Lecture 20: Future trends in mobile computing

Mythili Vutukuru

CS 653 Spring 2014

April 7, Monday

Future topics

- Improving capacity
  - Dynamic spectrum access
  - Massive MIMO
  - Heterogeneous networks
- Pervasive computing
  - Internet of things
  - NFC / RFID
  - Smartphones and wearable computing
- Other issues
  - Energy efficiency
  - Security and privacy

Cognitive radios, dynamic spectrum access in TCP white spaces

- The general idea of a cognitive radio – identify what spectrum is free, and adapt its PHY parameters suitably.
- A concrete realization of this idea is the recent concept of "TV white space networking"
  - There are unused portions of the spectrum in the TV frequency bands
  - This is low frequency spectrum that has much better propagation characteristics
  - The idea is to opportunistically use the free spectrum, without hurting the "primary" TV user.
  - Challenges – spectrum sensing, coordinating among transmitters and receivers to agree on the available spectrum to use, coexistence of multiple such "secondary" networks operating in the spectrum.

Massive MIMO

- The idea of placing multiple antennas at transmitters and receivers to linearly scale capacity is gaining popularity.
- Recap: multiple antennas placed close to each other at transmitter and receiver can be used to send multiple streams of data in parallel (multiplexing mode), or improve the rate of single stream (diversity mode).
- What limits the number of antennas?
  - Cost: each antennas costs extra hardware to process the radio signals to/from it
  - Form factor: spacing between antennas is half a wavelength. Makes is cumbersome, especially at lower frequencies (higher wavelengths)
- WiFi with 4 antennas is coming soon, 8 or more antennas likely in near future
- Since MIMO is mostly used for higher frequencies, propagation range is lower, so suitable for smaller (indoor) networks.

Heterogeneous networks

- The idea of stitching together multiple networks for connectivity, instead of just one network.
- Examples
  - LTE femto cells. Small “base stations” that serve a high-density environment like a building, stadium etc. The users are handed off to the “macro” cell when they go out.
  - WiFi offload of 3G/4G data traffic. Automatic authentication of WiFi, and seamless handoff to 3G when out of WiFi coverage.
- Different network designs for different use cases (e.g., massive MIMO for indoors vs. normal base stations for outdoors)
- Challenges
  - Configuring multiple networks so they don’t interfere
  - Seamless migration between networks

Internet-of-things and sensors

- Currently, most end hosts on the internet are people. They could be mostly machines in the near future.
- The vision of Internet-of-things: many objects have sensors that communicates over the internet (WiFi / cellular data) and can be monitored continuously. Examples:
  - Smart grid and smart meters
  - Home automation
  - Health monitoring
  - Environmental monitoring
- This is also called machine-to-machine (M2M) communication
- Challenges
  - Can current communication infrastructure scale when billions of machines talk over the internet?
  - What is the hardware and application platform to enable cheap deployment of these sensors?

NFC-based applications

- Near-field communication (e.g., based on RFID) can enable many applications in the future
  - Mobile payments
  - Inventory management
- Challenges
  - Scaling operation (e.g., reliably scan a cart of items once at checkout)
  - Lower costs (so that it is feasible to put an RFID tag everywhere)

Smartphones / Wearable computing

- More complex applications on smartphones beyond simple personal use
- Harness power of remote computing and code offload
- Smartphone / tablet as the general computing platforms for applications such as inventory monitoring, medical records etc.
- Better UI – gesture tracking, improved voice recognition, virtual reality
- Smaller form factor => wearable computing
- Lots of personal data streaming => can be harnessed for personalized experiences

Security and Privacy

- Localization techniques getting more accurate => users are always being tracked
- Applications trying to capture personal information for personalized ads and other things (sometimes in stealth)
- How to get personalized experiences without compromising privacy?
- Privacy-preserving computations and databases

Power and energy

- The idea of energy harvesting: harvest power from ambient signals such as cellular and TV signals.
- Other advances in energy such as wireless power.
- Better energy efficiency of networking protocols + advances in battery technology => longer periods of power for wireless devices
- Energy efficiency especially important for sensor networks