IES Technical Talk

Telecommunications and Access Network Evolution

Electronics & Computer Technical Committee, IES

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Telecommunications Evolution

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Telecommunications

Contents

- Networking Technologies
- Business and Residential Customers
- Traditional and New Access Methods
- Narrowband vs Broadband
- IP Services and Applications
- Benefits of New Access Systems
- QoS Requirements and Guarantees

Network Planning

As a network manager, you are asked to build a corporate communications network.

- How will you proceed?
- What are the issues?
- What are the system requirements?

Network Planning

5 Major issues :

- Meeting users' changing requirements
- Containing increasing costs
- Keeping up with technology
- Understanding vendor strategies
- Maintaining credibility with users and management

Networking Technologies

- Telecommunications Switching Systems
- Copper-based Transmission Systems
- Optical Communication Systems
- Wireless and Personal Communication Systems
- Satellite Communication Systems
- Video and Image Transmission Systems
- Multimedia Networks
- Broadband (High-speed) Networks

Types of Networks

LAN MAN WAN ATM

SONET SDH ISDN B-ISDN

WIRELESS SATELLITE PCS

BLUETOOTH WAP

INTERNET INTRANET EXTRANET

ENTERPRISE VPN

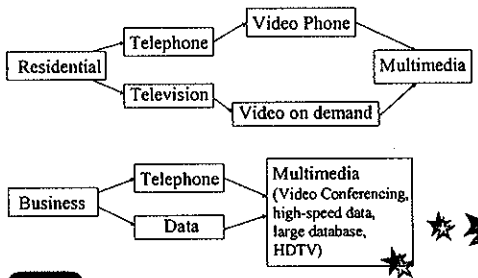
Networking Challenges

- Network configurations
- Applications / Services
- Internetworking
- Network Management and Control
- Network Evolution

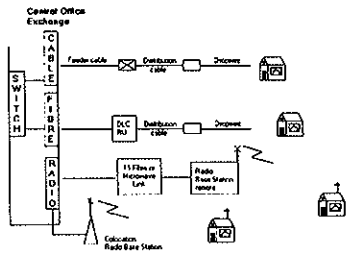
Residential vs Business

- Geographical dispersion
- Usage patterns
- Spending on telecommunication services
- Business factors
- Technology factors

Residential vs Business



Traditional Access Systems



New Access Systems

- x-DSL systems
- Cable networks
- Fixed / mobile wireless
- Satellite mobile
- Power-line networks
- .....?

Narrowband Services and Systems

- Telephony (4 kHz, 64 kbps)
- Data
  - voiceband modem (19.2 kbps ...?)
  - digital modem (56 kbps, 64 kbps)
- ISDN
  - Basic rate 144 kbps (2B+D channels)

Broadband Services

Service	Data Rate
Voice	64 kbps
Interactive data	1-100 kbps
Bulk data	1-10 Mbps
Standard quality video	20-30 Mbps
High Definition TV	100-150 Mbps
High quality video telephony	~ 2 Mbps

IP Services

Traditional Services
- Telephony (PSTN)
- Data (PSDN)
- Television (Broadcast and Cable TV)

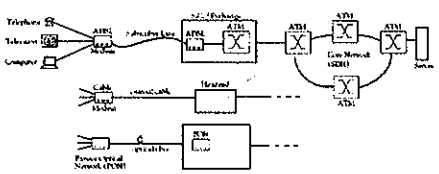
New Services
- Internet-based audio and video (DVD)
- Medical imaging
- Distance learning
- Video conferencing and video on demand

IP Services

New Services
- Audio and video streaming
- Voice over IP
- e-commerce
- Multimedia, high-speed, interconnected, heterogeneous network (converging services and networks)

Benefits of New Access Technologies

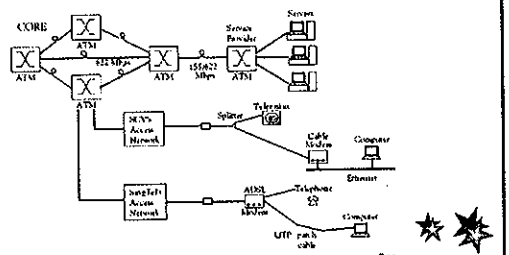
- Multimedia network (broadband / high-data rate access, low network delay / latency)



