

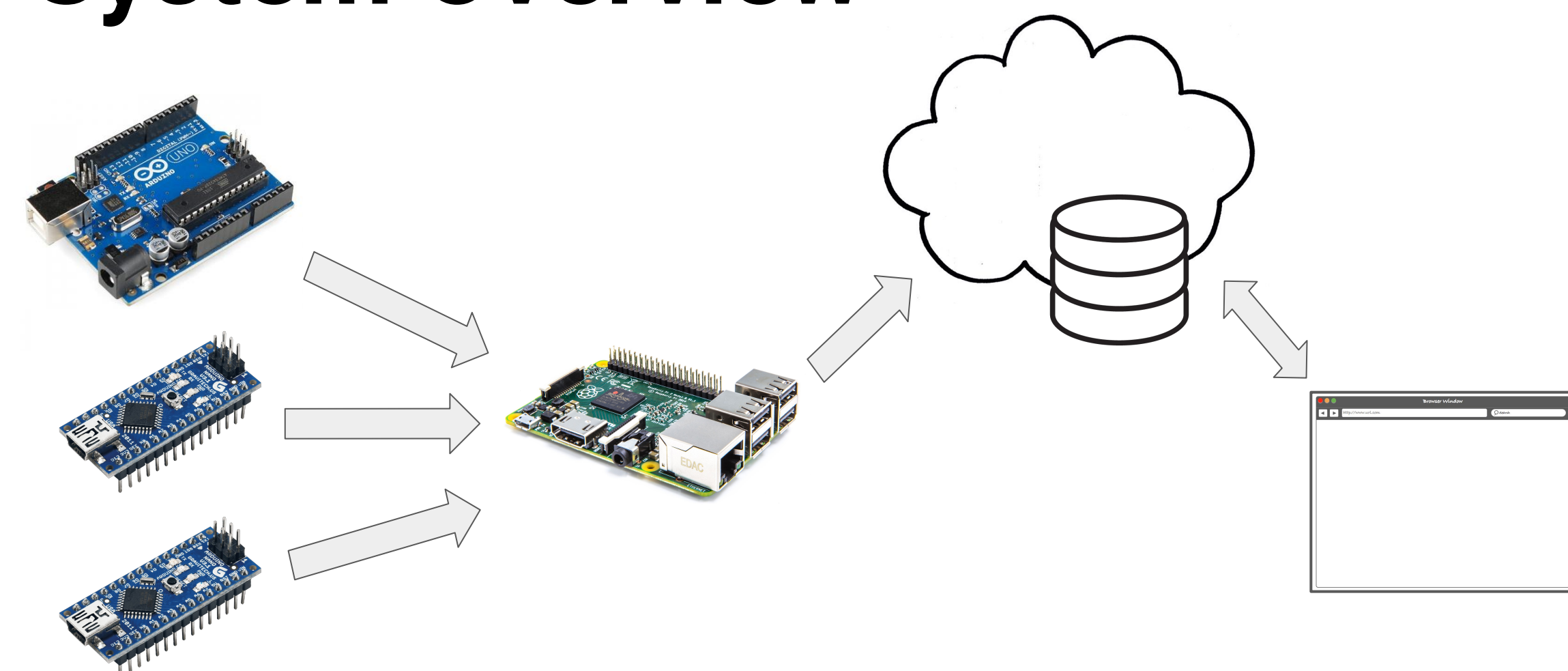
Lookout: A Distributed Sensing System for Arduino and Raspberry Pi

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Motivation

- Real-time distributed sensing system
 - Low battery and low cost
 - Non-intrusive: no user interaction after deployment
- Open-source general purpose implementation extensible for various applications
- Developed web application to monitor G9 room usage and environment
 - Data aggregation and insights over time
- Example problems:
 - How extensively are meeting rooms and work spaces used on G9?
 - How often are reserved rooms left unused?

