18-759: Wireless Networks

Lecture 1: Organization, History and Applications

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http://www.cs.cmu.edu/~prs/wirelessS10/

Schedule for Today

- Goals and structure of the course
- Administrative stuff
- Wireless technologies
- History
- Exciting Applications

Goals of the Course

- Learn about the unique challenges in wireless networking
  - » Starting point is "regular" wired networks
- Gain an understanding of wireless technologies at the physical, MAC, and higher layers
  - » Focus is on the wireless protocol layer
- Get experience in working with wireless networks
  - » Implementing protocols, algorithms
  - » Measurements of wireless networks
- Get a broad view of the ongoing research in the wireless domain
  - » Focus on the protocol level

Course Contents

- Lectures: unique features of wireless
  - » About 20 lectures on diverse topics
- Surveys of advanced research topics
  - » Critical thinking on exciting current research
  - » Comparison of proposed solutions
  - » Applicability and limitations
  - » Second half of the semester
- Project: team-based, hands-on
  - » More in-depth study of a particular topic
  - » Topic is flexible
  - » Organized as multiple phasis
- Guest lectures

Lectures

- History and applications (today)
  - Why are wireless networks so interesting?
- Challenges of wireless networks (Wednesday)
- Physical layer concepts (4-5)
  - Focus on impact on higher layers
  - Not an in-depth course on the communications field!
- Cellular networks and WiMax (3-4)
- WLAN (4)
- PAN, sensor networks, etc. (4-5)

Surveys

- Last part of the course will deal with advanced topics, that are the focus of current research in the wireless networking.
- Small teams will prepare a survey on a topic based on a small set of papers.
  - Summarize the state of the art
  - Apply critical thinking on the applicability and effectiveness of current proposals
  - Compare different solutions
  - Identify interesting future work
- Surveys will be presented in class and summarized in a short document
  - Work on communication skills

Projects

- In-depth study of a particular topic.
  - Performance evaluation studies, protocol modifications, applications, measurements, ..
  - Must be wireless, but otherwise flexible
  - List of sample topics will be provided
- Strongly prefer hands on projects
  - Real world is quite different from simulation and analysis
- Must carefully consider platform options:
  - Emulator
  - Real-world experiments
  - Simulator based (last resort)
  - Or could compare results in different environments

Prerequisites

- Prerequisites in basic probability, networking, and basic signals, programming
  - Or: 18-345 and 15-213 (or 15-441 as a substitute); 18-396; and 36-217 (36-225 or 36-325 as substitutes)
  - C/C++ and/or Java programming for the project
- Mostly taken by students who want to extend their networking background to wireless
  - Need to make sure you know some signals as the basis for the PHY material
- But, also accessible to students with more of an EE background
  - But need to read up on networking - see reading list
  - Need to consider programming experience as well
- Please fill out information form!

Administrative Stuff

- "Wireless Communications and Networks", William Stallings, Prentice Hall, 2002
  - Will not cover all the material in the book
  - Not all material is in the book - slides are fairly detailed
  - Some slides taken from various sources
  - Special credit to Dina Papagiannaki for many contributions
- Web page is primary source for information
  - May use blackboard for submission of assignments
- Course secretary: Angela Miller, Gates 9118, amiller@cs.cmu.edu
- Teaching assistant: Fahad Dogar and Anand Poovekurussi

Grading

Grade distribution:

- Homework: 10%
- Project: 25%
- Survey: 15%
- Exams: 50%

Collaboration

- Traditional rules of collaboration apply
  - http://www.cmu.edu/policies/documents/Cheating.html
- You must complete individual assignments and tests by yourself
- You must collaborate with your partner in the team-based project and survey assignment
- It is acceptable and encouraged to help fellow student with generic problems
  - E.g. where to find documentation, use of tools, ..

