CS 294-1: Special Topics: Mobile Computing and Wireless Networking

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Lecture 2
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Outline

- Administrivia
- Class Projects
- Technology changes since the papers were written
- The Challenges of Mobile Computing -- Forman, Zahorjan
- The Computer for the 21st Century -- Mark Weiser
- Wireless Personal Communications: what is it? – Cox
- We covered ICEBERG last week

Administrivia

- Sign up with majordomo for class list
- Password for external access to papers is ……
- Any problems with papers on the web?
- Scribe for today

Class Projects

- Start thinking about class projects:
- Projects will be two or three person teams
  - If the class remains large, 3 person teams will be required
- Projects should include a detailed technical investigation of a topic
  - Including background literature searches, and
  - An in-depth analysis of the existing situation, either the simulation of or the construction/modification of a demonstration system, and a detailed analysis of the simulation on system results

Class Projects (cont'd)

- Basically you can pick any project topic you want, subject to four constraints:
  - Related to the course topics, addresses significant issues, and is substantial in size
  - Related to the course topics generally means that the project must address an issue or topic discussed during the course or an area that is related to the coursework, but is not discussed
    - Example: you can use a project from your research if the project addresses an issue or problem in the the area of mobile computing or wireless networking

Class Projects (cont'd)

  - Significant issues generally means that performance and functionality are major constraints in the design
    - Other issues include security, complexity, and administrative complexity
  - Substantial size means system construction/modification projects should involve a system that is approximately 10k lines of code or larger
    - Smaller code bases may be acceptable if the problem domain is complex (e.g., an internet router)
    - Simulation projects should involve the construction of a simulation for significant portion of a system or protocol

Class Projects (cont'd)

- For those of people who are not currently working on a relevant research project, a list of project ideas will be posted (very soon) on the course web page
- Other examples from ICEBERG:
  - http://iceberg.cs.berkeley.edu/iceberg-projects.html
- Lots of related projects in:
  - Ninja, OceanStore, Telegraph, Smart Dust, etc.

HW changes since papers were written

- Basestations are smaller and cheaper
  - $299 for Apple airport, SW-based cellular micro-basestations
  - Cell management more difficult: it still takes months to do the site analysis/procurement for antenna/cell placement
- 802.11 standard: using one device to interact with several wireless networks
- Faster CPUs:
  - 1GHz PIII, power consumption high: 10's of watts
  - Low power alternatives
    - StrongArm, Transmeta: 200 Mhz, 450mW

More HW changes

- Battery improves much slower than CPU :
  - 2x every 5 to 10 years while CPU power doubles every 18 months
- RAM: 8MB on PDAs, 256MB(!) on laptops
- Fixed storage (disks):
  - 16GB(!), but very fragile (no backup)
- Display:
  - Megapixel display 15 inches, 16/24 bit display, high resolution small display 1-2 bit (saves power)
  - Display power consumption is second highest, right below that of processor

Software Changes

- New Mobile IP Standard without route optimization
  - Has triangle routing problem (indirect communication through mobile's home agent every time, instead of direct between sender and mobile)
- Proxy computing
  - TranSend (UC Berkeley/ProxiNet)
- Ubiquitous computing:
  - Computers everywhere (Palm Pilot PDA, XEROX tab, pad, liveboard)
  - Internet walls in hotels, portals in Soda halls
  - But not exactly everywhere yet

Different devices, Same story

- Changes in HW mean the issues move from laptops to handhelds
  - Limited power (AA or AAA cells)
  - Limited RAM
  - Limited stable storage
  - Small displays
- Changes in SW mean more complex functionality and UIs
  - Speech recognition

5-minute Break

The Challenges of Mobile Computing -- Forman, Zahorjan

- Nature of wireless communication is disconnections, why?
- Disconnection:
  - Network failure is of greater concern for mobiles
  - Disconnection causes loss of service/data availability
  - Techniques dealing with disconnected operations are asynchronous operations rather than mechanism like synchronous RPC, prefetching, delayed write back

Disconnection Issues

- The goal is to decouple the communication from the actual time a program consumes or produces data
- Ex: Coda file system
  - Made the observation that write conflicts are very rare, so it trades consistency for availability
  - Coda hoards the data (whole file) based on user profile on notebook's onboard cache, emulates server upon disconnection, and reintegrates or reconciles with replicated master repository upon reconnection

Low Bandwidth Issues

- Wireless networks delivers lower bandwidth than wired network
  - Will always be the case! Why?
- Software Solutions:
  - Data compression, caching, proxy computing, prefetching, background processing
  - Ex: buffering can be used to reduce the burstiness of the network (trade off is increased latency)

