Chapter 2

Networking Technologies and Multimedia

Outline

- Wired Networking Technologies
- LANs, MANs and WANs
- Open System Interconnection (OSI) model
- Traditional ("Legacy") LANs
  - Ethernet
  - Token Ring
- FDDI
- Switched Hubs
- Fast Ethernet (100 Mbps)
- Gigabit Ethernet (1 Gbps)
- Levels of Mobility
- Wireless Networking Revolution
  - Bluetooth
  - HomeRF
  - IEEE 802.11
- Dream Networking
  One network - No configuration
  Nomadic networking
  Always-on networking
  secure networks that scale

- The Connected Home
  No Pain Networking
  The Home as a platform
  Redefining Entertainment

- Weaving the User to User web
  Click to communicate
  Multimedia Collaboration
  Presence

The Dream

- Moore’s Law still going strong
  Smaller, more computing devices every 18 months
- Miniaturization continues
  100Gb per square inch hard disk density
  128MB memory on a single chip
- Dramatic innovation towards longer battery time
  Low power CPUs from Intel, AMD, etc…
  Long Live Cell battery
- Smaller, lighter PC, PDA, phone designs enabling
  new networking scenarios
  TVs on Cell phones (Vision), Wearable computers, digital cash, eBooks

Trends in Computing

- SUN J2EE, W3C-XML, MS-.Net
  revolution leading to web services
- “Presence” a paradigm shift in Real Time Communications and Collaboration
- Net attached Consumer Electronics and Gaming appliances emerging
- Applications assuming always on connectivity
- anytime, anywhere, anyhow accessibility
- Terminal, Personal & Session mobility

Trends in Applications
Network Classification

- Networks are often classified according to how large they are. The classical classes are called LAN, MAN and WAN.
  - A LAN (Local Area Network) connects hosts in a single building or across a single campus.
  - A MAN (Metropolitan Area Network) connects hosts across a town or a city.
  - A WAN (Wide Area Network) connects hosts across a country or the world.

Uses of LANs, MANs and WANs

- LANs tend to be used for small networks (up to 100 computers). Their small size allows them to be fast because signals are less distorted over small distances.
- MANs are often used to connect LANs in offices across a town or a city. They are also often used to connect LANs to Public Switched Data Networks (i.e. national networks provided by telephone companies for computer data).
- WANs are used to connect computers across a country or the world. The Internet is the most obvious example of a WAN.

Networking Technology for Multimedia

- Industrial communication networks can be modeled according to the Open System Interconnection (OSI) model:
  - The International Organization for Standardization (ISO) began developing the Open Systems Interconnection (OSI) model in 1977.
  - It is now the most accepted standard for network modeling.
  - The OSI model is not a protocol; it is a model for understanding and designing a network architecture that is flexible, robust and interoperable.
Defines rules that apply to the following issues:
1. how network devices contact each other
2. how network devices communicate with each other
3. who has the right to transmit data
4. are transmissions received correctly and by the right node
5. how physical media are arranged and connected
6. ensure that network devices maintain a proper rate of data flow
7. how bits are represented on the network media

**Open System Interconnection (OSI) model**

- All services directly called by the end user (Mail, File Transfer... e.g. Telnet, SMTP)
- Peer-to-peer communication
- End-to-end flow control and error recovery (e.g. TP4, TCP)
- Error detection, flow control and error recovery, medium access (e.g. HDLC)
- Coding, Modulation, Electrical and mechanical coupling (e.g. RS485)
- Routing, possibly segmenting (e.g. IP, X.25)
- Management of connections (e.g. ISO 8326)
- Definition and conversion of the data formats (e.g. DNS, DSD)
- how to encode/decode messages, security management of connections (e.g. ISO 8326)
- how to send packets reliably
- how to transmit bits
3 Sub-groups

Transport layer

Network support layers

User support layers

Application

Presentation

Session

Transport

Network

Link

Physical

Allow interoperability among unrelated software systems

Links the two subgroups

Deal with the physical aspects of moving data from one device to another

Internetworking

Protocol transparency

High Speed Data Network

Host

Ethernet

1.5 Mb/s

Token Ring

FDDI

DS-3 / OC-3

DS-3 / OC-3

Ethernet

56/64 Kbps

Ethernet

High Speed Data Network

Traditional ("legacy") LANs

ETHERNET (10 Mbps) (IEEE 802.3)

Carrier Sense Multiple Access with Collision Detection (CSMA-CD)

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ETHERNET (10 Mbps) (IEEE 802.3)

Carrier Sense Multiple Access with Collision Detection (CSMA-CD)

