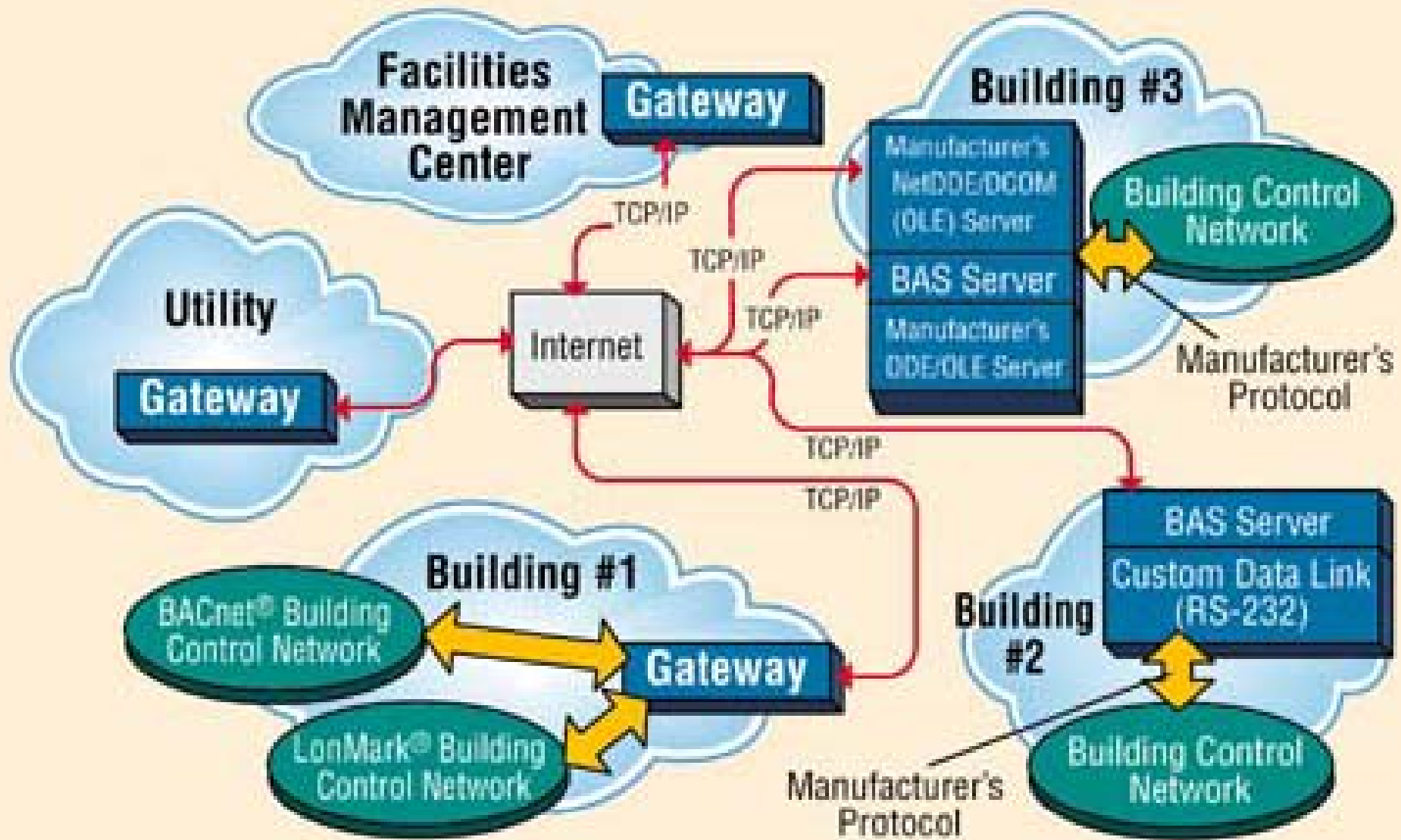


Enterprise



Open System Framework





Integration controls network from different buildings



Whole Building Network

- Challenges of multi-building networks
 - Lack of uniformity w/ individual systems
 - Increases the complexity
 - Some systems need to stand alone in each building
 - Such as fire alarm, security, UPS
 - Regulatory & administration practices
 - Fire alarm is often not allowed to be monitored remote
 - Lack of communication standards