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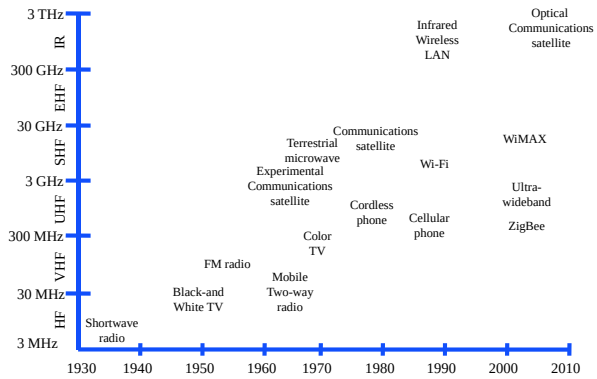
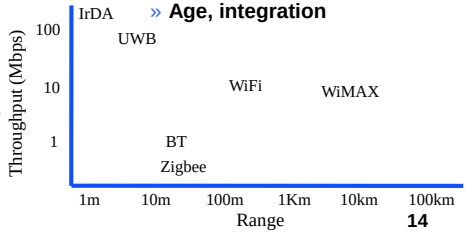
Wireless Technologies



Why so many?

- **Diverse application requirements**
  - » **Energy consumption**
  - » **Range**
  - » **Bandwidth**
  - » **Mobility**
  - » **Cost**
- **Diverse deployments**
  - » **Licensed versus unlicensed**
  - » **Provisioned or not**
- **Technologies have different**
  - » **Signal penetration**
  - » **Frequency use**
  - » **Cost**
  - » **Market size**
  - » **Age, integration**



Some History…

- **Wireless telegraph invented by Guglielmo Marconi in 1896**
- **Tesla credited with first radio communication in 1893**
- **First telegraphic signal traveled across the Atlantic ocean in 1901**
- **Used analog signals to transmit alphanumeric characters**

Satellites

- **Launched in 1960**
- **First satellites could carry 240 voice circuits**
- **In 1998 satellites carried:**
  - » **1/3 of all voice traffic**
  - » **All television signals between countries!**
- **Modern satellites induce 250 ms propagation delay**
- **New ones in lower orbits can allow for data services such as Internet access**
- **Throughput of 100s Mbps (http://www.viasat.com/news/md1366-disa-certified-ebem-satcom-modem-establishes-new-high-throughput-exceeding-200-mbps-xtar)**

Mobile phones

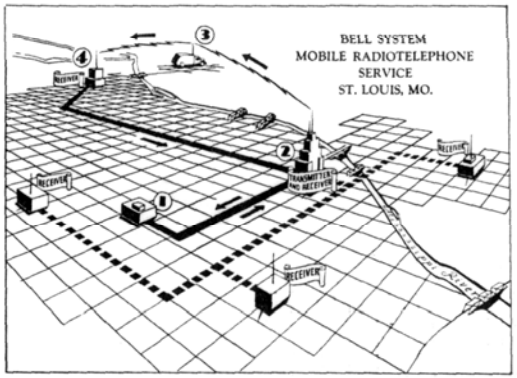
- 2-way 2-party communication using digital transmission technology
- In 2002 the number of mobile phones exceeded that of land lines
- More than 1 billion mobile phones!
- The only telecommunications solution in developing regions
- How did it all start?

The origin of mobile phone

- America's mobile phone age started in 1946 with MTS – weighing 40 Kg!
- First mobile phones very bulky, expensive and hardly portable
- Operator assisted with 250 maximum users

The MTS network

http://www.privateline.com/PCS/images/SaintLouis2.gif



The cellular idea

- In December 1947 Donald H. Ring outlined the idea in a Bell labs memo
- Split an area into cells with their own low power towers
- Each cell would use its own frequency
- Did not take off due to "extreme-at-the-time" processing needs
  - » Handoff for thousands of users
  - » Rapid switching infeasible – maintain call while changing frequency

… the remaining components

- In December 1947 the transistor was invented by William Shockley, John Bardeen, and Walter Brattain
- Why no portable phones at that time?
- A mobile phone needs to send a signal – not just receive and amplify
- The energy required for a mobile phone transmission still too high for the high power/high tower approach – could only be done with a car battery

… and the regulatory bodies

The FCC commissioner Robert E. Lee said that mobile phones were a status symbol and worried that every family might someday believe that its car had to have one.

Lee called this a case of people "frivolously using spectrum" simply because they could afford to.

