

Wi-Fi Access Point as a Sensing Platform

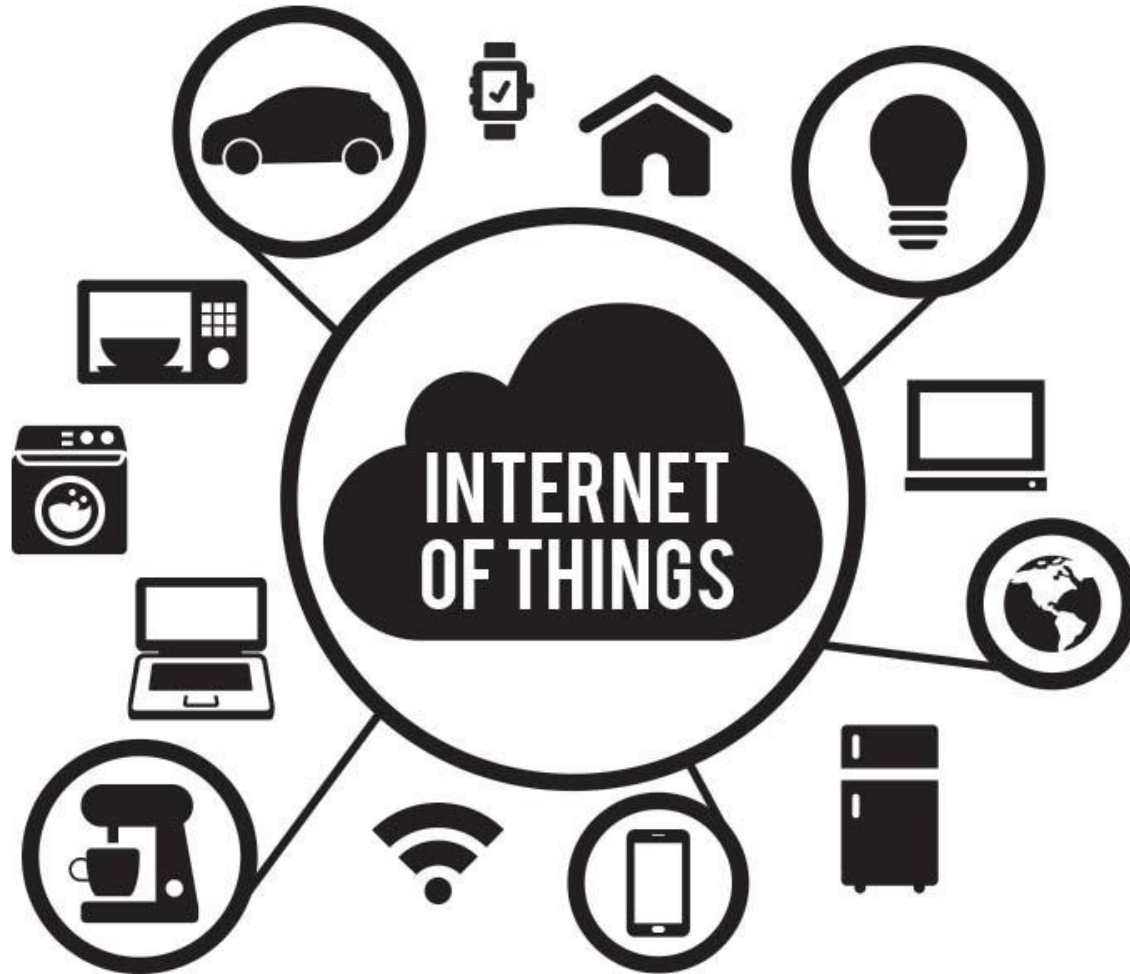
Milad Heydariaan and Omprakash Gnawali

University of Houston, Networked Systems Laboratory

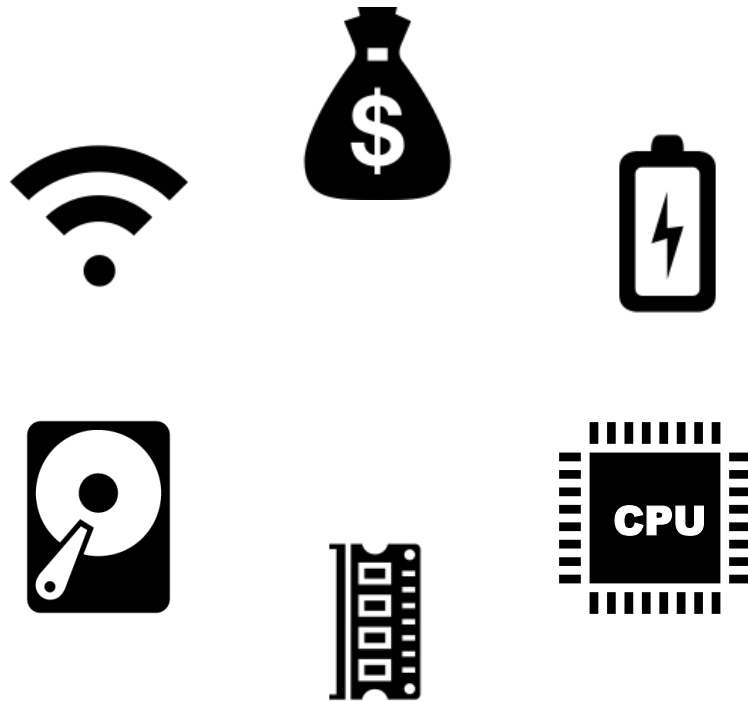
Contact: milad@cs.uh.edu

December 6, 2016

Internet of Things – Sensors Everywhere



IoT Sensor Node Architecture



