Mobile Technology – An Overview

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Plan of the Talk

- Mobile technology and its benefits
- Mobile technology overview
- Different mobile technologies
  - Cellular networks
  - WLAN(Wi-Fi)
  - WPAN(Blue tooth, Zigbee)
  - WMAN(WiMax)
  - Mobile wireless Broadband
  - IrDA
  - MANET
Mobile technology & its benefits

- Mobile technology is exactly what the name implies - technology that is portable.

**Benefits:**

- It allows user to use it without being tied to a single location.
- It improves the service offered to the users.
- It leads to great flexibility in working.
Mobile technology overview

- Broadcast Networks
  - Television, Radio Networks

- Cellular Networks
  - AMPS
  - cdmaOne
  - GPRS
  - GSM
  - EDGE
  - 0G
  - 0.5G
  - 1G
  - 2G
  - 2.5 G
  - 2.75 G
  - 3G
  - 3.5G
  - 4G

- Non-broadcast Networks
  - Non-cellular Networks
    - Infrastructure Mode
    - Non-Infrastructure Mode
    - WLAN
    - WPAN
    - WiMax
    - WiBro
    - MANET
Data Rates & Coverage Area of various Mobile Technologies

- **Spread Spectrum Wireless LANs**
- **Wireless LAN 802.11b**
- **Wireless Data Networks**
- **Infrared Wireless LANs**
- **Broadband PCS**
- **Metricom**
- **Circuit & Packet Data Cellular, CDPD, RAM, ARDIS**
- **Narrowband PCS**
- **Satellite**

**Data Rates**
- 10 Mbps
- 4 Mbps
- 2 Mbps
- 1 Mbps
- 56 Kbps
- 19.6 Kbps
- 9.6 Kbps

**Coverage Area**
- Local
- Wide
Basic structure of Cellular Network

- **Cells**
- Different Frequencies or Codes

- **Base Station**
  - Fixed transceiver

- **Mobile Station**
  - Distributed transceivers

- **Multiple Access**

- **Downlink**

- **Uplink**

- **Handoff**

- **Cells**
  - Different Frequencies or Codes
Basic Cellular access mechanisms

FDMA (TACS)

TDMA (GSM, DECT)

ATDMA (UMTS)

CDMA (UMTS)

P - Power
T - Time
F - Frequency
Cellular Technology Evolution

- 0G: Mobile radio telephones (PTT, MTS)
- 1G: Analog
- 2G/3G and beyond - digital:

**GSM Family**
- GSM
- GPRS
- EDGE
- HSCSD

**cdmaOne/CDMA2000 Family**
- cdmaOne/IS-95
- WCDMA (UMTS)
- HSPA
- CDMA2000 EV-DO
EVOLUTION
OF
MOBILE COMMUNICATION SYSTEM
(1G, 2G, 3G, 4G)
0G

- pre-cellular mobile telephony technology
- mobile telephones mounted in cars/trucks
- transceiver was mounted in the vehicle trunk and attached to the "head" (dial, display, and handset) mounted near the driver seat.
- Autoradiopuhelin (ARP) launched in 1971 in Finland as the country's first public commercial mobile phone network.
First-generation wireless telephone technology, cellphones.

- 800 MHz band — two 20 MHz bands
- Analog cellphone standards introduced in 80s and were replaced by 2G digital cellphones.
- NMT (Nordic Mobile Telephone), used in Nordic countries, Eastern Europe and Russia.
- AMPS (Advanced Mobile Phone System) used in the United States
- TACS (Total Access Communications System) in the United Kingdom
2G

- Digital data
- Higher voice quality
- Cannot transfer data, such as email or software, other than the digital voice call, and other basic ancillary data such as time and date
- TDMA Based
  - GSM
  - IDEN
  - IS-136 (D-AMPS)
- CDMA Based
  - IS-95 (cdmaOne), PDC
2.75G - EDGE

- For systems which don't meet (or just meet) the 3G requirements
  - CDMA-2000 without multi-carrier
  - EDGE systems (upto 200kbps)
- Enhanced Data rates for Global Evolution
- A method to increase the data rates on the radio link for GSM.
- New modulation technique and new channel coding can be used to transmit both packet-switched and circuit-switched voice and data services.