Networking Trends

• Dedicated services	- Multi-services
• Dedicated networks	- Multimedia networks
• Proprietary	- Open standards
• Shared LANs	- Switched LANs
• Copper is still in	- Fiber is delayed
• On-line services	- Internet
• Groupware / Interconnected LANs	- Intranet / Extranet / Enterprise / VPN
• Telco	- ISP

Access - Core Networks



Access Network

Cable Modem

- Hybrid Fibre Coaxial (HFC) cable
- Both cable TV and computer data
- Interface with PC via Ethernet
- Share the allotted bandwidth (30 Mbps downstream)
- 512 kbps to 10 Mbps upstream per channel (typical speed - 768 kbps)

Access Network

Cable Modem

- Downstream spectrum
  - 54 to 750 MHz
  - Analogue and digital TV, voice telephony, 6 MHz NTSC (8 MHz PAL) - one analogue TV, five digital video, one 30 Mbps data stream or 384 digitized voice conversations

Access Network

Cable Modem

- Upstream spectrum
  - 5 to 42 MHz
  - Pay-per-view signaling, cable modem data return, voice return
  - The 6 MHz band at the end of the spectrum is much noisier and requires robust modulation schemes

Access Network

xDSL

- DSL - Digital Subscriber Line
  - 160 kbps, duplex, 4 wires
  - ISDN service, leased digital data, Internet access
- HDSL - High data rate DSL
  - 1.544 Mbps / 2.048 Mbps, duplex, 4 wires
  - WAN / LAN access
- VDSL - Very high data rate DSL
  - 13 to 52 Mbps downstream, 1.5 to 2.3 Mbps duplex
  - ATM access

Access Network

xDSL

- RADSL - Rate adaptive DSL
  - 600 kbps to 8 Mbps downstream, 128 kbps to 1 Mbps duplex
  - Longer distance than ADSL
- ADSL - Asymmetric DSL
  - 1 to 8 Mbps downstream, 16 to 640 kbps duplex, 2 wires
  - Internet access, VoD, Remote LAN access, Interactive multimedia

Access Network

ADSL - Asymmetric DSL

- Downstream data rates depend on a number of factors including the length of copper wire, its wire gauge, presence of bridged taps, and cross-coupled interference :

Data Rate	Wire Gauge (Wire size)	Distance km (ft)
1.5 or 2 Mbps	24 AWG (0.5mm)	5.5km (18,000ft)
1.5 or 2 Mbps	26 AWG (0.4mm)	4.6km (15,000ft)
6.1 Mbps	24 AWG (0.5mm)	3.7km (12,000ft)
6.1 Mbps	26 AWG (0.4mm)	2.7km (9,000ft)
8.448 Mbps	24 AWG (0.5mm)	2.7km (9,000ft)

BxD
= Constant

Optical Fiber

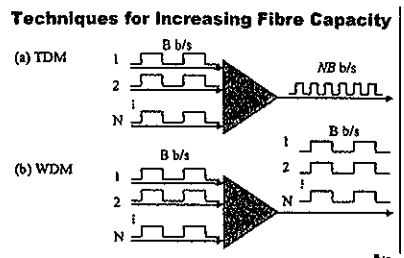
- Multi-mode and single-mode
- Large bandwidth
- Low attenuation
- EMI reduced
- Repeater-less Transmission for hundreds of km
- Data rate in the order Gbps
- Expensive and complex

Optical Fiber

- SONET / SDH
- WDM / DWDM
- Optical switching
- Passive optical network (PON)
- Fiber in the local loop (FITL)
- Fiber to the home (FTTH)
- Fiber to the curb (FTTC)
- Hybrid fiber coax (HFC)

