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Getting the Most out of your Wi-Fi Deployment: Next Generation Wireless Location Based Services

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Cisco

"The greatest value of a picture is when it forces us to notice what we never expected to see."

- John Tukey, American Mathematician

AGENDA

- Why do Location Tracking?
- Introduction to Location Tracking
- From Wi-Fi Location to Hyperlocation
- CMX Architecture
- Conclusion

Gain Business Insights Through Analytics

Presence Analytics

Building/Floor   **Timeframe**

Repeat vs. New Visitors
Dwell Time
Busiest Hour, Day
Visitor Sentiment
Conversion Rate

Heat Maps

Parameters   **Heat Map**

Where do visitors spend time?

Correlation

Which paths
did visitors take?

Understand How People Interact in the Location

Detect

- Number of people by venue and zones

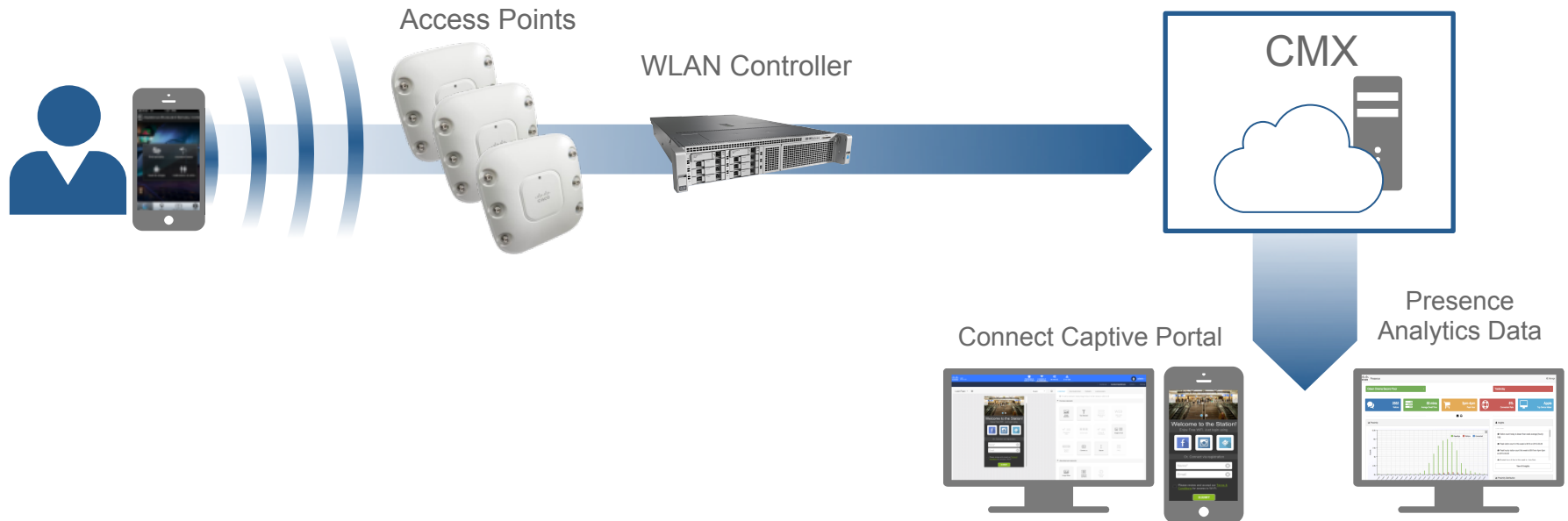- Peak time in venue

- **NEW** New compared to repeat visitors

- Common traffic patterns

- Where people spend time

Cisco CMX

Access Points

WLAN Controller

CMX

Connect Captive Portal

Presence Analytics Data

Generate Customer Insights

Increase Mobile Engagement

Boost Customer Satisfaction

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Location Tracking Approaches

- Real-time location tracking and positioning systems can be classified by the measurement techniques they employ to determine mobile device location

- Approaches differ in terms of the specific technique used to sense and measure the position of the mobile device in the target environment

- Real-Time Location Systems (RTLS) can be grouped into four basic categories of systems that determine position on the basis of the following:

Name	Type of Measurement
Cell of origin	Nearest cell
Distance	Lateration
Angle	Angulation

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Cell of Origin

- One of the simplest mechanisms of estimating approximate location in any system based on RF cells is the concept of 'cell of origin'

- To better determine which areas of the cell possess the highest probability of containing the mobile device, some additional method of resolving location within the cell is usually required.