EDGE is an add-on to GPRS and cannot work alone.
3G

- third-generation mobile telephone technology.
- Data rates upto 3 Mbps
- provide the ability to transfer both voice data (a telephone call) and non-voice data (such as downloading information, exchanging email, and instant messaging).
  - UMTS (W-CDMA)
  - CDMA 2000
  - TD-SCDMA
Migration to 3G

1G Analog Voice
- NMT
- TACS
- AMPS
- 1984 - 1996+

2G Digital Voice
- GSM
- TDMA
- iDEN
- PDC
- CDMA
- PHS
- 1992 - 2000+

2.5G Packet Data
- GPRS
- GSM/GPRS
- (Overlay) 115 Kbps
- 2001+

2.75G Intermediate Multimedia
- EDGE
- 384 Kbps
- 2003+

3G Multimedia
- W-CDMA (UMTS)
- Up to 2 Mbps
- TD-SCDMA
- 2 Mbps?
- cdma2000 1X-EV-DO
- Over 2.4 Mbps
- 2003 - 2004+

Source: U.S. Bancorp Piper Jaffray
4G

- Enhanced Mobile Gaming
  - Experience enhanced wireless capabilities that deliver mobile gaming interaction with latency less than five milliseconds.

- Broadband Access in Remote Locations
  - 4G will provide the first opportunity for broadband access in remote locations without an infrastructure to support cable or DSL access.

- Virtual Presence
  - Use hologram-generating virtual reality programs that provide an artificial presence just about anywhere.

- Personal Media Repository
  - Create a personal media repository that can be accessed from home and on the road to view photos, watch movies and listen to your personal music collection.
Wireless Local Area Networks (WLAN)

- Wi-Fi is the dominant technology for WLANs
- Multiple flavours (802.11a, b, g & n)
- 802.11b was first widespread technology
- 802.11a came along and offered five times higher data rate but it made it expensive to implement combined a/b devices because it used a different frequency range
- 802.11g is the latest technology and it offers the same data rate as 11a, but uses the same frequency as 11b. It has quickly become more popular than 11a as the fast wireless LAN protocol.
- 802.11b is still the least expensive technology, but will eventually be obsoleted by 11g
Typical WLAN architecture

Channel 1
- LAN Backbone
- Access Point
- Wireless Clients

Channel 6
- Access Point
- Wireless Clients
Topologies in WLAN

- **Infrastructure Mode**
  - Access points/BS
  - The mobile node can move while communicating
  - Mobile communicate via access points/BS
  - Needs to install infrastructure before connection setup.

- **Peer-To-Peer (Ad-hoc)**
  - Computer to computer direct radio transmission
  - One computer can act as a gateway to the wired network
  - Need not install infrastructure before connection setup
  - Dynamic topology
WLAN(802.11) Specification

- Large coverage areas of up to a few miles radius
- Support significantly lower bandwidths than their LAN counterparts (up to a few hundred kilobits per second)
- Data rate maximum of 1Mbps, Typical rates 56Kbps
  - Fast (up to 54MB)
  - High Power
  - Long range
  - Single-purpose
  - Ethernet replacement
  - Easily Available
    - Apple Airport, iBook, G4
    - Cisco Aironet 350
## IEEE 802.11

<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>802.11b</td>
<td>11 Mbps</td>
<td>5 Mbps</td>
</tr>
<tr>
<td>802.11g</td>
<td>54 Mbps</td>
<td>25 Mbps (when .11b is not present)</td>
</tr>
<tr>
<td>802.11a</td>
<td>54 Mbps</td>
<td>25 Mbps</td>
</tr>
<tr>
<td>802.11n</td>
<td>200+ Mbps</td>
<td>100 Mbps</td>
</tr>
</tbody>
</table>

Table 1. Comparison of different 802.11 transfer rates (Source: Intel Labs).
Wireless Personal Area Networks (WPAN)