Optical Fiber

Techniques for Increasing Fibre Capacity



Optical Fiber

Time Division Multiplexing

- Increase bit rate requires higher speed electronics
- 10 Gb/s system is available commercially
- 40 Gb/s system is being developed in research laboratories
- OTDM of 25x10Gb/s streams have been demonstrated in laboratory experiments
- Due to various impairments, it is difficult to transmit beyond 10 Gb/s with TDM over significant distances

Optical Fiber

Wavelength Division Multiplexing

- Transmit different data streams simultaneously using multiple carrier wavelengths
- 32x2.5Gb/s systems are available commercially
- 8x10Gb/s systems will be available soon
- TDM and WDM are complementary technologies
- 2 Tb/s over a single fibre has been demonstrated using a combination of TDM and WDM in research laboratories
- Possible to transmit 10 Tb/s over a single fibre using 1000 wavelengths

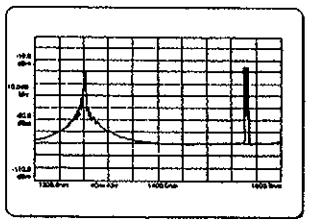
Optical Fiber

Wavelength Division Multiplexing

- Basic technology of next generation optical networks
- A technique for using a fibre to carry many separate and independent optical channels using different wavelengths (or different colours of light)
- Two varieties of WDM : sparse and dense WDM
- Sparse WDM could be constructed using 1330nm and 1550nm or 1310nm and 850nm etc, where the splicing between the wavelengths used are wide
- Dense WDM has much closer wavelength spacing of 1nm or less and could pack many channels within the 1550nm band or 1310nm band

Optical Fiber

Spectrum of Sparse and Dense WDM



Broadband Wireless

- Wireless revolution
- Advances in highly efficient RF circuitry (GHz bands)
- Improvement in rechargeable batteries
- Advances in spread-spectrum communications
- Need to work out of the office
- Personal mobility
- Timeliness as a source of competitive advantage

Broadband Wireless

- High Speed Access (HSA) Requirements
- Multipoint Multi-channel Distribution Service (MMDS)
- Local Multipoint Distribution Services (LMDS)
- Satellite Mobile Communications
- Wireless Local Loop (WLL)
- Wireless Access Protocol (WAP)

Broadband Wireless

System Requirements

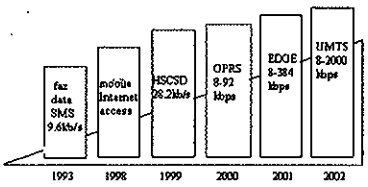
- Data rate
- Frequency of operation
- Transmitted power
- Coverage area
- Throughput and network delay

Broadband Wireless

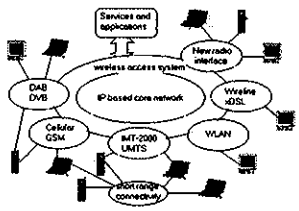
- Need for High Speed
- Downloading time for the 3-1/4 hour movie "Titanic"

28.8 kbps modem	42 hrs 30 min (13 times longer than the movie itself)
ISDN	9 hrs 14 min
T1	49 min 20 sec
8 Mbps (ADSL or cable modem)	9 min 14 sec
10 Mbps wireless modem	7 min 23 sec

Broadband Wireless



Broadband Wireless



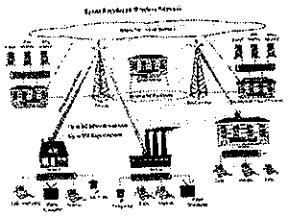
Broadband Wireless

- Multipoint Multichannel Distribution Service (MMDS)
- Data rate : 1 Gbps (raw capacity)
- Throughput : 128kbps to 10Mbps
- Frequency of Operation : 2.5 to 2.7GHz (200 MHz bandwidth)
- Coverage area : 50km radius , 10 000 sq km
- Cable modem technology
  - downstream 10 to 30 Mbps
  - upstream 32 kbps
- Services : 33 analogue video (~ 6MHz)
  99 digital data streams (~10Mbps)