Traditional ("legacy") LANs

Database Server

10 Mbps bus

transceiver

Database Server

10 Mbps bus

transceiver

Database Server

10 Mbps bus

transceiver

Database Server

10 Mbps bus

transceiver

Database Server

10 Mbps bus

transceiver

Database Server

10 Mbps bus

transceiver
**Networking Devices**

- **HUBs** (also called “repeaters”)  
  - work at Physical Layer  
  - every bit of incoming data will go out to everyone
- **Switches** (also called “bridges”)  
  - work at Data Link Layer  
  - incoming data is only sent to the named destination, not to all machines on the network
- **Routers**  
  - work at Internet Layer  
  - when data comes in, chooses best way to send it from possible alternatives (smart)

**Repeaters**

- Regenerate the signal  
- Provide more flexibility in network design  
- Extend the distance over which a signal may travel down a cable  
- Example → Ethernet HUB

**Ethernet**

- Only one station can transmit at a time  
- Even in multi-hub LANs  
- Others must wait  
- This causes delay

**HUB**

- Hubs are a form of repeater which has multiple ports ("multi-port repeaters" or "active star networks")  
- Whatever the type of connector, a single hub is only able to connect a group of equipment operating at the same speed (i.e. all equipment connected to a 10BT hub must operate at 10 Mbps)  
- Each port (or interface) allows one piece of equipment to be connected to the hub.  
- The hub is not able to recognize the addresses in the header of a frame, and therefore is unable to identify which port to send to. Therefore, every frame is sent to every output port.
Switches

- A bridge stores the hardware addresses observed from frames received by each interface and uses this information to learn which frames need to be forwarded by the bridge.
- Signal comes in one port
- Signal only goes out one port - the receiver’s
- No broadcasting
- No blocking of other ports

Switches

- Multiple conversations can take place simultaneously
- No need to wait!
- unless the receiver’s port is busy
- Switches reduce latency and congestion

Switched Ethernet

- Ethernet Switches must be Arranged in a Hierarchy (or daisy chain)
- Only one possible path between any two stations, switches

Path=4,5,2,1,3
Traditional ("legacy") LANs

- Token Ring (4 or 16 Mbps) (IEEE 802.5)
  - Physical Medium: twisted pairs, coaxial cables or fiber optics
  - Operating Speed: 4-16 Mbps
  - Token:
    - Special bit pattern circulating around the ring when all stations are idle.
    - When a station wants to transmit,
      1. It gets and remove the token,
      2. Then sends and remove the data frame,
      3. Finally regenerates the token.

Token Ring (IEEE 802.5)

FDDI: Fiber Distributed Data Interface

- 100Mbps, distance up to 200km, 100 hosts mainly used as a backbone
Corporate Networking Example

Wireless & Mobile Communication

Levels of Mobility
Wireless Networking Revolution

<table>
<thead>
<tr>
<th>Past</th>
<th>Present Demand</th>
<th>Future</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed Data</strong></td>
<td><strong>Mobility with Network Connectivity (Data + Voice)</strong></td>
<td><strong>WLAN Unlicensed Bands</strong></td>
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<tr>
<td><strong>Mobile Voice</strong></td>
<td></td>
<td>Local Area - On campus - At home</td>
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<tr>
<td></td>
<td></td>
<td>• Personal mobility</td>
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<tr>
<td></td>
<td></td>
<td>• High data rate</td>
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<tr>
<td></td>
<td></td>
<td>• Incremental infrastructure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Start 1998</td>
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</tbody>
</table>

“3G” WWAN Licensed Bands

| **Wide Area** |
| On the road |
| • Full mobility |
| • Modest data rate |
| • All new infrastructure |
| • Start 2001 |

Wireless Technology

- **PAN**
  - Bluetooth
  - Infrared systems (IR-LAN)
  - Digital European Cordless Telecommunication (DECT)
- **LAN**
  - HomeRF
  - WiFi - wireless fidelity - (802.11b)
- **WAN**
  - GSM
  - GPRS
  - UMTS

Bluetooth

**Requirements:**
- Goes where users go (global use, 2.4GHz ISM band, airline safe)
- Highly secure (business data)
- High capacity (High interference immunity to itself and others)
- Integrated feature in notebooks, cell-phones and handhelds (low cost, very small, low power)
- Replace the cables common to mobile devices (short range)
- The system must operate worldwide
- The system must support voice and data
- The transceivers must be small and operate at low power.
Bluetooth Primer

- Low-power, short-range “cable replacement”
  720 Kbps
  10 meters
  voice and data support
- Perfect for mobile devices
  small, low power, and low cost (Goal: $5 parts cost), but good performance
- Interconnecting a computer and peripherals
  Clear the snake’s nest behind the desk!
- Interconnecting various handheld devices
  Laptop computer, cell phone, palmtop
  Preplanning of network is impractical