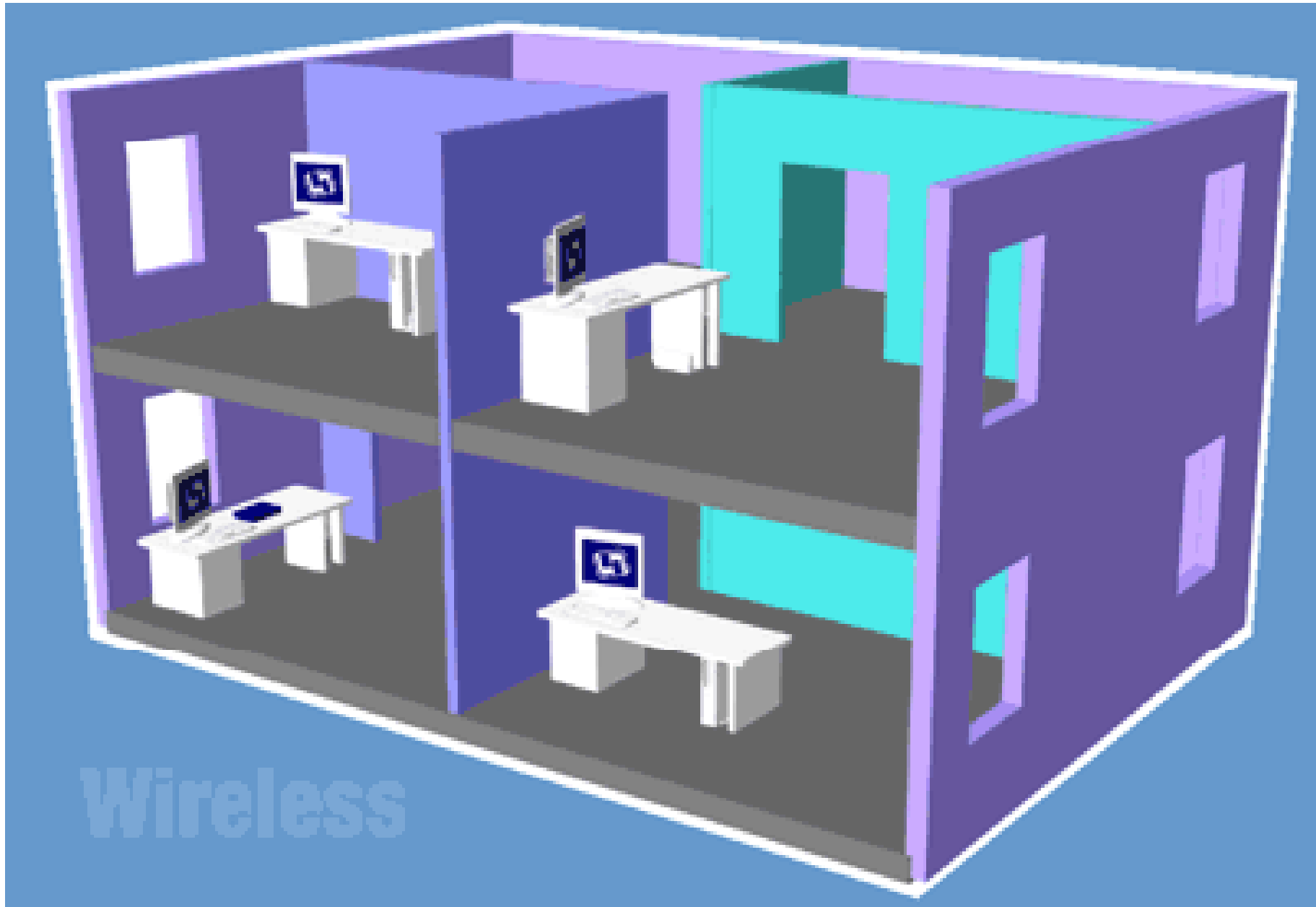


Wireless and Small

- Megatrend 1: building operating systems
 - ‘Linux’ operating system (vs. MS Windows)
 - Easy to use, stable, scalable, and FREE of charge
 - COBA (connected open building automation)
 - A linux-based operating system for BAS, by Nokia, ABB, Elisa, HP & Lonix
 - Open standard for easy & secure access
 - Internet browser & mobile devices