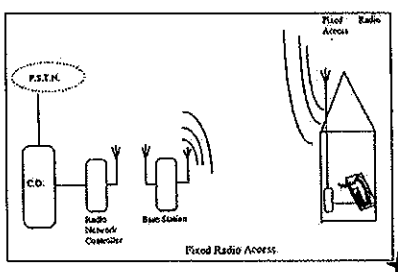
Broadband Wireless

- Local Multi-point Distribution Services (LMDS)
- Data rate : downstream - 1.5 Gbps
  upstream - 200 Mbps
- Frequency of Operation : 28 GHz
- Bandwidth : 'A' block - 1150 MHz
  'B' block - 150 MHz
- Coverage area : 3 to 5km (cell size)
  80,000 customers

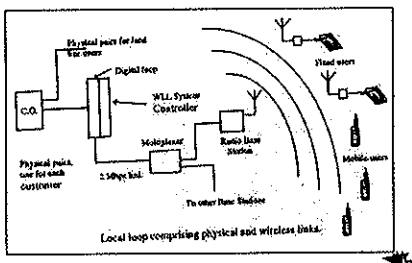
Broadband Wireless



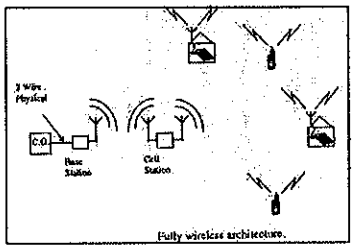
Wireless Technology



Wireless Technology

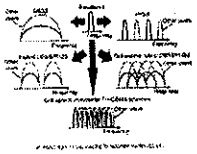


Wireless Technology



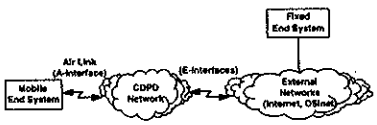
Broadband Wireless

- **Code Division Multiple Access (CDMA)**
  The CDMA system assigns digital codes to active subscribers. Each small voice sample is repeated many times. Even if some samples are lost, a sufficient amount reaches the receiver to ensure the receipt of an acceptable signal.



Broadband Wireless

- **Cellular Digital Packet Data (CDPD)**
  - Wireless IP overlay to the digital cellular network
  - Based on TCP/IP (Internet access to mobile users up to 19.2 kbps)



Broadband Wireless

- **Cellular Digital Packet Data (CDPD)**
  - Communications over a pair of RF channels
  - Gaussian-filtered Minimum Shift Keying (GMSK) modulation
  - Reed Solomon forward error correction coding

Wireless Technology

Wideband CDMA

- High capacity, high quality PCS
- EIA/TIA Interim Standard IS-665
- Wideband spreading, coherent detection(CD), interference canceller system (ICS)
- 32 kbps waveform speech coder
- 128 voice channels per cell
- Data 64 kbps by 5 MHz spreading

Wireless Technology

Lucent cdma2000

- IS95A evolves to IS95B, cdma2000 3G-1X, 3G-3X
- 20% capacity increase by handoff improvement
- Carrier bandwidth 1.25 MHz (-1X) & 3.75 MHz (-3X)
- 144 kbps & 384 kbps
- 128 voice channels per cell
- 800 MHz & 1.9 GHz

Wireless Technology

4G wireless nets

- Edge combined with wideband OFDM
  (enhanced data rate for GSM evolution & orthogonal frequency division multiplexing)
- Software radios, wideband transceivers, power amplifiers to deliver 20 Mbps and above
- Better than 3G UMTS specs

Wireless Technology

Software radio

- Functions of contemporary radio systems are implemented in software
- **Just** transmit/receive – **NO**
- Characterizes the available transmission channels, probes the propagation path, constructs an appropriate channel modulation, electronically finds the right direction and power level and then transmits
- Finds the mode of incoming transmission, estimates the desired multi-path signal, adaptively equalizes, corrects the errors (FEC) and decodes with the lowest possible BER
- Software defined services

Wireless Security

Security – the main concern

- Data link confidentiality
- Mobile end station authentication
- Key management
- Upgrade of security algorithms
- Access control

Data Compression and Video Quality

Quality	Data Rate
Blurry picture	64 kbps
Noticeable defects	128 kbps
Sub-VHS; some defects	384 kbps
VHS Quality	0.9 - 1.5 Mbps
Broadcast Quality	45 Mbps
HDTV	45 - 150 Mbps