HW Solutions to Low BW Issues

- Add more cells by overlapping cells, each cell with different frequency range
  - Does NOT scale due to scarce frequency spectrum resources
  - An advantage is the flexibility of allowing software to allocate bandwidth
- Shorten range of cells
  - Simpler, reduce power consumption because of lower transmission intensity within a short range, less interference
  - But it requires more hardware equipments and their management, will be easier to deploy once equipments get cheaper
    - A side note, more aggressive power saving can be done by power adaptation between handset and base station, there is tradeoff of fine grained and coarse grained negotiation

Heterogeneous Networks

- Vertical handoff
  - A mobile is able to access several heterogeneous networks at the same time, switch to the best network interface based on connectivity and bandwidth
  - The next generation vertical handoff will incorporate policies when deciding which network to switch to
  - The policies include tradeoffs among cost, latency, bandwidth, traffic load, etc
- But, we need mobility support

Mobility

- Address migration
  - There are four mechanisms broadcast, central services, home base, and forwarding pointers
- Location dependent information
  - Location dependent queries/alerts on local name server, printer, current time zone, closest gas station
- Issue of privacy -- one can be traced
  - Is this good or bad?

Security Risks

- All the information is in the air, much easier to intercept
  - Not as true for Infrared systems
- Requirement for strong encryption
- But, what about law enforcement?

Portability: Power consumption

- SW power mgmt
  - Turn device down if idle (e.g., spinning down disk, turning off screen light)
- HW solutions
  - Reduce capacitance through VLSI solutions, reduce voltage, reduce clock frequency

Portability: Fragile data on laptop

- Can be mitigated by depending on the laptop less, turn it to a terminal/thin client (e.g. XEROX tab), and rely on servers
- But this will increase the load to networking (more QoS and bandwidth issues)
- Server overloading can be mitigated by sending deltas (changes) instead of whole file, or reconstructing executable, or rate controlling through buffering

Portability

- Small UI
  - Pen based, voice recognition, hand recognition
- Limited storage capacity
  - Weighted storage vs. availability
  - But, capacities are growing

Discussion

- Apple Newton vs. Palm Pilot
  - Why did Pilot succeed or why did Newton fail?
- Pilot:
  - Smaller size, better extensibility, and it does a small number of things well
  - Adapts computer to people rather than the reverse
- What is mobile end point:
  - Phone, laptop, or PDA
  - Future cellular phones will download Java code

The Computer for the 21st Century -- Mark Weiser

- Mark Weiser: true visionary
  - What do we want computing to be?
- Ubiquitous!
  - Highly integrated in our lives, not noticeable, subconscious computing
  - Not the kind of computing that adapts people to computers, like virtual reality and Apple Newton
- Created three kinds of computing devices:
  - Tab (button size), pad (paper size, 200dpi, $10k), liveboard (white board size)

Example: Motors

- Small motors enabled major changes
- Today it's small CPUs
- Consider the automobile
- How many motors?
- How many CPUs?
- What about interconnections between both?
  - Good or bad?

Requirements

- Low cost, low power, mass producible, pervasive network
  - Unnoticeable computers need to be able to connect to a server on the network for different services
- Software support is the main issue, and not sufficient yet
  - Goal: microkernel on tiny devices that dynamically connects to the network infrastructure

Example: A Responsive Environment

- Brightness of the light in the room will be adjusted automatically and dynamically according to the daylight
- Your *active* ID-badge indicates your identity (and your preferences)
- System knows your current location, and light turns on as you enter a room, and the seat you are sitting on is adjusted to your size
- Great?

What are the Limits?

- How much functionality should be pushed to computers (and to background) without people realizing it is a computer world?
- Problems manifest themselves when computers crash
  - E.g., lights do not turn on when you enter a room, or cardkey doesn't open door, or computerized toast burned your bread, or your home is robbed because the computerized door lock has a fault
- Where haven't you discovered that there isn't a computer?

Challenges

- Technology
  - Cheap computers and display (here)
  - Large displays (almost here)
  - Fast CPUs (here)
  - Large storage (here)
  - Operating systems for UbiComp (almost here)
  - User interfaces (not quite yet)
    - WindowsCE? PalmOS?
  - Networking (almost here)
    - Bluetooth?