A little bit of history

- The Bluetooth SIG (Special Interest Group) was formed in February 1998 by 5 promoter companies
  Ericsson, IBM, Intel, Nokia, Toshiba
- The Bluetooth SIG went “public” in May 1998
- The Bluetooth SIG work (the spec: 1,600+ pages)
  became public on July 26, 1999 (ver. 1.0A)
  ver. 1.0B was released on December 6, 1999
  ver. 1.1 was released on March 1, 2001
- The promoter group increased in December 1999 to nine
  added: 3Com, Lucent, Microsoft, Motorola
- There are 10,000 adopters (as of 9/25/2008)
  adopters enjoy royalty free use of the Bluetooth technology

What does Bluetooth do for you & me?

- Personal Ad-hoc Connectivity
- Landline Data/Voice Access Points
- Cable Replacement
Bluetooth Penetration by Device Type

- A short-range wireless technology: a couple of meters
- Low-cost, reasonable data rate: 4 MBit/s (IRDA 2.0)
- Pushed by Hewlett-Packard
- Most laptops adopted it
- Lots of cell phones and most palmtops have it
- But no software for general connectivity
- Even HP printers don’t have IR ports!
- MORAL: a very nonlinear process
  Value is low until most devices have it (cf. adoption of fax)
  People won’t bother with it until probability of benefit is high
- + cheap technology
- + no license required
- - low transmission range (a couple of meters)

● (large transmission range possible only with laser in point-to-point mode)

Deja Vu: Remember Infra-Red?

<table>
<thead>
<tr>
<th>Technology</th>
<th>Topology</th>
<th>Support up to 7 simultaneous links</th>
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<tbody>
<tr>
<td></td>
<td>Flexibility</td>
<td>None through walls, bodies, cloth...</td>
<td>Line of sight or modified environment</td>
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<tr>
<td></td>
<td>Data rate</td>
<td>720 Kbps</td>
<td>Varies with use and cost</td>
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<td></td>
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<tr>
<td></td>
<td>Power</td>
<td>0.1 watts active power</td>
<td>0.05 watts active power or higher</td>
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<tr>
<td></td>
<td>Size/Weight</td>
<td>25 mm x 13 mm x 2 mm, several grams</td>
<td>Size is equal to range, typically 1-2 meters. Weight varies with length (ounces to pounds)</td>
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<tr>
<td></td>
<td>Cost</td>
<td>roughly $5 per endpoint</td>
<td>$3-$100/meter (end user cost)</td>
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<td></td>
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<tr>
<td></td>
<td>Range</td>
<td>10 meters or less</td>
<td>100 meters with PA</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td>Universal</td>
<td>Intended to work anywhere in the world</td>
<td>Cables vary with local customs</td>
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<tr>
<td></td>
<td>Security</td>
<td>vary, link layer security, 3rd party secure (as a cable)</td>
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Cable Replacement
**Technology Specifications**

- **License Free band**
  - The 2.45 GHz ISM band
  - Ranges from 2.400 GHz to 2.4835 GHz

- **Frequency Hopping**
  - Considerable interferences (license free)
  - Apply spread spectrum techniques beyond 0 dBm power
  - Uses Frequency hopping spread spectrum (low cost and low power)
  - Slotted Bandwidth: 79 hop frequencies, 1 MHz each, 625 µsec hop intervals (1600 hops/sec)
  - 10-meter range.
  - Up to 1 Mbps data rate.

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**What is a Piconet?**

- A collection of devices connected in an ad hoc fashion.
- One unit will act as a master and the others as slaves for the duration of the piconet connection.
- Master sets the clock and hopping pattern.
- Each piconet has a unique hopping pattern/ID
- Each master can connect to 7 simultaneous or 200+ inactive (parked) slaves per piconet

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**What is a Scatternet?**

- A Scatternet is the linking of multiple co-located piconets through the sharing of common master or slave devices.
- A device can be both a master and a slave.
- Radios are symmetric (same radio can be master or slave).
- High capacity system, each piconet has maximum capacity (720 Kbps)
Bluetooth Wireless Market Scenarios

Bluetooth Usage Scenarios in Wireless-Enabled Environments:
- Corporate Office
- Personal Mobile
- Home Leisure

Bluetooth Current Multi-Media Technology & Devices

Bluetooth Current Multi-Media Applications

Applications:
- Automated Vending Machines
- Wireless Transfers
- Digital Camera Printing Kiosks
- and Printing
- MP3 player – Music applications - Video streams and Games
- Transfer of digital media to Bluetooth printers/scanners
- Transfer of digital media for commercial printing
- Concept of mCommerce technology
Bluetooth Future Multi-media Technology

• Automatic collision warning
• Intelligent personal safety
• Wireless in-car entertainment
• Wireless personal safety

Bluetooth Future New Media Technology for Future Bluetooth Integrated Ideas

Tablet PC/Dynasheet
• Reusable paper
• Ebooks

Bluetooth connectivity solution provides data, image, and future embedded video stream for new Media devices/peripherals.