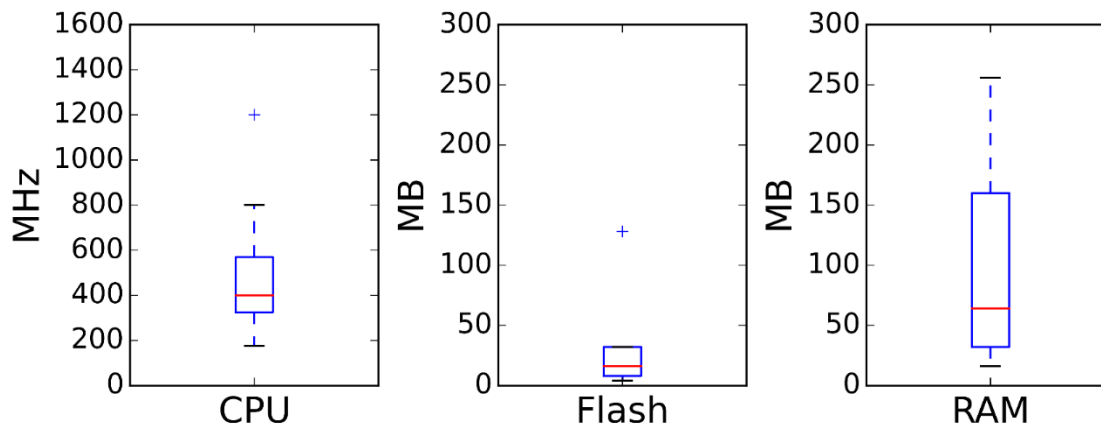
Use Wi-Fi AP as host node for sensors?

Rationale:

Over-provisioning and underutilization
of resources

Over-provisioned Computation Resources

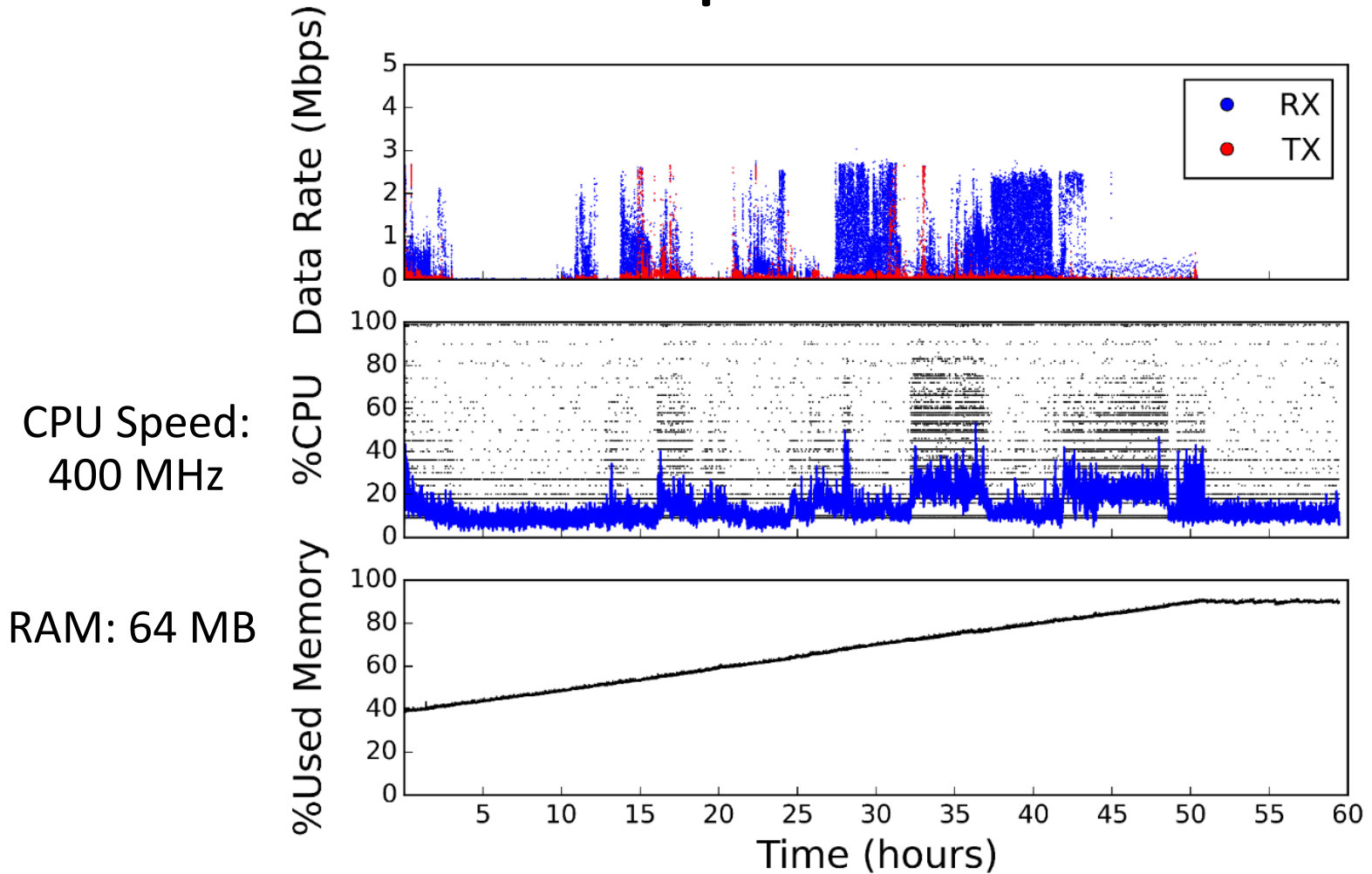
- 521+ million home Wi-Fi AP by the end of 2015 (Strategy Analytics Inc.)
- 1000+ types of routers with OpenWRT support (openwrt.org)



