Emerging Research Challenges in the Era of IoT

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IoT for Emergency Response

Infrastructure

- Erdogan used FaceTime to reach out during military coup in Turkey (July 2016)

Infrastructureless

- 6 millions people without power for two weeks in South Florida (Nov. 2005, hurricane Wilma)

Evolution of Smart-Phone Based Emergency Communications Network (NSF project)
Theoretical Foundations: Autonomous IoT

Approximate computing
- Energy- and accuracy-aware
- Online vs. offline
- Local vs. global algorithms

Local algorithms
- Local interactions with global properties
- Minimizing state information
- Adaptive to changes
- Implicit coordination

What can be efficiently and locally computed?

E.g. Virtual backbone coverage & connectivity

Marking process: A node is marked if it has two unconnected neighbors

Good performance for geometric graphs

ICCCN'16 IoT Panel
Human-in-the-loop: Crowdsensing

- Crowdsourcing: crowdsensing
  - Security, privacy, and trust

- Things (Intelligent IoT)
  - Smarter Than You Think

- Who is smarter?
  - Human, things, or a combination of both?

1997 (Chess)
- Kasparov vs. Deep Blue

1998
- Kasparov vs. Topalov: 4:0
- Kasparov + machine vs. Topalov + machine: 3:3

2005 (Freestyle tournament)
- Grand-master (>2,500)
- Machine (Hydra)
- Grand-master + machine
- Amateurs (>1,500) + machine *

2016 (Go game)
- AlphaGo vs. Lee Sedol: 4:1

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Energy-Related Technology

Wireless Energy Transfer & Battery Free Devices

Energy from RFID reader
Achieving average accuracy of 97% for distances of up to 2.5 feet (outdoor) and 1.5 feet (NSDI’14)

Energy from Wi-Fi signal
Achieving rates of 1 kbps and ranges of up to 2.1 meters (SIGCOMM’15)

Energy from TV tower
Achieving rates of 1 kbps over distances of 2.5 feet and 1.5 feet (SIGCOMM’13)

Energy from visible light
600 bps is achieved at 2 meters (airXiv’16)
Applications in US Ignite for Smart City

- Safety surveillance system on campus police

Key features

- Use 3D cameras (e.g. Kinect) for monitoring
- Supercluster backend for video surveillance
- QoS-based rate adaptation
- Secure data transmission and data sharing

Mobility-Enhanced Public Safety Surveillance System using 3D Cameras and High Speed Broadband Networks (NSF project)
Advanced Wireless Research Initiative

Exciting news
- $400M: next seven years
- FCC Spectrum Frontier: open up spectrum bands
- 21 companies

Applications
- Environmental sensing
- Telemedicine
- Autonomous vehicles
- Immersive communications

Future
- 200B connected devices globally by 2020
- 1000x improvements

Technologies
- mmWave
- Dynamic spectrum sharing
- Network virtualization (SDN)
- Mobility-at-scale
- ...

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