From The Cell-Phone Revolution, AmericanHeritage.com

DynaTAC8000X: the first cell phone

The "brick":
- weighed 2 pounds,
- offered 30 mins of talk time for every recharging and
- sold for $3,995!

It took 10 years to develop (1973-1983) and cost $100 million! (delay due to infrastructure)

Size primarily determined by the size of batteries, antennas, keypads, etc.

Today size determined by the UI!

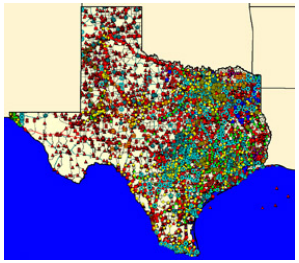
Dr. Martin Cooper of Motorola, made the first US analogue mobile phone call on a larger prototype model in 1973

Cellular Landscape

THEN

- First complete cellular system (not handheld) deployed in 1978 in the suburbs of Chicago.
- The system had 10 cells, each about a mile across
- With 135 custom-designed car phones.

NOW

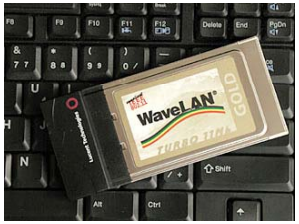


A map of cell-phone towers in Texas as of 2005, with different colors representing different companies.

How about WiFi – a little history

Wavelan at 900MHz
1 Mbps throughput

PCMCIA form factor make Wavelan more portable



WiFi in laptops

- Antennas placed on the frame of the screen
- Mini-PCI format allows for full integration
- Latest radio technology may feature up to 3 antennas

Food for thought

- How large will tomorrow's mobile devices be?
- How many wireless interfaces will they have?
- Will they have any of the interfaces we use today?☺

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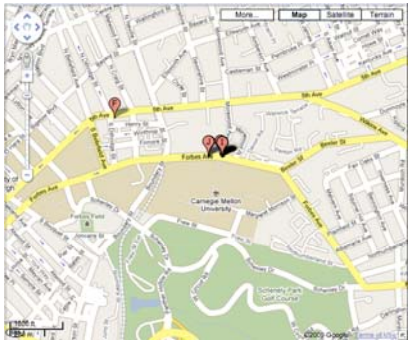
What do we use wireless for?

- Limited set of "special" users … everyone
  - » Broadcasting, emergency services, etc.
  - » 10s .. 100s of devices per person
- Device to infrastructure … people to people … device to device
  - » Broadcasting, Internet access
  - » Phone calls, social networking, …
  - » Sensor networks, health, …
- Special-purpose applications … wired link replacement … wireless application market
  - » Often single-use devices
  - » Make application/protocol work over wireless
  - » Wireless only applications for multi-purpose devices

Cellular applications

- The first killer application – SMS text messaging
- Then ring tones…
- Now replacement for landlines…
- … and with data communication a dominant use
- Always-on connectivity…
- … while on the move