Interface	Availability
USB	100%
Serial	85%
JTAG	50%
Unused GPIO	20%

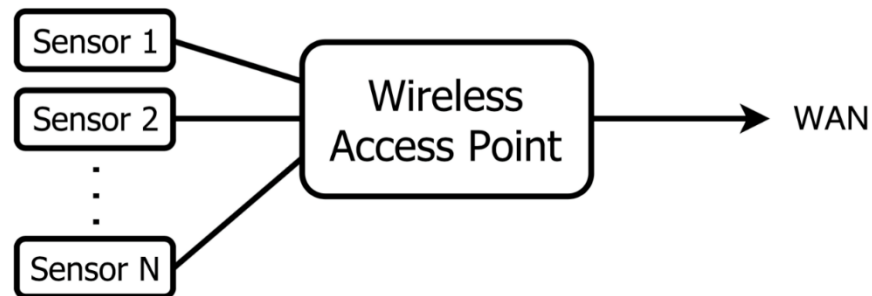
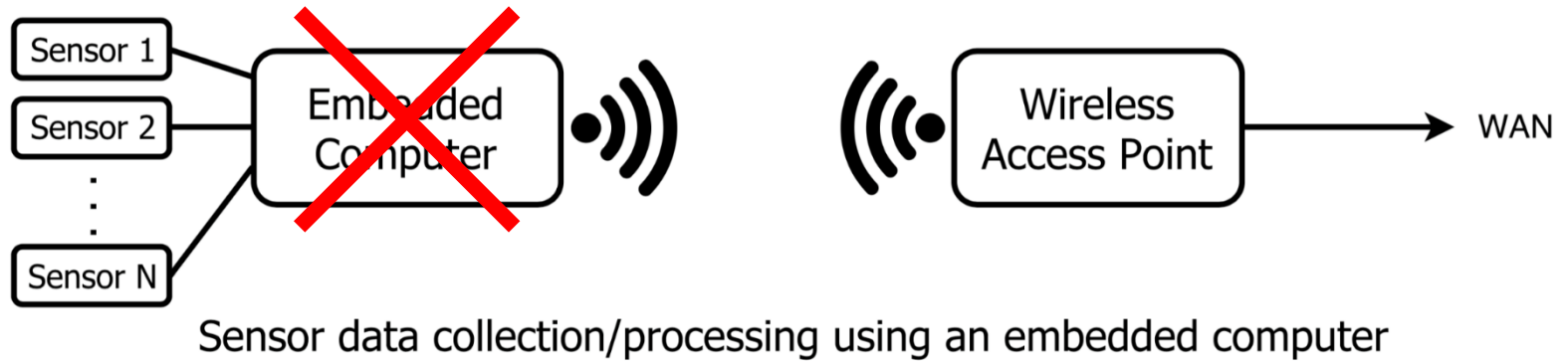
OpenWRT-supported routers are over-provisioned

Underutilized Computational Resources



Home Wi-Fi AP resources are not fully utilized.