- When receiving cells, provide received signal strength indication (RSSI) for mobile devices; the use of the highest signal strength technique can improve location granularity over the cell of origin.

- This level of positioning granularity would only suffice to provide presence information

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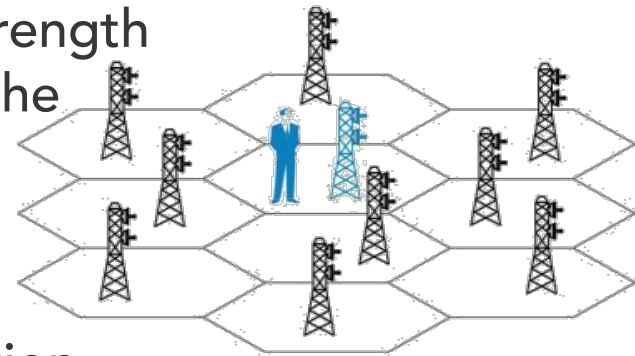
Distance-Based (Lateration) Techniques

- Lateration can be performed by using RSSI
  - Measured by either the mobile device or the receiving sensor
- Path loss represents the level of signal attenuation present in the environment due to the effects of free space propagation, reflection, diffraction, and scattering
  - Path loss exponent indicates the rate at which the path loss increases with distance; the value depends on frequency and environment
  - Is highly dependent on the degree of obstruction (or clutter) present

Typical path loss exponent for:
- Indoor office environment - 3.5
- Dense commercial or industrial environment - 3.7 to 4.0
- Dense home environment - as high as 4.5

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Relationship Between RSSI & Distance

- This localization works best when the relationship between the RSS and the distance from the AP poses a clearly monotonic relationship

- Monotonic means Y only moves up or down in relation to X

The closer the distance the greater the rate of change in RSS in relationship to distance
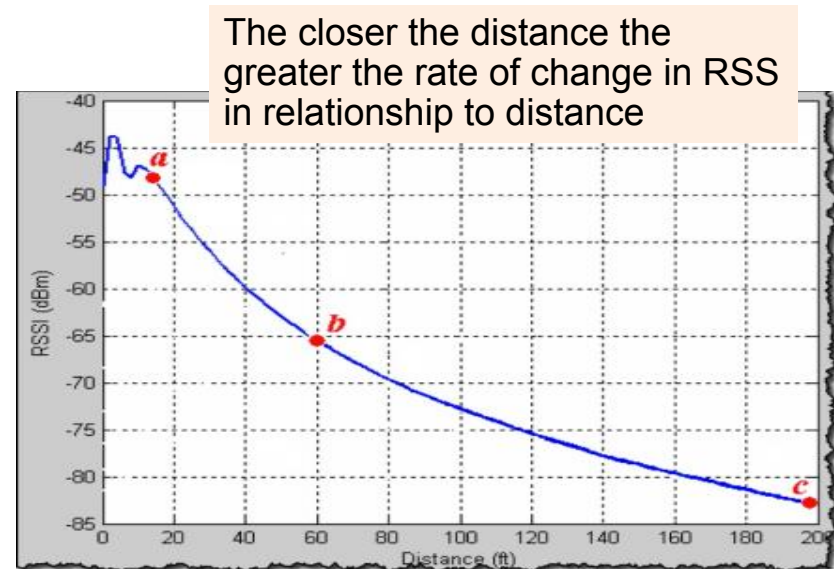
The change in RSS in relationship to distance flattens out at greater distances

Example: Wi-Fi Location Tracking

- Multiple APs triangulate the location of the mobile device
- Based on Probe Requests send by mobile device: RSSI
- Accuracy 5m – 10m
- Currency depending on device probing behavior
- Works for non-associated devices

