Occupancy State Detection using WiFi Signals

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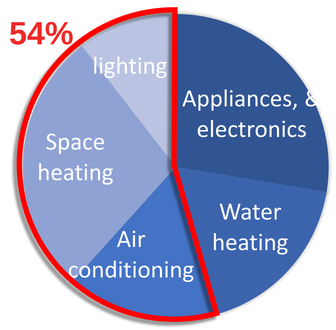
Motivation

Occupancy sensing can reduce energy consumption in buildings by up to **30-40%.**



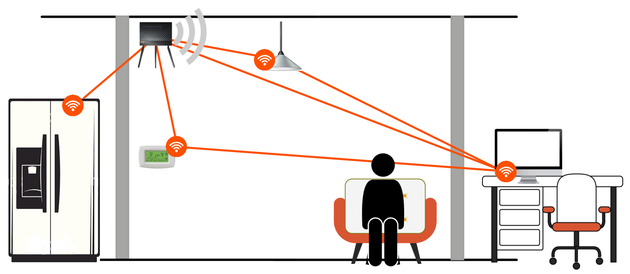
Residential and Commercial Energy Usage, National Academy of Sciences

Motion Sensors ≠ Occupancy Sensors

However, existing sensors only detect motion, not occupancy. Therefore, they often miss people when are sitting still.

Solution: WiFi as Sensor

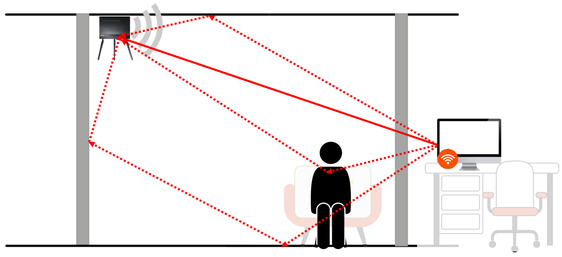
Can a network of WiFi devices serve as a sensor network by detecting disturbances caused by the human body?



If so, they could be used everywhere, including in the millions of buildings that do not yet have motion sensors.

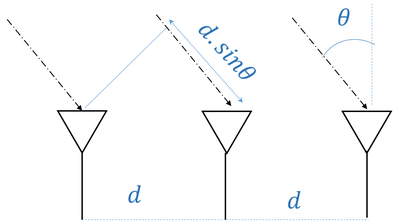
Challenge of Multipath Propagation

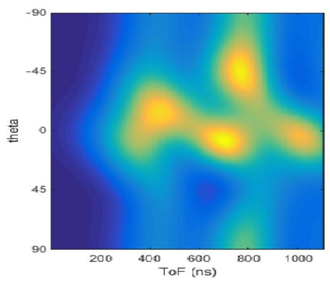
The main challenge is that received RF power is not sensitive to small movements or stationary people unless they are in the line of sight signal.



Approach

Our approach is to resolve individual multipaths, using each one as an independent sensor rather than just considering them to be interference.





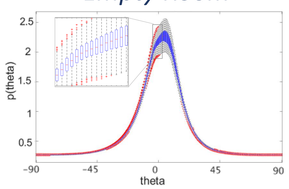
Angle of Arrival (θ)

$$\phi(\theta) = e^{-i2\pi f dsin(\theta)/c}$$

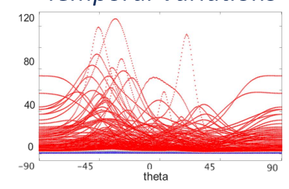
Time of Flight (τ)

$$\Omega(\tau) = e^{-i2\pi f_\delta \tau}$$

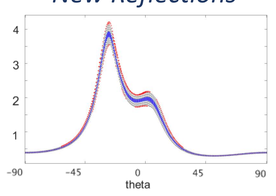
Empty Room



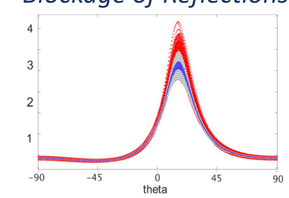
Temporal Variations



New Reflections

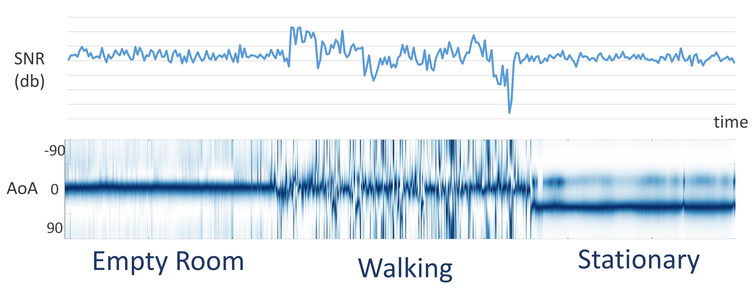


Blockage of Reflections



Main Results

Results show that this approach greatly increases sensitivity, and can even detect people who are completely still.



PeriFi

	empty	occupied
empty	100.00	0.00
occupied	7.60	92.40

Temporal-base Baseline

	empty	occupied
empty	30.48	69.52
occupied	11.05	88.95

%96.7 Accuracy vs. %56.1