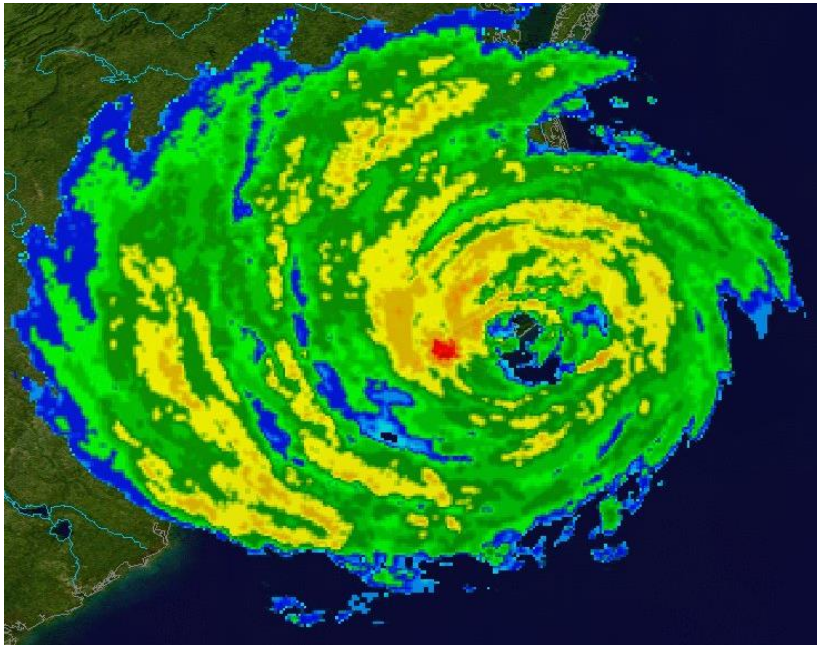
Idea



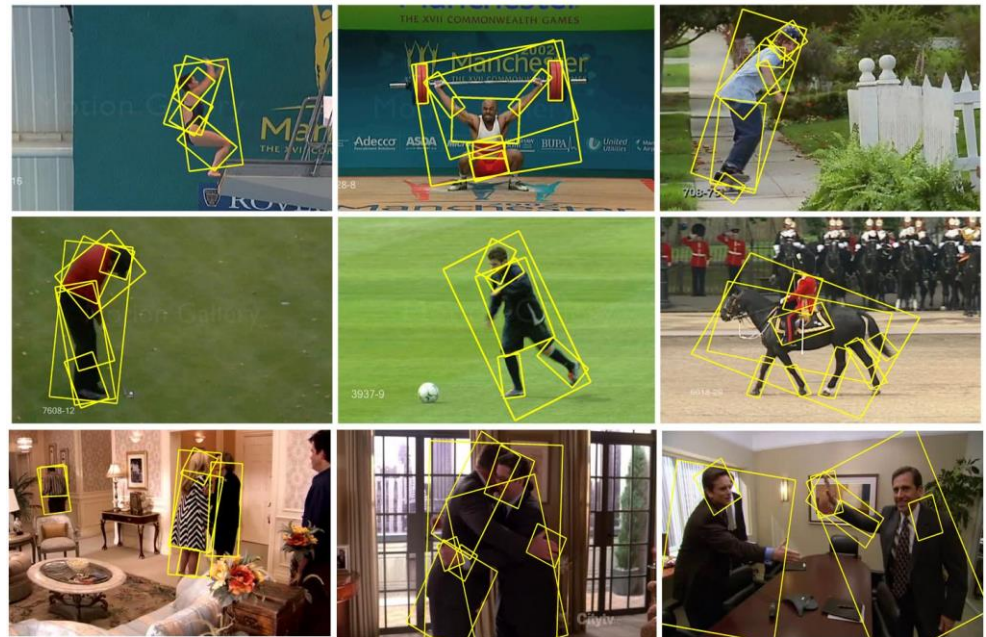
Sensor data collection/processing using a wireless access point

Data Processing on Wi-Fi Access Point

- Weather simulation
- Computer vision algorithms



https://commons.wikimedia.org/wiki/File:Hurricane_Isabel_NC_landfall_radar.jpg

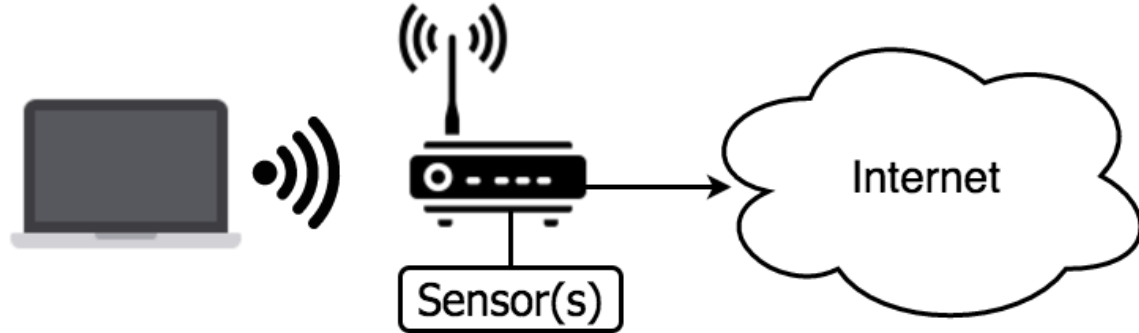


http://cs-people.bu.edu/shugaoma/segtree_icon.jpg

Concerns

	Affect Wi-Fi Users?
	Different Type and Number of Sensors?
	Real Applications?
	Time-sensitive Sensing Applications?

Experiment Approach



- **Attach** sensors to Wi-Fi AP
- **Inject** network traffic from laptop
- **Run** sensing application on Wi-Fi AP
- **Monitor**
 - Network performance
 - Wi-Fi AP system resources
 - Sensing application performance

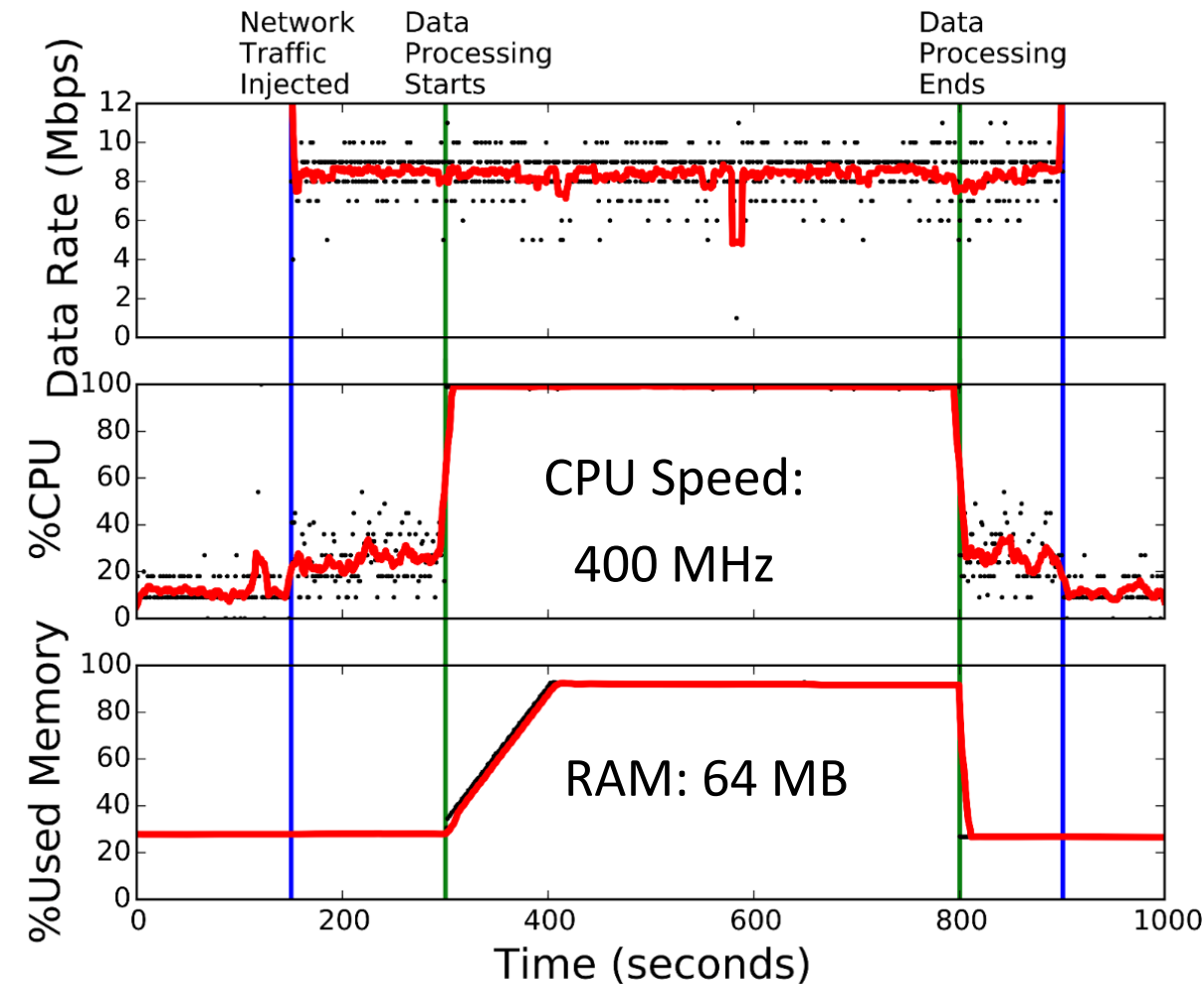
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Performance Metrics