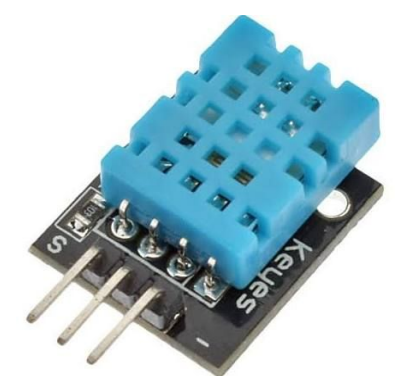
System Overview



- Arduinos collect motion, humidity, and temperature information
- Transmit via RF transceiver to Raspberry Pi gateway (~50 ft range)
- Internet-connected gateway send data to cloud web server
- Access data via web application
- Hardware accessories:



PIR motion sensor

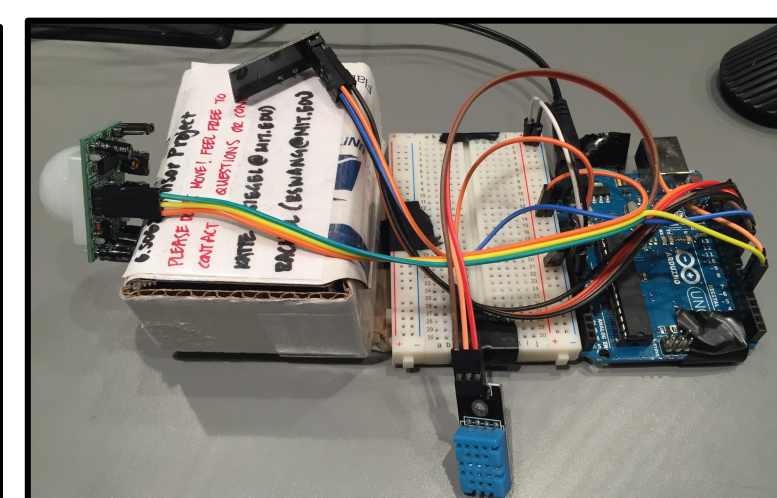
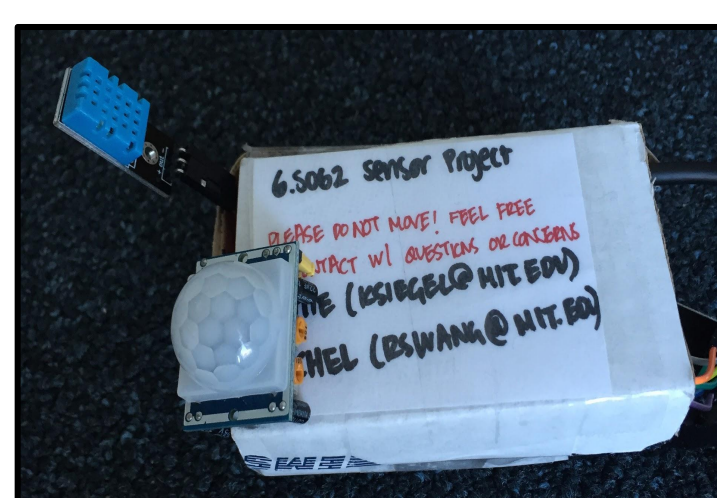