Social issues

- Privacy and security can be easily violated
  - Use of mobile phone can identify which cell you are in, for emergency purpose, it is required to locate you within a few hundred yards
- Means you can be tracked by some bad guys as well
- By putting computer into background, it can improve social interactions between computer geeks and society?
- In a CSCW (Computer Supported Collaborative Work) environment, it loses the visual cues, some cues need to be added back in

Discussion

- What do you do with a networked PDA ?
- iMode: instant messaging with all your friends
- Network video game, web surfing, email -- anything but paying attention to lectures

5-minute Break

Wireless Personal Communications: what is it? -- Cox

- Paper classifies the current wireless technology into six groups:
  - Cellular mobile radio systems, paging/messaging systems, cordless telephones, wide area wireless data systems, high-speed wireless local-area networks, and satellite-based mobile systems
- These six groups differ in the applications and the mobility they support

Evolution

- Prediction that these six groups will evolve toward three groups:
  - High-tier PCS, high-speed wireless LANs, and low-tier PCS (an evolution from several current groups)
- *Satellite*, cellular, and *paging/messaging* have merged into high-tier PCS
  - Short Message Service (1B msgs/yr!)
- Overlap between cordless telephones and high-speed wireless LANs: low-tier PCS
  - VoIP wireless phone from Symbol, Bluetooth
  - DECT phones in Europe (everywhere! Offices, hotels)
- Wide-area wireless data: Metricom

High-tier versus low-tier PCS

- Capacity and quality
- The high-tier PCS provides higher quality, but lower capacity, costs more and consumes more power, also supports vehicular speed
- The low-tier PCS provides higher capacity, but lower quality, and supports only walking speed, it costs less and consumes less power
- Low tier and high tier PCS can be combined
  - Ex: a low-tier PCS can be installed on a train communicating with high-tier PCS
- Proposes using the low-tier PCS's air interface instead of the high-tier PCS's to connect the low-tier PCS with the high-tier PCS
  - Example: in-building GSM (GSM on the Net)

Good Ideas

- Reducing the cost of providing packet data service
  - By sharing the costs of base stations with the better-established and higher cell-site capacity of the voice cellular systems
- CDPD is an example
  - Overlaid on spare analog cellular channels
- Not successful (at first):
  - Data hops from channel to channel as voice calls arrive
  - Leads to lots of retransmissions and very poor performance
  - Also, bad pricing model ($/packet)
- Today:
  - Fixed channels allocated
  - Flat pricing model

Wireless LANs

- 900 Mhz ISM band has had little success
  - WaveLAN one of the biggest
- 2 Ghz ISM band has had better success
  - Apple Airport: $299 for a basestation
  - Laptops with built-in networking
- Bluetooth
  - Will it be successful? Will it ever arrive?

Discussions

- In Northern America, there are many standards:
  - AMPS, FDMA, TDMA, CDMA, GSM
- But in Europe (and the rest of the world), there is a single standard, GSM
  - >180 countries and >200 million people

Which is better?

- GSM is good for voice, but high latency for data
  - One phone works for all
- But in Northern America,
  - One cellular phone does not work at a different service provider if it is using a different standard
  - Nonetheless, many standards encourages market competition, and technology advancement

What Kind of End Device is Desirable?

- Nokia Communicator is cellular phone plus PDA
  - It did not succeed because it is too big as a phone
- People like to accessorize!
  - Mostly likely people will carry more than one devices with them instead of a single device with all the functionalities

Centralized Intelligence vs. Distributed Intelligence:

- Good to scatter intelligence in network and among base-stations to achieve scalability
  - Avoid bottleneck at the centralized intelligence
- Dumb end device vs. more intelligent ones
  - Question of putting complexity into the network infrastructure or at the end device

Intelligence Tradeoffs

- Complex end devices shorten battery life, and are more costly
- But, caching can be used to save transmissions to save some battery power and because the communication is the bottleneck in wireless communication
- Cost is not really a problem since processing power is cheaper and cheaper

Network Challenges

- Can we build one network that integrates both voice and data?
- The big question here is what are the tradeoffs and design decisions in architecting a system for voice instead of data
  - Each has very different characteristics

Voice vs. Data

- Voice
  - Continuous, real-time, requires low latency, and therefore requires Forward Error Connection (FEC) because it cannot wait for retransmission
  - Usually transported in a connection oriented way
  - Needs full duplex channels

Voice vs. Data

- Data
  - Data traffic is bursty, reliability relies on retransmission, no need of FEC
  - It is transported in a connectionless fashion
  - It does not require duplex channels
- CDPD exploits the cellular infrastructure to transmit data
  - But data is second class citizen, and only get transmitted when there is an idle voice channel

What is the wireless killer application?

- Instant messaging?
- 10 million iMode users in Japan in 18 months
- > 1 Billion SMS messages/year worldwide
- Location dependent services?
- Do we really need both the high-tier PCS and the low-tier PCS?
  - The question here is what is the functionality mismatch