- Feasibility
 - Program Size
 - Difficulty of Implementation
- Network and Device I/O Performance
 - Network Throughput
 - I/O Read and Write Speed
 - Round-trip Latencies
- System Resources Utilization
 - CPU
 - Memory

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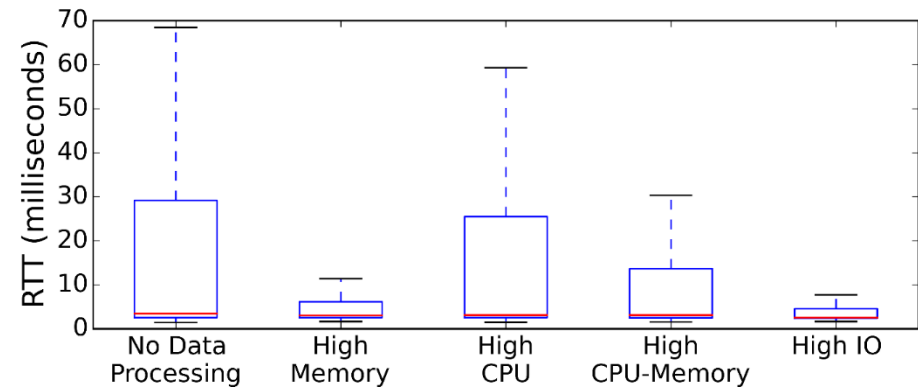
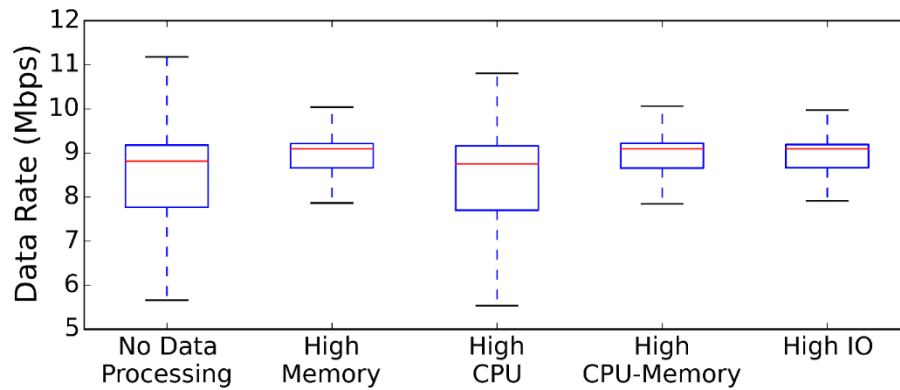
Throughput vs. CPU and Memory Load



Throughput is not affected by high load on CPU and memory. (less than 1% impact)

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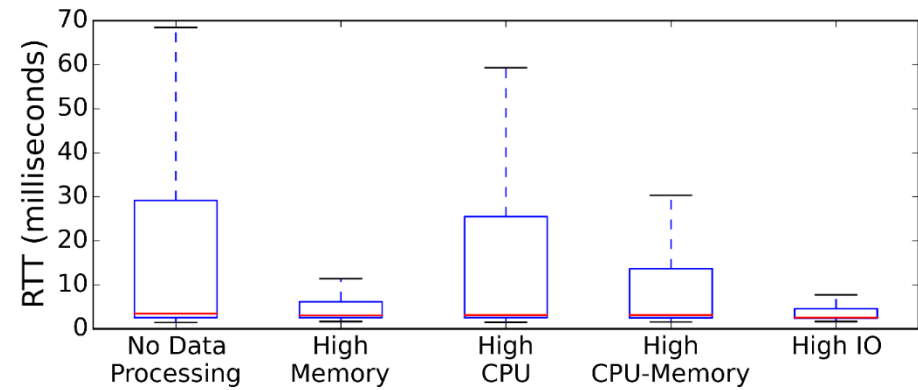
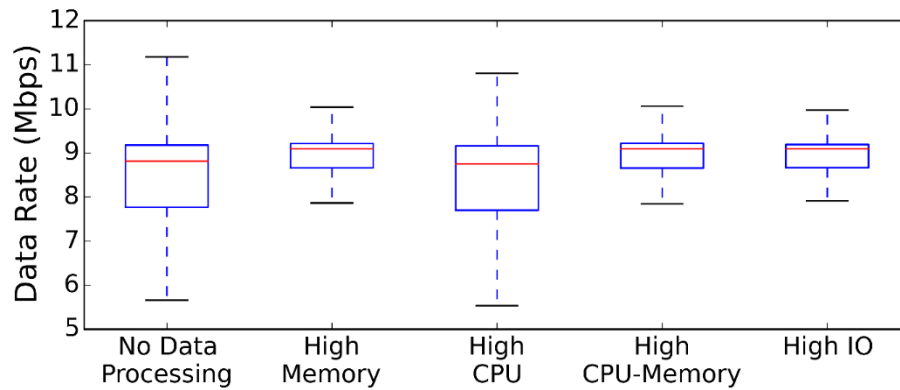
Impact of Sensing and Sensor Data Processing on Wi-Fi Performance