25dB

A

B

15dB

X

C

10dB

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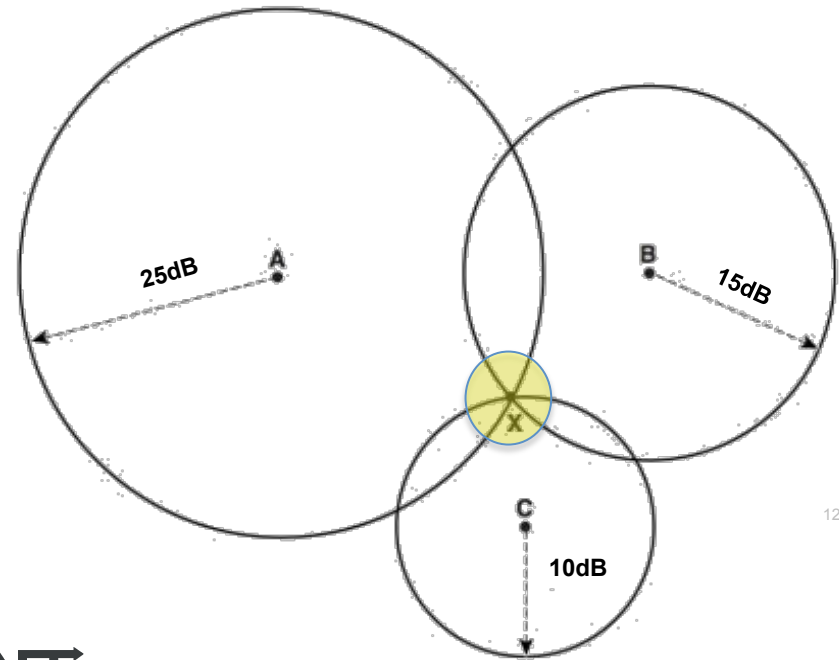
Factors Affecting Location Accuracy

- Location accuracy refers to the quantifiable error distance between the estimated and the actual location of a tracked device
  - The error distance creates an area of RF uncertainty around a client
- Factors that create some RF uncertainty include:
  - Probe requests transmitted at power levels that deviate abnormally from that expected by the RTLS
  - Frequency at which the client transmits probe requests
  - Noise present in the RF environment at any given instant
  - Short-term physical obstructions between the AP and client
- A Cisco WLAN locates clients based on the RSS of probe requests detected by APs, forwarded via their controllers to the MSE
  - Consistent and regular probing of the network is very important to good WLAN client location
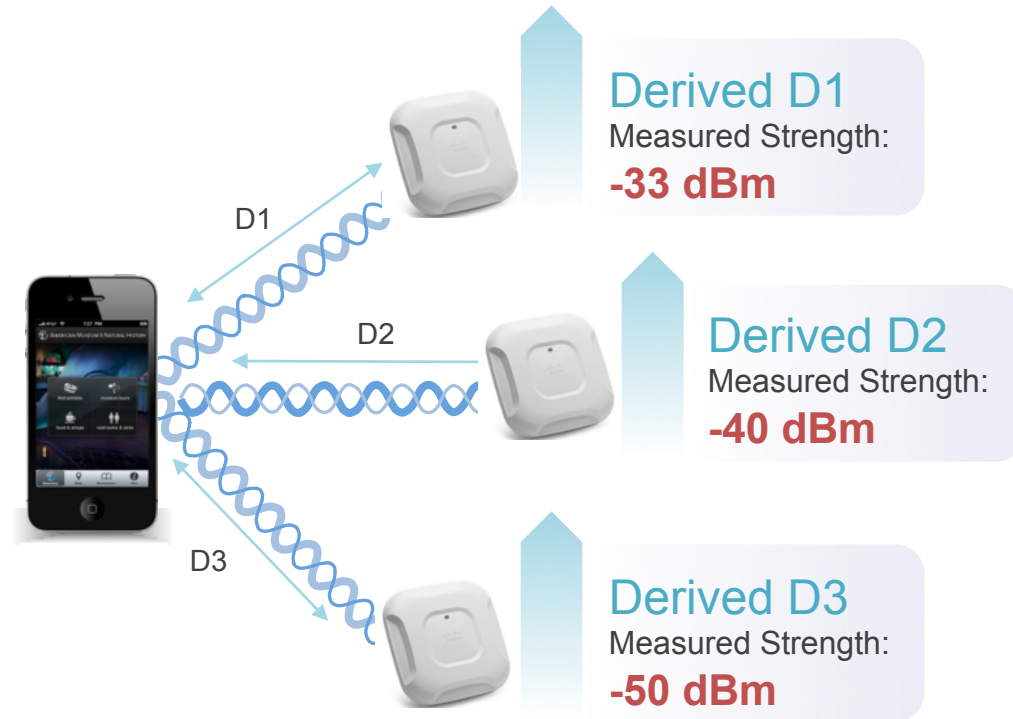
Client Probing

- Probing occurs when a client is discovering the network and, once connected, at regular intervals
- When discovering the network:
  - Some clients actively probe all channels and all SSIDs
  - Some clients probe passively
  - Any variation between these two extremes is possible under the 802.11 protocol
- Once connected:
  - Some clients refrain from scanning for long durations
  - Some clients probe only their active channel
  - Some clients use low power values to probe only close APs
- IEEE 802.11 does not impose a specific behavior

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How Location Is Calculated

- Access points detect mobile devices and measure RSSI from all frames sent over Wi-Fi.