Wireless revolution



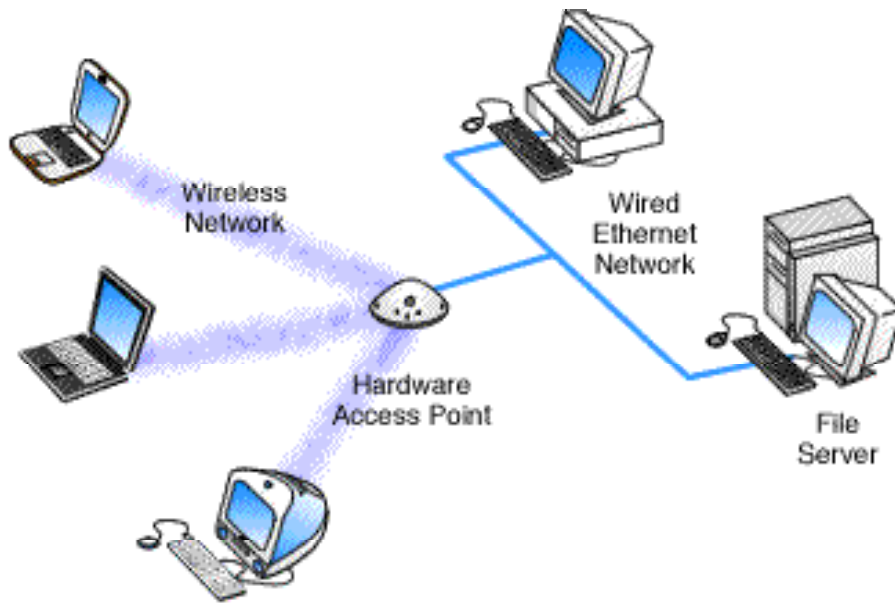
(Source: www.linksys.com)



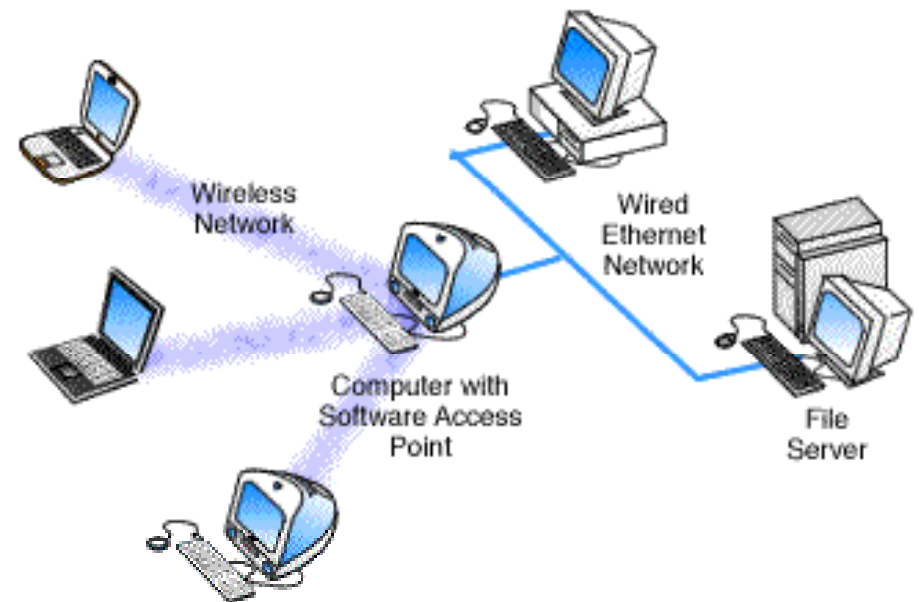
Wireless and Small

- Two kinds of wireless networks
 - Ad-hoc or peer-to-peer
 - Computers with wireless interface can communicate directly with each other
 - Access point or base station
 - Acts like a hub, providing connectivity for the wireless computers
 - Dedicated hardware access points
 - Software access points