Throughput and delay are not affected by various resource-demanding applications. (less than 1% impact)

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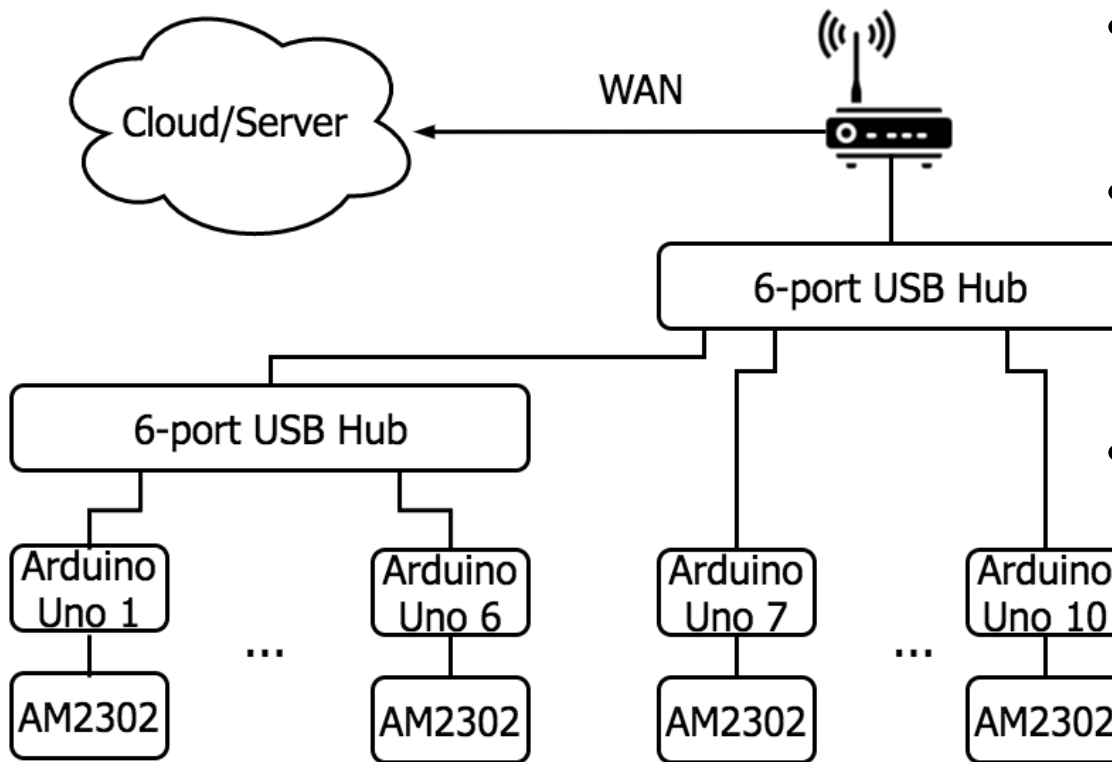
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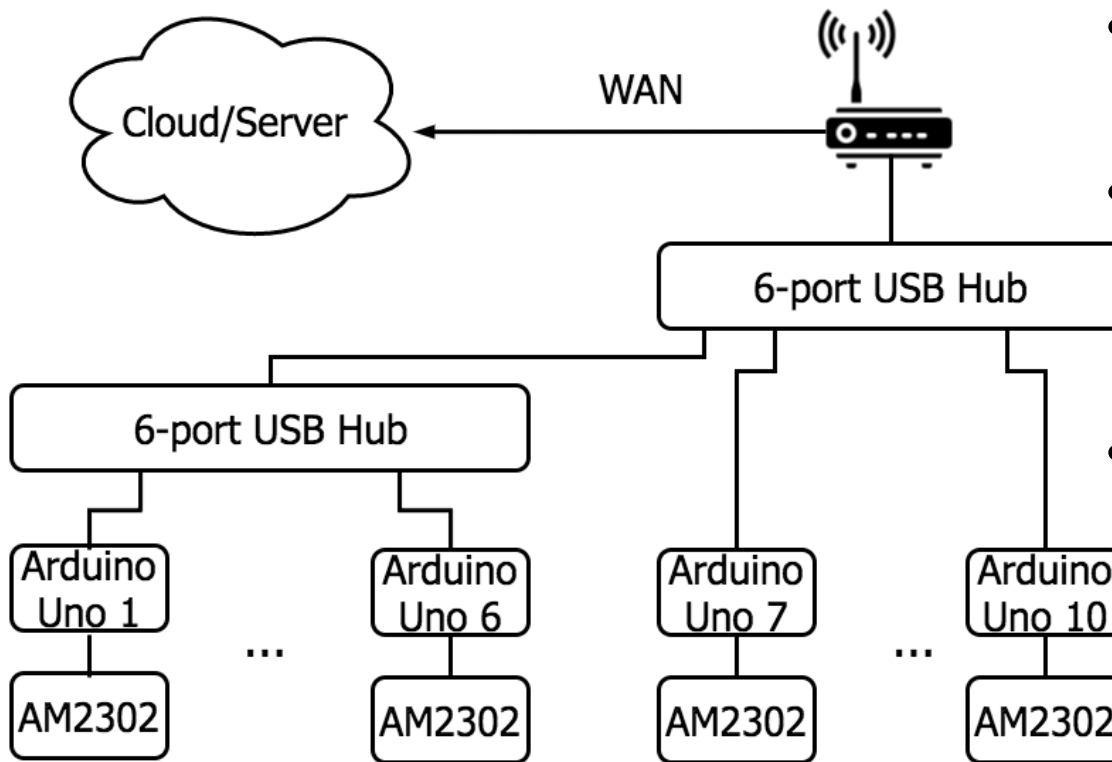
Different Type and Number of Sensors to Connect to a Wi-Fi Access Point