Temp/humidity sensor

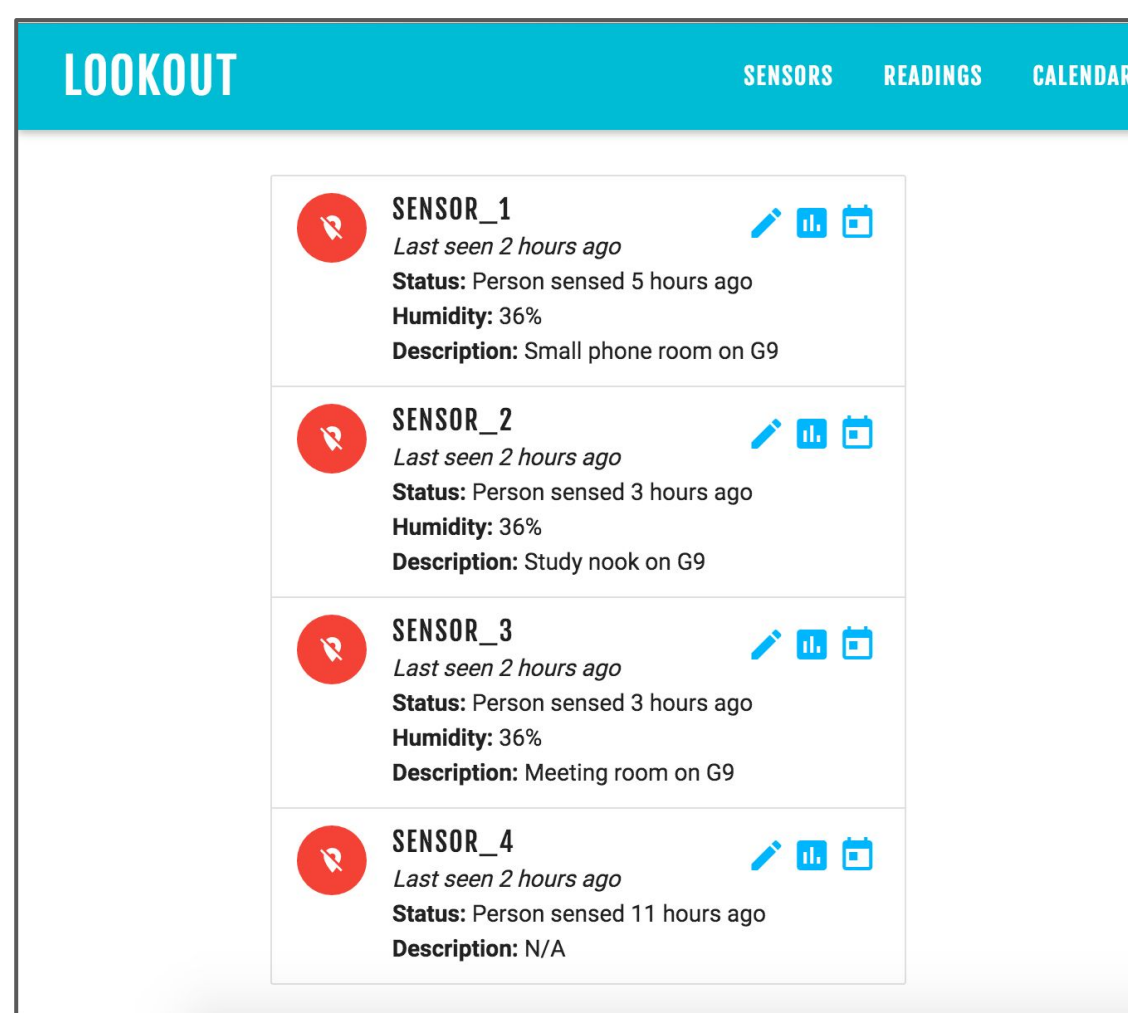


nRF24L01 transceiver

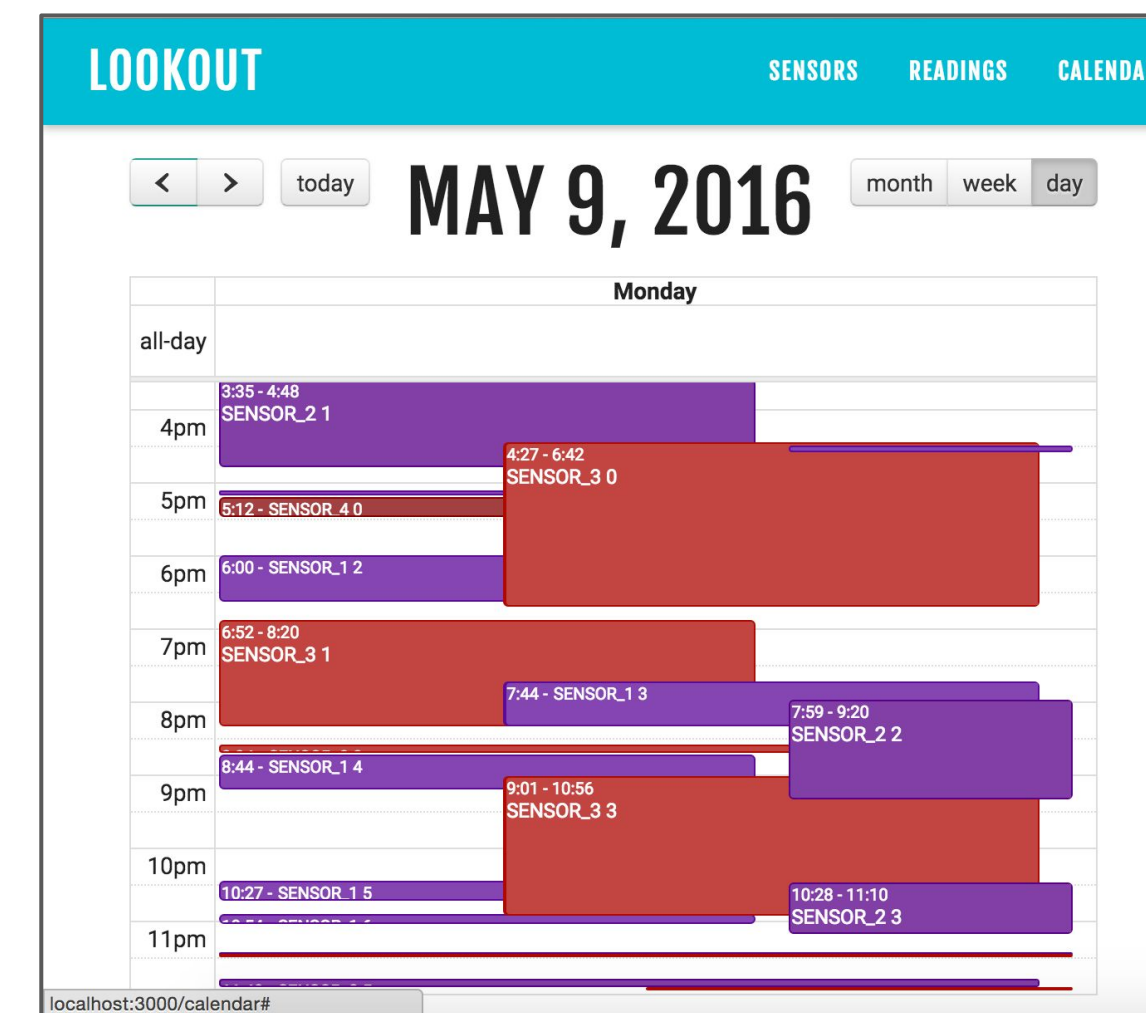
- Deployed on G9



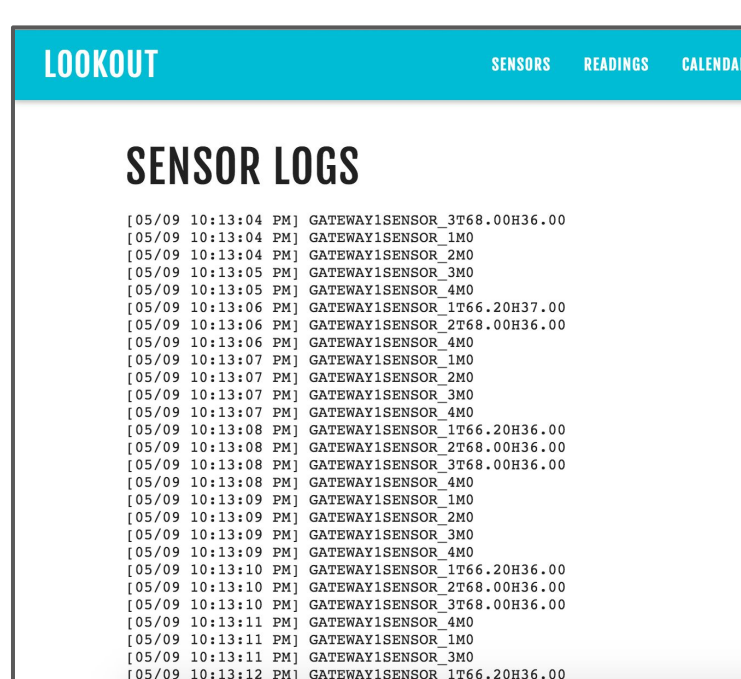
User Interface



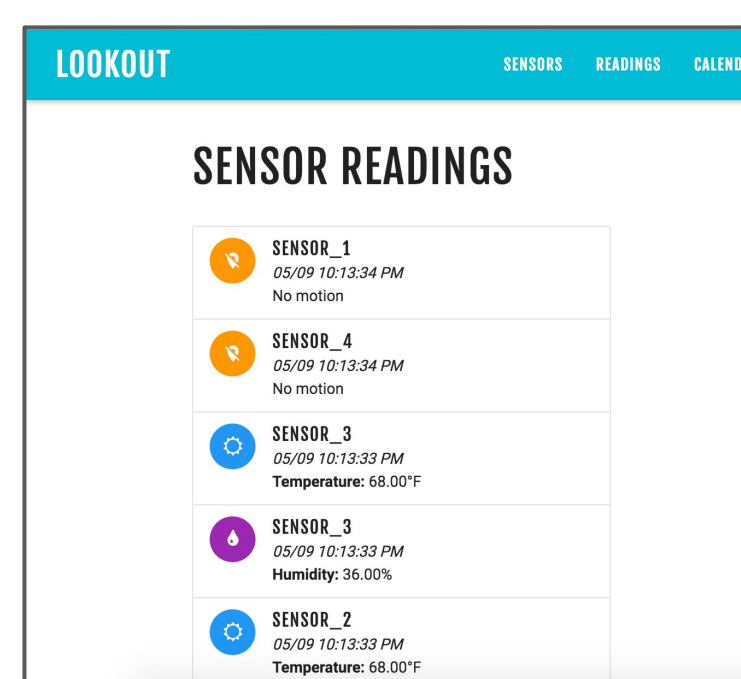
