CS 294-7: Course Overview

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Radio Basics

Wavelength (m)

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Radio Spectrum</th>
</tr>
</thead>
<tbody>
<tr>
<td>10^4</td>
<td>10^6</td>
</tr>
<tr>
<td>10^2</td>
<td>10^8</td>
</tr>
<tr>
<td>10^0</td>
<td>10^10</td>
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<tr>
<td>10^-2</td>
<td>10^12</td>
</tr>
<tr>
<td>10^-4</td>
<td>10^14</td>
</tr>
<tr>
<td>10^-6</td>
<td>10^16</td>
</tr>
<tr>
<td>10^-8</td>
<td>10^18</td>
</tr>
<tr>
<td>10^-10</td>
<td>10^20</td>
</tr>
<tr>
<td>10^-12</td>
<td>10^22</td>
</tr>
<tr>
<td>10^-14</td>
<td>10^24</td>
</tr>
</tbody>
</table>

1 MHz == 100 m
100 MHz == 1 m
10 GHz == 10 cm

Visible Light
R O Y G B I V

< 30 KHz
30 - 300 KHz
300 KHz - 3 MHz
3 - 30 MHz
30 - 300 MHz
300 MHz - 3 GHz
3 - 30 GHz
> 30 GHz

VLF
LF
MF
HF
VHF
UHF
SHF
EHF

Cosmic Rays
Radio Basics

HF Transmission

Ionosphere

Reflected

Absorption

Directional Antenna

VHF Transmission

Line of Sight

Reflected wave interferes with signal
Wireless Spectrum
Radio Telegraphy (also known as “Wireless”)

• Radio technology
  – Communicate with ships and other moving vehicles
  – Messages sprayed into the “ether” crossing natl boundaries
  – Downfall of the nationally supported monopolistic telegraph companies

• 1896: Guglielmo Marconi
  – First demonstration of wireless telegraphy
  – Built on work of Maxwell and Hertz to send and receive Morse Code (first radio broadcasts were digital!)
  – Based on long wave (>> 1 km), spark transmitter technology, requiring very large, high power transmitters
  – First used by British Army and Navy in the Boer War (first research funding by the military!)
  – 1899: Reported to shore America’s Cup yacht races
Wireless

• 1907: Commercial Trans-Atlantic Wireless Service
  – Huge ground stations: 30 x 100m antenna masts
  – Beginning of the end for cable-based telegraphy

• WW I: Rapid development of communications intelligence, intercept technology, cryptography

• 1920: Marconi discovers shortwave (<100 m) radio
  – Longwave follow contour of land
    » Very high transmit power, 200 KW+
  – Shortwaves reflect, refract, and absorb, like light
    » Bounce off ionosphere
    » Higher frequencies made possible by vacuum tube (1906)
    » Cheaper, smaller, better quality transmitters
Other Important Dates in Mobile Radio

• 1915: Wireless voice transmission NY to SF
• 1920: First commercial radio broadcast (Pittsburgh)
• 1921: Police car dispatch radios, Detroit
• 1935: First telephone call around the world
• WW II: Rapid development of radio technology
• 1968: Carterphone decision
• 1974: FCC allocates 40 MHz for cellular telephony
• 1982: European GSM and Inmarsat established
• 1984: Breakup of AT&T
• 1984: Initial deployment of AMPS cellular system
Tradition View of Wireless Communications

• Physical Layer
  – Radio Propagation
  – Modulation Schemes

• Link Layer
  – Media Access
  – Channel Allocation
    » Frequency Division Multiple Access (FDMA)
    » Time Division Multiple Access (TDMA)
    » Code Division Multiple Access (CDMA)
  – Error Coding

• Cellular Telephony
  – Frequency Reuse Schemes
  – Speech Coding
  – Algorithms for Handoff
Topics to be Covered

- Basics of Radio Propagation
- Wireless Media Access
- Wireless Telecommunications Systems
- Wide Area Packet Radio Networks
- Wireless Local Area Networks
- Mobile IP/Wireless TCP
- Mobile Handoff and Network Services
- Security and Authentications
- Mobile Satellite Systems
Effect of Mobility on Communications Systems