- 10 Humidity/Temperature Sensors (AM2302)
- 2 Passive USB 2.0 Hubs (No external power)
- Camera, Accelerometer, Motion, Lux, PM2.5, CO, Hydrogen, CNG, LPG

✓	Affect Wi-Fi Users?
	Different Type and Number of Sensors?
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Different Type and Number of Sensors We Can Connect to a Wi-Fi Access Point



- 10 Humidity/Temperature Sensors (AM2302)
- 2 Passive USB 2.0 Hubs (No external power)
- Camera, Accelerometer, Motion, Lux, PM2.5, CO, Hydrogen, CNG, LPG

✓	Affect Wi-Fi Users?
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Feasibility of Real-world Applications

- The Quake-Catcher Network
- Intrusion Detection
- Surveillance
- Indoor Climate Monitoring
- Indoor Air Quality Monitoring
- Occupancy Detection
- Fire Alarm System

Application	Program Size	Difficulty of Implementation
Surveillance	1870 bytes	Medium
Indoor Climate Monitoring	1140 bytes	Easy

Sensor applications related to environment monitoring are small programs and are relatively easy to implement.

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Background Subtraction



Original Images

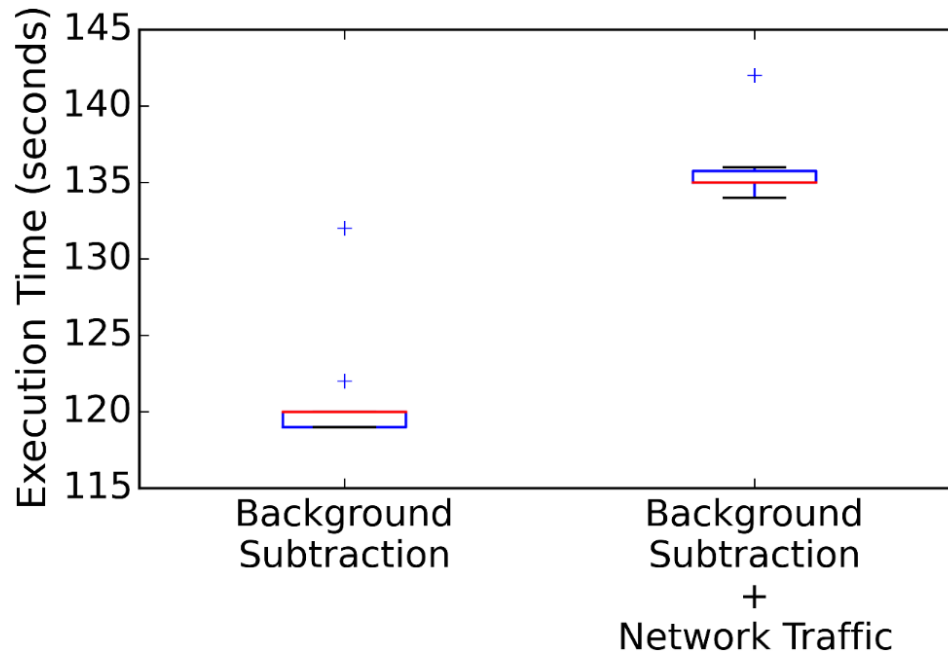