Satellite Based Mobile & Personal Communication Systems

- Satellite Orbits
- GEO Systems
- MEO and Big LEO Systems
- Little LEO Systems
- Satellite advantages
  - Wide Coverage
  - High Elevation Angles
- Disadvantages
  - Long Distances
  - Long Delay Times

Bluetooth

- Wireless Technology Evolution

  Second generation (2G) cellular wireless technology : GSM, GSM1800, CDMAone (9.6 kbps to 14.4 kbps)

  2.5G cellular; GPRS – packet wireless data (144 kbps), HSCSD – circuit-switched wireless data (9.6 kbps to 64 kbps)

  3G or UMTS or W-CDMA (384 kbps to 2 Mbps)
- Shared usage concept

Bluetooth

- Range

  eduPAD - 6 to 10 m

  Bluetooth - 1 to 10 m

  Cordless telephone - 20 m

  WLAN - 50 m

  GSM - typically 10 km
- Bluetooth (www.bluetooth.com) - Intel, IBM, Lucent, Microsoft, Motorola, Nokia, 3com, Toshiba and many more

Bluetooth

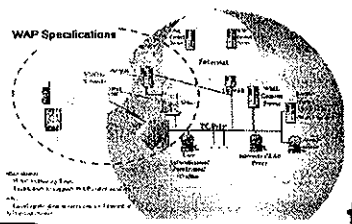
- **Activities in KRDL**
  - Developing bluetooth products
  - Bluetooth for wireless home network (R&Bnet@Home Alliance) and for enhancing future versions of eduPAD
  - Use ad hoc networking technologies in collaborative learning and working environments

What is WAP?

- The Wireless Application Protocol is a family of protocols allowing mobile wireless services
- It is based on Internet standards
- It provides an environment for all service providers to build applications and services that can reach wide platforms.

WAP End-to-end Solution

- Potential WAP Solution for large customer/ Network Operators



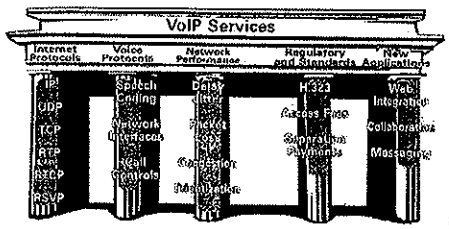
Compression and Streaming

- Multimedia services
- Streaming audio and video
- Real time and stored
- Latency
- Voice over IP

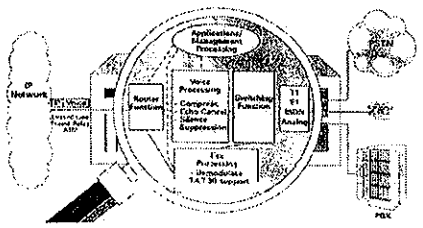
Emerging Applications

- DSP-based Voice-over-Internet Protocol
- Growing trend
- System efficiency and lower calling costs
- DSP advances in processing power and reduction in power dissipation
- Designers integrate as much functionality as possible on a single DSP or DSP chipset

VoIP Building Blocks



Generic Gateway



Summary

- Telecommunications Evolution
- Terminals, Switching, Transmission
- Core and Access Network
- New (broadband) Access Network

Summary

- New Access Network - Infrastructure
- Carriers and ISPs to provide new value-added products and services
- Reduce cost
- Simplify network operations and management
- Improve resource utilization
- Optical networking
- ASIC technology (DSP)
- Subscriber management software
- Distributed control

Summary

- Integration - key word
- Systems integration and services integration
- SONET / SDH, IP, cable, wireless, Frame Relay, ATM
- End-to-end solution to increase network efficiency
- Services - quality and bandwidth levels
- Innovative services

Summary

- Wired media
  - Twisted-pair, coax, optical fibre
- Wireless
  - The combination of Bluetooth, 3G and WAP will lead to a new mobile Internet that features a widespread connectivity, faster connections, and more possibilities for inter-device communications