Ad-hoc or peer-to-peer networking



Hardware access point



Software access point

Wireless and Small



- Megatrend 2: linking devices

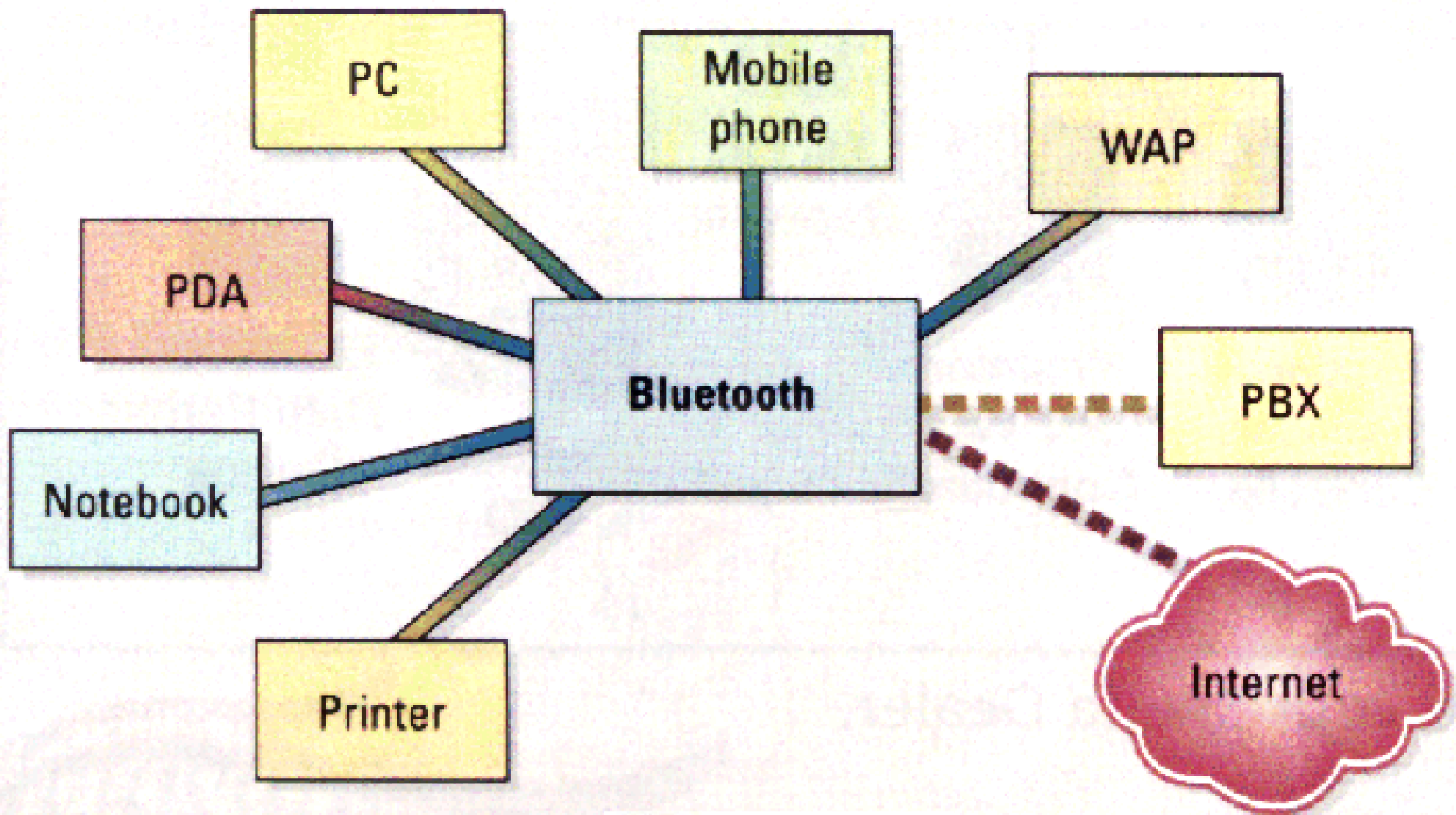
- IEEE wireless local area network (**WLAN**)
 - 802.11(b) – Wi-Fi, over short distances, up to 11Mbps
 - 802.11(g) or (a) – up to 54 Mbps



- *Bluetooth* wireless technology

- Originally designed for mobile devices
 - Does not require a large power source
- Allows personal area networks (PANs) (mini-instant network) using radio frequency identification (RFID)
 - Communicate w/o a server or a single point of routing
 - Connect up to 8 devices at a time (PicoNet)
 - ‘Invisible’ technologies: user acceptance?

