- Displays summary information
 - Latest statistics
 - Space occupation



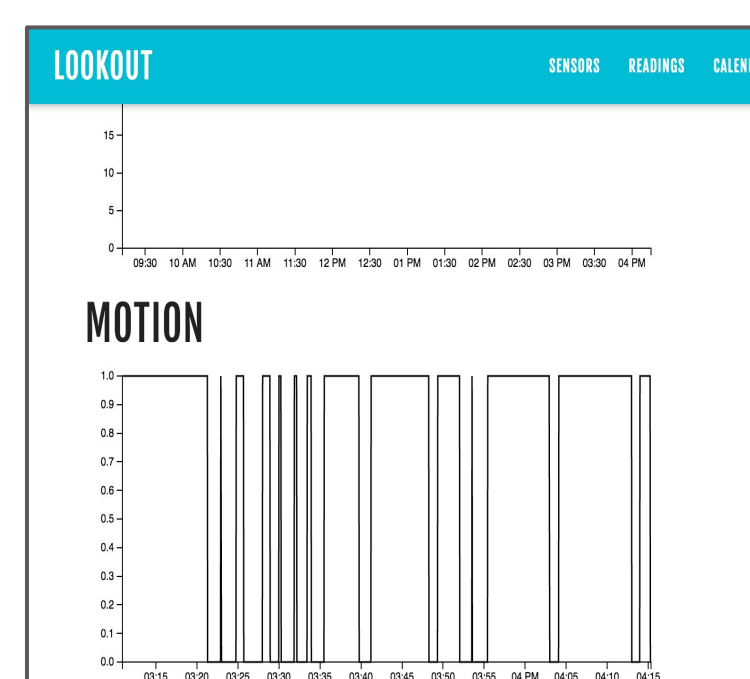
- Calendar view of sensor motion detection
- Use an inactivity threshold to aggregate values



- Raw logs received from sensors
- Each payload includes Sensor ID, Gateway ID, Sensor Type, and Reading



- Sensor readings
- Different icons indicate different types of readings
- Updated in real-time using sockets



- Real-time graphs of sensor readings
- D3.js to chart values
- Sockets to load data dynamically