- **Data Link Layer**
  - Fading radio channels, characterized by burst errors
  - Reliable communications interrupted by fades

- **Network Layer**
  - Rerouting due to movement

- **Presentation Layer**
  - Source coding for better spectrum efficiency

- **Application Layer**
  - Location dependent applications
Mobile Systems Architecture

This Course

TCP/IP

Mobile/ Wireless Subnet Cntr

Link Controller

Tranceiver Frame Controller

Physical Radio

Non-RT Subnet Control
Routing, QoS
Multicasting
Neighbor Discovery
Pwr Save Modes
Pre-transport cond
Internet-to-subnet routing & addr xlation
Subnet Security
Subnet Mgmt Client
Subnet Measurements

Realtime Subnet Control
MAC-layer sched
Cntl radio char
LL Acks/Nacks
LL Queuing
Xcvr Src/Dst Addr
for link addresses
Routing/QoS cache
table for MH nets
Link Measurements

Continuous framing ops
Frame synch
Zero insertion
Xcvr src/dst/bcast
Xmt/Rcv FIFOs
CRC
ECC
Framing stats

Continuous radio ops
Carrier Freq.
Code Cntl/Scan Phase/
Packet Acquisition
RSSI
Pwr Cntl
Bit & Symbol Rates
Carrier Detect
Capture Detect
Why Mobile Computing?
Natural Evolution of Computing

- More
- Flexible
- Resource
- Usage

- Single User
- OS

- Batch

- Timesharing

- Networking

- LANs + WSs

- Mobile Computing

Freedom from Collocation
Why Mobile Computing? Proliferation of Wireless Services

Yankee Group Forecast

Millions of Subscribers

You are here!

PCS
Cellular+PCS
Why Mobile Computing?
Global Markets for Portable Computers

$ Billions

You Are Here!
Universal Interactor: Adaptation to Services

"Today’s specials are 45 cents off Pepsi"

"Where is the Wonderbread?"

"Lights on"

"Someone’s at the door"

"Smart” Home Infrastructure

Supermarket Information Infrastructure

VCR

Home Security

Stereo

Lighting
The Computer for the 21st Century, Mark Weiser

• Not personal computing, but “ubiquitous computing”
  – Computers so pervasive and so cheap that they “disappear” into the work environment
  – Computers as devices so interchangeable that they can be swapped and shared like pieces of paper
  – Not screen focused, by embedded in the woodwork
The Computer for the 21st Century, Mark Weiser

• Technology that Disappears into the Background
  – Location
    » Ubiquitous computers must know where they are (to adapt to the local environment)
  – Scale
    » Many sizes, suited to the task at hand
    » Tabs, Pads, Boards
    » Potentially 100s of computers in a room
The Computer for the 21st Century, Mark Weiser

- Active Badge System: the value of location awareness
  - Tab sized unit
    - Doors open to right wearer
    - Telephone call directed to nearest telephone
    - Terminals retrieve user preferences

- Pad
  - Notebook sized
  - “Scrap” computers
  - Reverse of windows: many pads per desktop

- (Live) Boards
  - 40 x 60 inch display devices
The Computer for the 21st Century, Mark Weiser

• Technology underpinnings
  – Cheap, low power computers
    » 1 gigop, 16 MB (???) by end of decade
    » 60 MByte disk drives size of matchbook
  – Displays
    » 1000 x 800 pixels, high contrast, weigh only 100 grams
  – Software for ubiquitous applications
    » Limitations of existing windowing software
  – Network
    » New protocols for machines that move space
    » Needs for high bandwidth per cubic meter
    » Multiple interfaces: tiny range wireless, long range wireless, very high speed wired interfaces
The Computer for the 21st Century, Mark Weiser

• So What Ever Happened to Ubiquitous Computing?
  – Some real developments
    » Echelon: a computer in every light switch
    » Personal Digital Assistants (PDA)
    » Lots of computers in my office
  – No killer application for Ubiquitous Computing (or PDAs for that matter)
    » People who use computers are computer users
    » Needed: breakthroughs in user interfaces and usability
  – Is it computers that are ubiquitous or information?
    » The net is everywhere
    » $500 Web computers?