- WPAN primarily meant for networking personal devices (music systems, speakers, microwaves, refrigerators, etc.)
- Small, low-power, short-range, cheap, versatile radios
- Lower data rates and transmission ranges (hence low power)
- Created by Ericsson, IBM, Intel, Nokia, Toshiba
- PAN - Personal Area Network
  - 1-2 Mbps connections
  - 1600 hops per second FHSS
  - Includes synchronous, asynchronous, voice connections, Piconet routing
- Applications
  - Mobile Device interconnection, Cable replacement
  - Small networks
WPAN Technologies

- Bluetooth (IEEE 802.15.1)
- WiMedia (IEEE 802.15.3)
- ZigBee (IEEE 802.15.4)
Bluetooth (802.15.1)

- Introduced in 1998
- Emerging replacement for IrDA to connect peripherals/devices to computers or cell phones
- 2.4 GHz band (crowded)
- Very low power (1mW-100 mW)
- Short range (10m-100m)
- Standard controlled by Bluetooth Special Interest Group (Bluetooth SIG)
- 3 synchronous voice channels (64kbps, Synchronous Connection Oriented (SCO))
- Frequency-hopping for multiple access with a carrier spacing of 1 MHz for 8 devices per piconet. 80 carriers => 80MHz. Collisions when multiple piconets nearby.
Bluetooth Application

- Headset-hands free cell phone (road, office, car)
- 3in 1 Phone-Intercom (no charge), portable phone (fixed line charge), cellular
  - Office- LAN/PSTN, Home- PSTN
- Automatic Synchronizer-background syncs between PC & PDA, Phone & PC. Etc.
- Instant postcard-digital camera send to cell phone
- Interactive Conference-Exchange business cards & data in meetings
- Wireless Workplace-Peripherals connected to your PC or LAN without wires

Mobile telephone to notebook
LAN access point to laptop or palmtop
Wi-Media (IEEE 802.15.3)

- Operates in 2.4GHz with 15MHz bandwidth
- High data rates (11, 22, 33, 44, 55Mbps)
- IEEE 802.15a
  - Higher data rate with UWB technology
  - Data rate more than 100Mbps
- IEEE 802.15c
  - Very high data rate with millimeter wave (57-64GHz)
  - Data rate more than 2Gbps
- Applications - For examples
  - Streaming video and audio
  - Wireless printing kiosk
  - High speed data transfer
ZigBee (IEEE 802.15.4)

- Low Rate WPAN
- Data rate of 250Kbps, 40Kbps and 20Kbps
- CSMA-CA channel access
- Frequency band of operation
  - 16 channels in the 2.4GHz ISM band
  - 10 channels in the 915MHz ISM band
  - 1 channels in the European 868Mhz band
- Low cost, Very low power consumption (no recharge for months or years!), Low latency
- Applications- Monitoring and control
Zig Bee (IEEE 802.15.4) Application

- Home Automation
- Remote Control
- HVAC (Heating Ventilating Air Conditioning Refrigeration)
- Interactive Toys
- Consumer electronics applications
- RFID/tagging applications (supply-chain)
## Comparison of WPAN technologies

<table>
<thead>
<tr>
<th>Feature(s)</th>
<th>IEEE 802.11b</th>
<th>Bluetooth</th>
<th>ZigBee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Profile</td>
<td>Hours</td>
<td>Days</td>
<td>Years</td>
</tr>
<tr>
<td>Complexity</td>
<td>Very Complex</td>
<td>Complex</td>
<td>Simple</td>
</tr>
<tr>
<td>Nodes/Master</td>
<td>32</td>
<td>7</td>
<td>64000</td>
</tr>
<tr>
<td>Latency</td>
<td>Enumeration upto 3 seconds</td>
<td>Enumeration upto 10 seconds</td>
<td>Enumeration 30ms</td>
</tr>
<tr>
<td>Range</td>
<td>100 m</td>
<td>10 m</td>
<td>70m-300m</td>
</tr>
<tr>
<td>Extendability</td>
<td>Roaming possible</td>
<td>No</td>
<td>YES</td>
</tr>
<tr>
<td>Data Rate</td>
<td>11Mbps</td>
<td>1Mbps</td>
<td>250Kbps</td>
</tr>
<tr>
<td>Security</td>
<td>Authentication Service Set ID (SSID)</td>
<td>64 bit, 128 bit</td>
<td>128 bit AES and Application Layer user defined</td>
</tr>
</tbody>
</table>
Wireless Metropolitan Area Network (WMAN)-WiMax