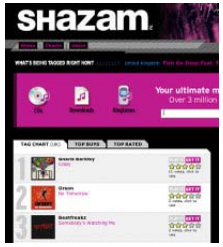
Googlemaps



Localization through GPS

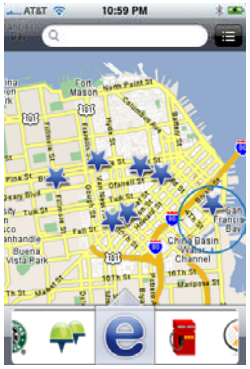
Shazam

- Song discovery using the web



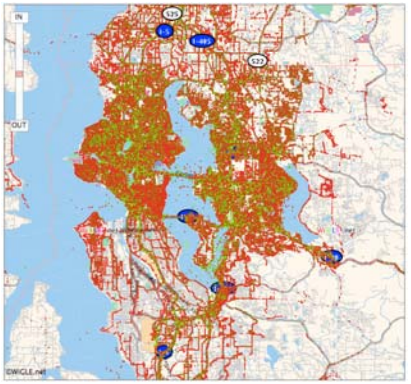
Where

- Find where your friends are – Where, Whrrl, Loopt

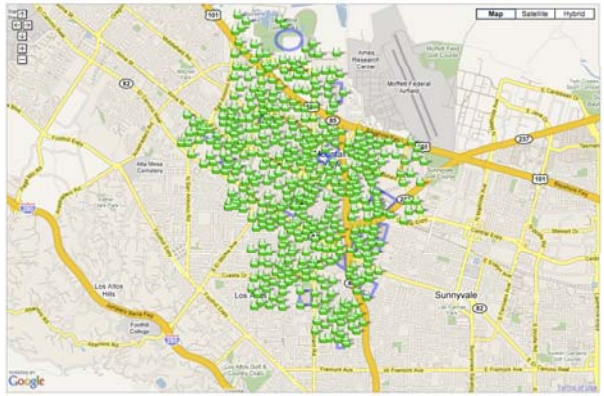


WiFi applications

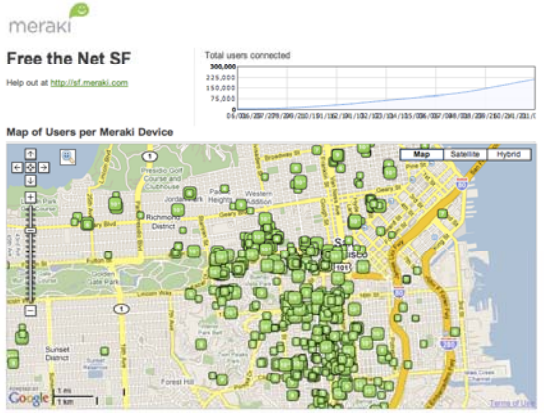
- Wireless access to the Internet!
  - In home
  - Through hotspots
  - While on the move…
- Seattle map through wigle.net



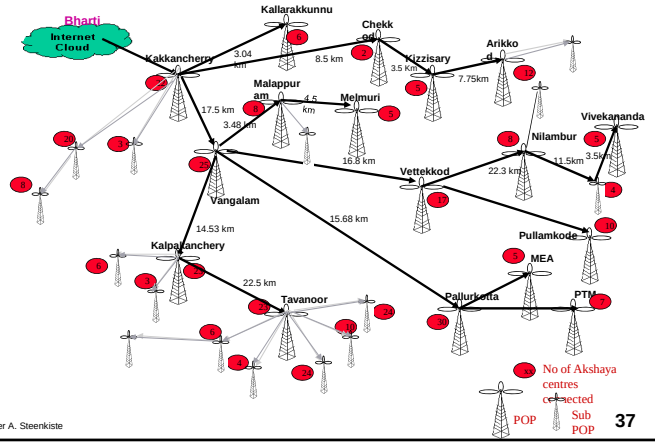
Google WiFi Network in CA



Free Internet access through mesh WiFi



WiFi in developing regions

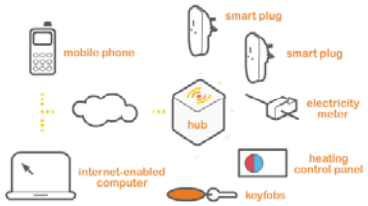


Home security and energy mgmt through WiFi (AlertMe)

http://www.alertme.com/home-security/

No wiring needed!
Security sensors communicate through WiFi

Smart plugs allow for energy consumption monitoring



http://www.alertme.com/energy-saving/

Vehicle to vehicle communication

- The motorcycles form and ad hoc WLAN
- The system continuously monitors the position, speed, distance and direction of surrounding road users, even in conditions of darkness and poor visibility.

- Data is centralized and sent to the drivers to warn them of traffic conditions ahead
- Motorcycle riders can view information on a display, and receive safety warnings through advanced interfaces such as an in-helmet audio system

Future?

- 60 GHz for in-home entertainment
- Software defined radios

From http://www.springerlink.com/content/9202x47k06358x8v/fulltext.pdf

Rest of the course

- Challenges in delivering wireless networking solutions (physical layer, protocols, and supporting infrastructure)
- How things work and limitations
- Current research topics that will enable more uses

References

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