Background Subtracted Images

Useful for motion analysis

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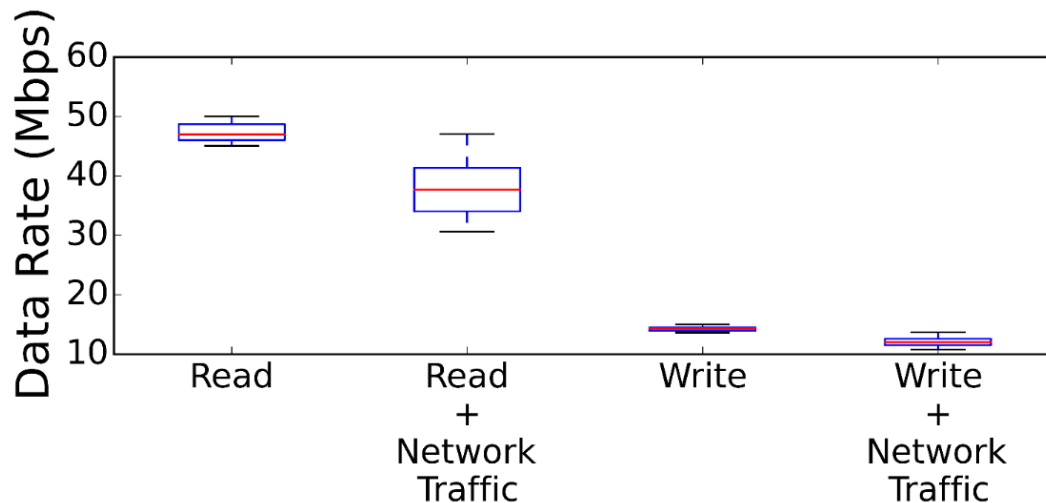
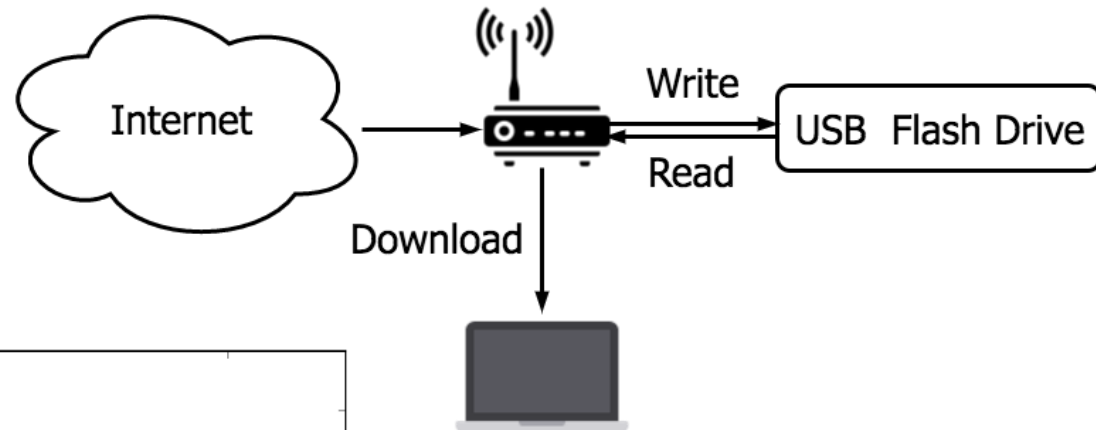
Impact of Wi-Fi Traffic on Sensing and Sensor Data Processing Performance



Execution time increases with presence of network traffic

✓	Affect Wi-Fi Users?
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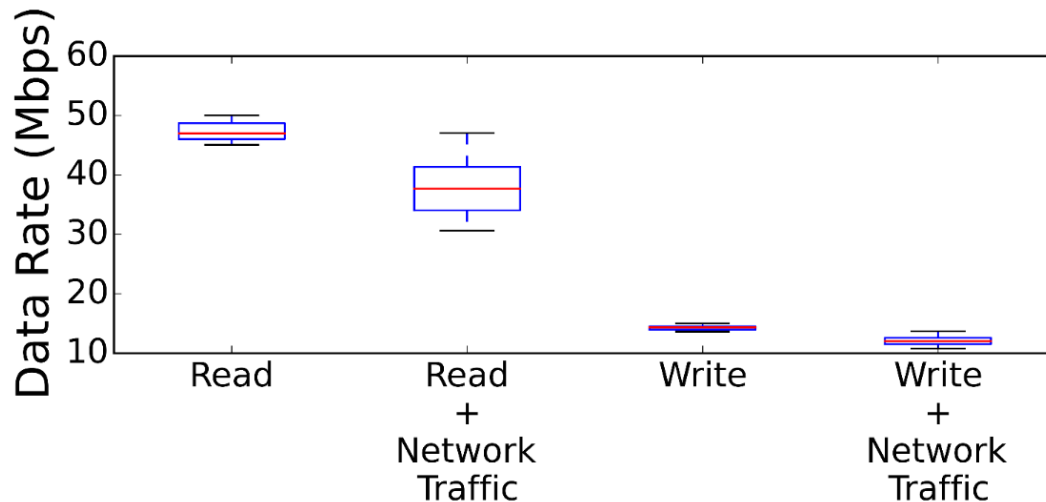
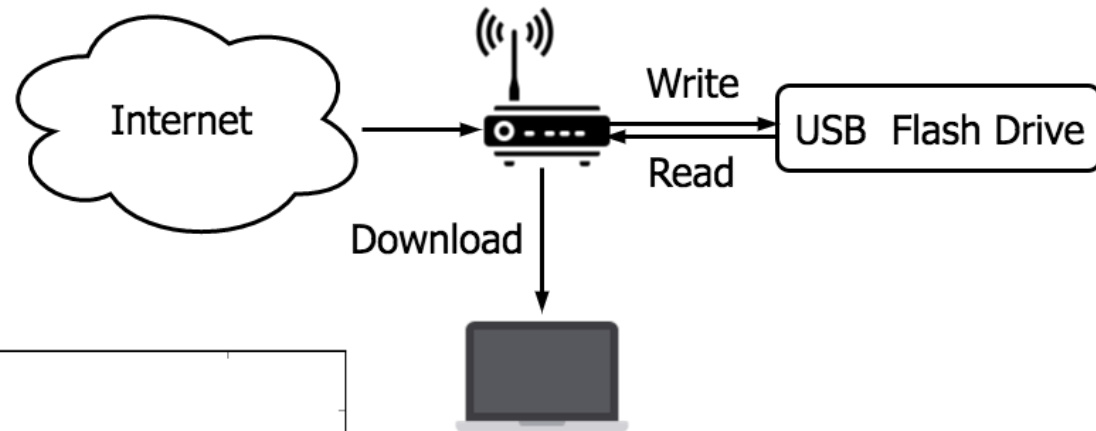
Impact of Wi-Fi Traffic on Device I/O Performance



USB Flash Disk I/O data rate decreases with presence of network traffic

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Impact of Wi-Fi Traffic on Device I/O Performance



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Conclusions and Discussions

- Design and evaluation of running IoT applications on top of Wi-Fi access points.
- For time-sensitive sensing and sensor data processing we can delay the network traffic by modifying kernel scheduler mechanism.
- Codes are available at <http://nsl.cs.uh.edu/projects/apsensor>

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