 **Bluetooth™**

Why Choose? A vs B vs G

Wireless Technology Comparison Chart

Wireless Standard	802.11b	802.11a	802.11g
Popularity	 Widely adopted. Readily available everywhere.	 New technology.	 New technology with rapid growth expected.
Speed	11 Mbps Up to 11Mbps (note: cable modem service typically averages no more than 4 to 5Mbps).	54 Mbps Up to 54Mbps (5X greater than 802.11b).	54 Mbps Up to 54Mbps (5X greater than 802.11b).
Relative Cost	 Inexpensive.	 Relatively more expensive.	 Relatively inexpensive.
Frequency	2.4 GHz More crowded 2.4GHz band. Some conflict may occur with other 2.4GHz devices like cordless phones, microwave ovens, etc.	5 GHz Uncrowded 5GHz band can coexist with 2.4 GHz networks without interference.	2.4 GHz More crowded 2.4GHz band. Some conflict may occur with other 2.4GHz devices like cordless phones, microwave ovens, etc.
Range	 Good Range. Typically up to 100-150 feet indoors, depending on construction, building materials, room layout.	 Shorter range than 802.11b & 802.11g. Typically 25 to 75 feet indoors.	 Good Range. Typically up to 100-150 feet indoors, depending on construction, building materials, room layout.
Public Access	 The number of public "hotspots" is growing rapidly, allowing wireless connectivity in many airports, hotels, college campuses, public areas, and restaurants.	 None at this time.	 Compatible with current 802.11b hotspots (at 11Mbps). Also, it is expected that most 802.11b hotspots will quickly convert to 802.11g.
Compatibility	OK 802.11b Widest adoption.	OK 802.11a Incompatible with 802.11b or 802.11g.	OK 802.11b 802.11g Interoperates with 802.11b networks (at 11Mbps). Incompatible with 802.11a.



Wireless and Small

- Megatrend 3: invisible connections through nanotechnology
 - Chips small enough to be in clothing/jewelry
 - ‘Wearable’ computing products
 - Transmit comfort needs of individual wearer
 - Invisible to the end user
 - Connect to building/environmental control systems



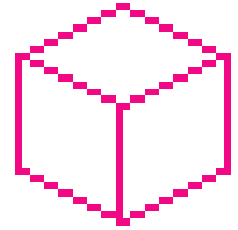
‘Wearable’ computing products



Wireless and Small

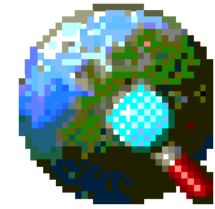
- Create your future
 - Not easy to predict the technology trends
 - Speed of change can be drastic (e.g. after 9-11)
- New definition of “controls”
 - Multifunctional, centrally controlled systems
 - High performance routers in computing
 - *‘The building as computer’*

System Concepts



- Future development potentials
 - World Wide Web (Web-based controls)
 - Communication standards (BACnet & LonMark)
 - Wireless revolution
 - Integration of communication & automation
- Emerging issues
 - ‘Green’ building environment
 - Evolution of DDC to facility wide control
 - Occupant connectivity & control

Further Reading



- 11 Revolutionary Automation Trends
 - <http://www.automatedbuildings.com/news/may01/articles/trends/trends.htm>
- Hui, S. C. M., 2007. Latest trends in building automation and control systems, Invited paper presented at the *CAI Symposium 2007 on Intelligent Facility Management and Intelligent Transport*, 28 March 2007, Hong Kong, 10 pages.
 - http://web.hku.hk/~cmhui/CAI-2007_SamHui.pdf