MM Voice Control
• MM Mobility & Comm.
• MM mp3, PDA’s synch.

Integration of Bluetooth enabled PDA’s, headsets, and car-stereo @ Bosch Research enable personal comfort in future multimedia applications.

Analog Cellular Radio

• Pre-cellular trunked radio system
  • Successful services such as emergency dispatch
• 1920s

• 1978 Field trials in Chicago of Bell Systems

• 1980s

AMPS (Advanced Mobile Phone System)
• Deployed in North America

TACS: Total Access Cellular System
• Deployed in Europe
• 900 MHz derivative of AMPS

NMT: Nordic Mobile Telephones
• 450 & 900 MHz versions

Second Generation (2G)

• Digital radio technology
• Added services such as data
• Improved in capacity, voice quality, and spectral efficiency over 1G
• Data rates between 10 & 20 Kbps
• Enhanced telephony features such as caller ID
• Text based messaging “The famous SMS”
• Not suitable for web browsing and multimedia applications
TDMA: Time Division Multiple Access
- 30 kHz channels
- Used in North and South America

CDMA: Code Division Multiple Access
- 1.25 MHz band
- Used all over the globe (started in USA)

PDC: Personal Digital Cellular
- Used only in Japan

2G Technologies (contd.)

GSM: Global System for Mobiles
- Combination of FDMA and TDMA
- Started in Europe
- Uses 900, 1800, 1900 MHz bands
- Bands divided into 200 kHz carrier frequencies
- Each carrier frequency is divided into 8 time slots or channels
- 1995 5.5 million users in 60 countries
- 2000 270 million users in Europe alone!

Wireless Communications Evolution
GPRS: General packet radio service

- An extension of GSM & TDMA toward 3G
- Packet-based data service
  - Supplement to circuit switched network
  - More spectrum efficient
- Improved quality of data service
  - Faster (max of 17.1 Kbps → real 56Kbps)
  - Robust
  - Security support
- Immediacy
  - Always-on connection
- Allow IP-based architecture

GPRS Network

GPRS Network (contd.)
GPRS Applications

- Communications
  - Email
  - Fax
  - Internet Access
  - Unified messaging
- Advertising
- E-commerce
  - Retail
  - Packet purchasing
  - Banking
  - Financial trading
- Location-based Applications
  - Location finder
  - Airline/rail schedules
- Value Added Services (VAS)
  - Information services
  - Games
- Vertical Applications
  - Fleet management
  - Sales-force automation

EDGE: Enhanced Data GSM Environment

- It is an add-on to GPRS
- Method to increase data rates on GSM radio links (384 Kbps)
- Increase spectrum efficiency
- Facilitate new applications

CDMA: Code Division Multiple Access

- It allows frequency reuse
- Security
- Soft Handoff
- Multiple Access Capability
- Efficient power control
Cells and Data Rate in 3G

- **Global**: Indoor 512 Kbps, Up to 64 Kbps
- **Macro-Cell**
  - Up to 144 Kbps
- **Micro-Cell**
  - Up to 384 Kbps
- **Pico-Cell**
  - Up to 2.048 Mbps

Applications:
- Still/Moving Images
- Email
- Electronic Commerce
- Web Browsing
- Chat
- Positioning
- Audio
- File Transfer
- Electronic Commerce

Many others

Applications Along Evolution

- **2G**
  - Simple text
  - SMS
- **2.5G**
  - Richer messaging
  - Enhanced SMS
- **3G**
  - Multimedia Messaging
  - MMS
Is a VISION or CONCEPT to be discussed by governments, research organizations and wireless vendors

No official definition…

4G means different things to different people

4G: What is 4G?

WLANs + 2.5G/3G?

- Mobile on the move
  - Applications: Voice, SMS/E-mail, stock quotes, weather, time-tables, driving directions, bank accounts, yellow pages, delayed flights...
  - High mobility, lower bandwidths
- Semi-Mobile i.e. WLAN
  - Laptop or PDA download of e-mail and files
  - Low mobility, high bandwidths

Some new radio interface (e.g. UWB)?

Some Suggestions

- Use smaller cell size than 3G
- Will be far cheaper than 3G
- Convergence of cellular with IPv6, cable TV, PC, ATM, etc.
- Smooth transition from 3G
- Coexist with 3G and 2G

4G Characteristics