- Wireless Metropolitan Area Network (WMAN) Standard, Broadband Wireless Access (BWA)
- Last mile connectivity, Range up to 50 km
- It provides high speed connectivity that supports data, voice and video
- Fast deployment, cost saving
- IEEE 802.16 specification allows many frequencies and channel bandwidths
  - Anywhere from 2 – 66 GHz
  - Licensed or unlicensed bands
  - 3 – 20 Mhz channel bandwidth
- Specification allows 4 PHYs-SC (single Carrier), SCa, OFDM, OFDMA
  - Interoperability requires options match between equipment
Comparison between fixed and mobile WiMax

- **WiMAX Mobile**
  - Usage: Long-distance mobile wireless broadband
  - Devices: PC Cards, Notebooks and future handsets
  - Frequencies: 2.5GHz
  - Description: Wireless connections to laptops, PDAs and handsets when outside of Wi-Fi hotspot coverage

- **WiMAX Fixed / Nomadic**
  - 802.16d or 802.16-2004
  - Usage: Backhaul, Wireless DSL
  - Devices: outdoor and indoor installed CPE
  - Frequencies: 2.5GHz, 3.5GHz and 5.8GHz (Licensed and LE)
  - Description: wireless connections to homes, businesses, and other WiMAX or cellular network towers
IrDA

- Established in 1993
- Infrared connection (same basic technology as is used in a TV remote control)
- Low power (doesn’t burn battery very fast)
- Cheap
- Requires devices to be in close proximity and lined up
- Very short range (3 - 6 ft)
Mobile Ad hoc Networks (MANET)

- Self-configuring network of mobile hosts may form a temporary network without the aid of any established infrastructure or centralized administration (base station).
- This union forms a random topology.
- Routers move randomly free.
- Topology changes rapidly and unpredictably.
- Standalone fashion or connected to the larger Internet.
- Suitable for emergency situations like natural or human-induced disasters, military conflicts, emergency medical situations, etc.
Typical MANET scenario
Challenges in MANETs

- No centralized entity
- Mobile host is no longer just an end system
- Acting as an intermediate system
- Changing network topology over time
- Every node can be mobile
Applications of MANETs

- Ad hoc conferencing
- Battle fields
- Rural networking
- Emergency services
- Nature disaster areas
- Fleet in oceans
- Historical cites
- Festival ground
Route Discovery in MANETs

Represents a node that has received RREQ for D from $S$. 
Route Discovery in MANETs

- **Broadcast transmission**
- **[S]** Represents transmission of RREQ
- **[X,Y]** Represents list of identifiers appended to RREQ
• Node H receives packet RREQ from two neighbors: potential for collision
Route Discovery in MANETs

- Node C receives RREQ from G and H, but does not forward it again, because node C has already forwarded RREQ once.
Nodes J and K both broadcast RREQ to node D.
Since nodes J and K are hidden from each other, their transmissions may collide.
Node D does not forward RREQ, because node D is the intended target of the route discovery.
Route reply

Represents RREP control message
Data delivery

Packet header size grows with route length
Summary

- Mobile technology is the next step in networking, which makes its more demanding and essential in near future.
- Specifications and applications of different mobile technologies like cellular, wi-fi, bluetooth, zigbee, wimax, etc which are in use at present are discussed in brief.
- Some of the next generation technologies like 4G, WiBro have been discussed.
- In the near future, mobile technologies may become so widespread that you can access the internet just about any where at anytimes without using wires.
Thank you