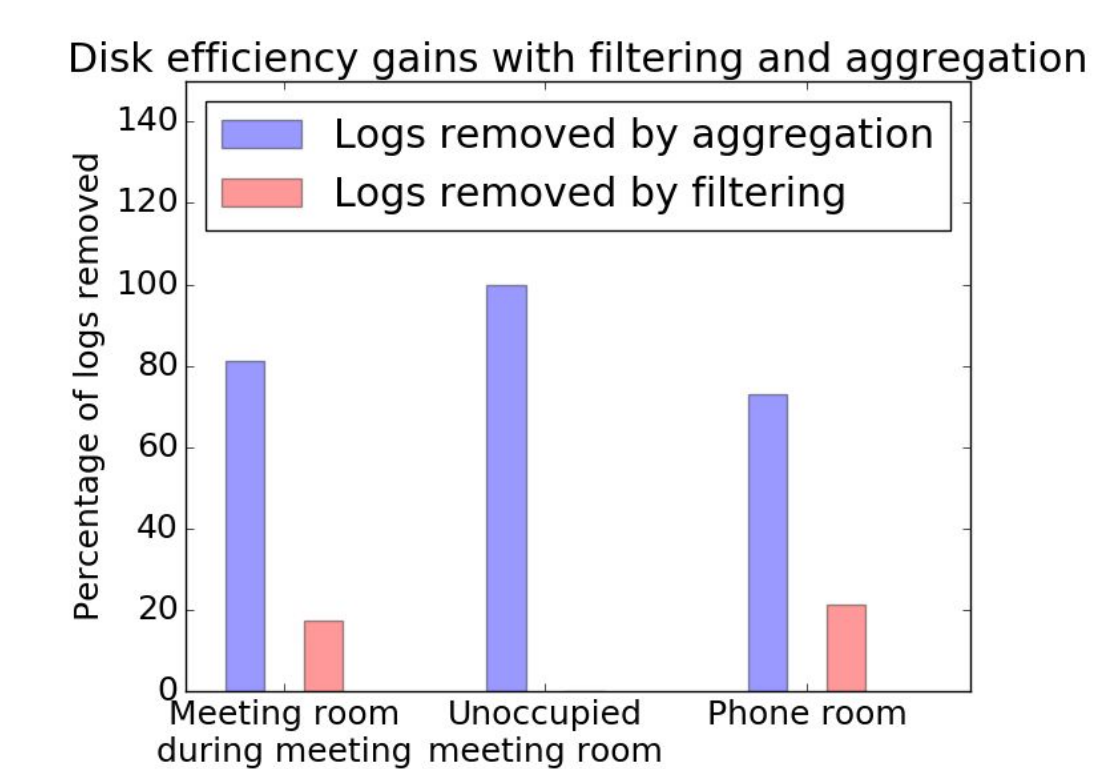
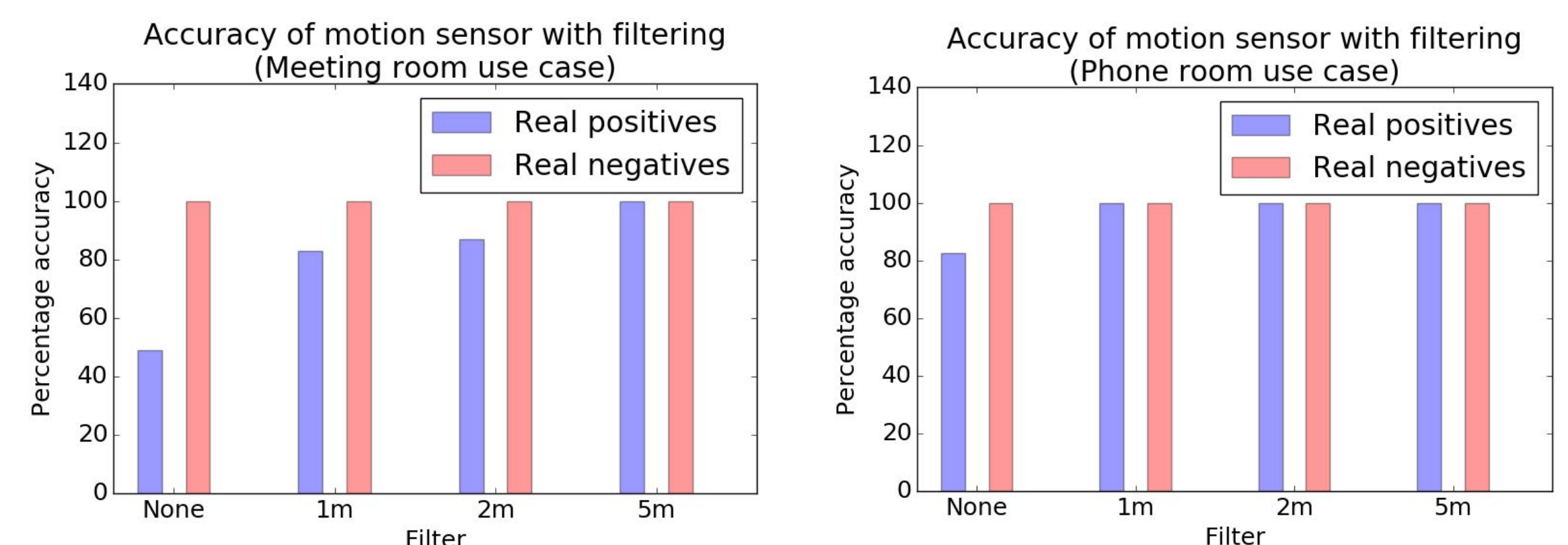
Optimizations

- Watchdog - Arduino library for low battery sleep
- Sensor-side data aggregation
 - Send aggregated data every 5-15 minutes
 - Transceiver = highest battery drain
- Server-side data aggregation
 - Use case: three identical readings in a row
 - Delete middle reading -- redundant
- Server-side motion filtering
 - Motion sensor only shows false negatives
 - Tunable low pass filter for eliminating false negatives (filter width $X = 1-5$ minutes)
 - If 2 motion signals detected within X minutes, count as same motion and delete negative motions readings in the interim time period

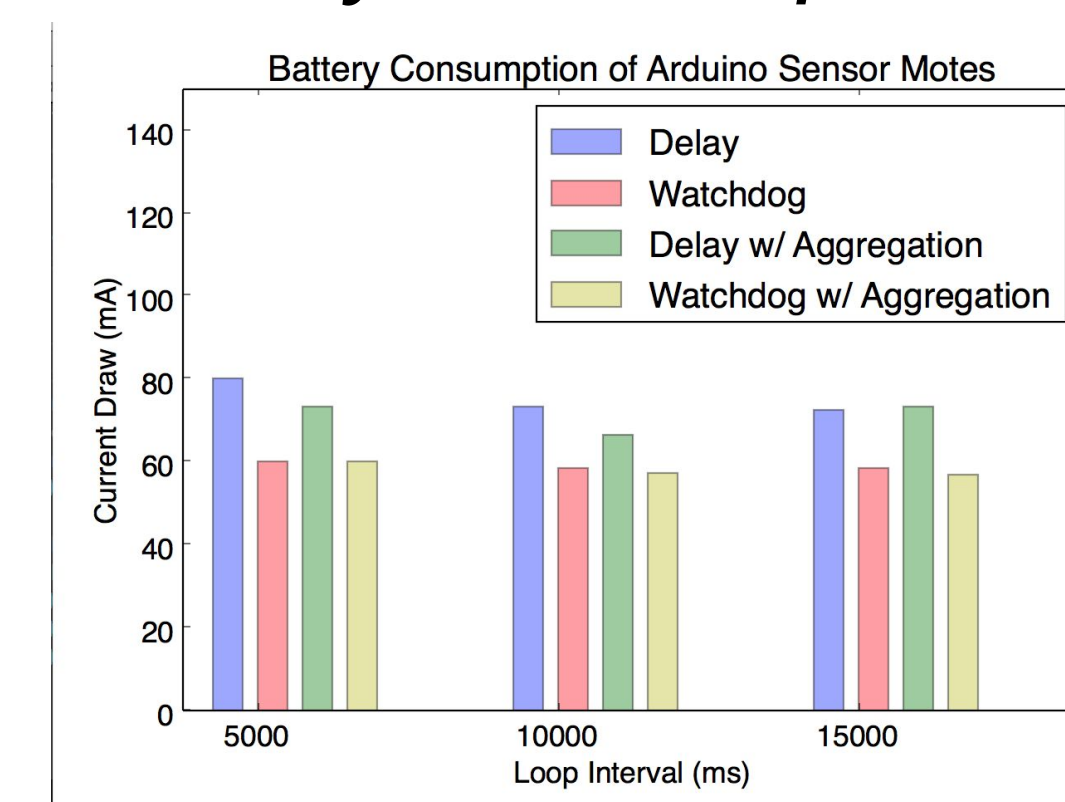
Analysis

Analysis of server-side filtering and aggregation

- Meeting room use case: low movement
- Phone room use case: med/high movement



Battery Consumption



- Watchdog (low-battery sleep) decreased battery consumption by ~25%
- Aggregation marginally improves battery consumption

Cost Analysis

- Central Raspberry Pi gateway (total cost: \$41.10)
 - Raspberry Pi: \$40.00
 - RF transceiver: \$1.10
- Arduino sensor mote (total cost: \$11.30 - \$28.10)
 - RF transceiver: \$1.10
 - Arduino Nano: \$3.20; Uno: \$20
 - Sensors: DHT: \$6.00; PIR: \$1.00

Future Work

- Extensible interface for adding other sensors
 - CO₂, light sensitivity, microphone
- Applications
 - Room reservation system integration
 - Environment monitoring system - e.g. alert if CO sensor exceeds safe value