- Controllers send RSSI information signal to CMX for location calculation.

- RF triangulation, based on signal strengths is used to calculate device location.

D1

D2

D3

Derived D1
Measured Strength:
-33 dBm

Derived D2
Measured Strength:
-40 dBm

Derived D3
Measured Strength:
-50 dBm

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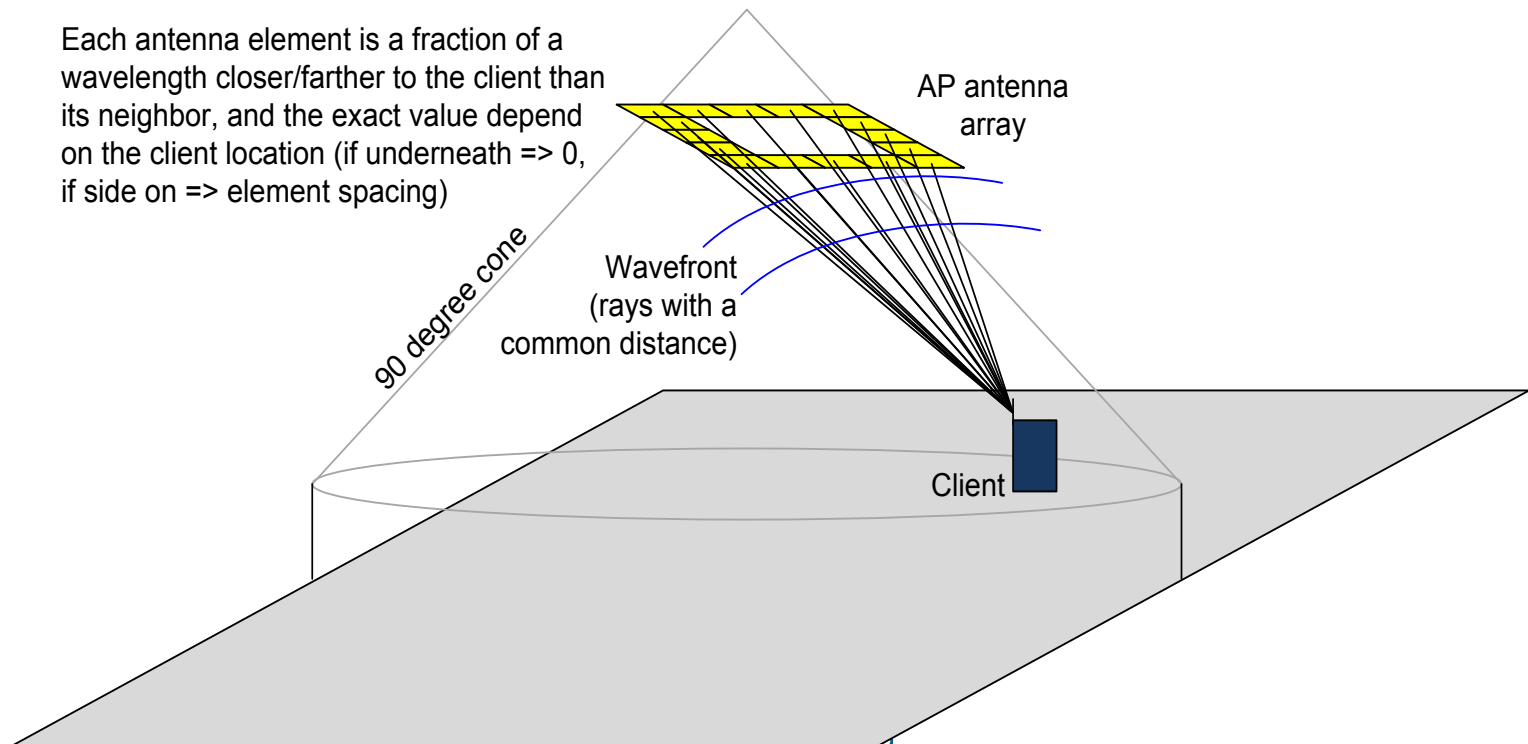
Angle-Based (Angulation) Techniques

- The AoA locates the mobile station by determining the angle of incidence at which signals arrive at the receiving sensor

- Requires two receiving sensors for location estimation, with improved accuracy coming from at least three or more receiving sensors (triangulation)

- Requires multiple element antenna arrays or mechanically-agile directional antennas

- Works well in situations with direct line of sight, but suffers from decreased accuracy and precision when confronted with signal reflections from surrounding objects

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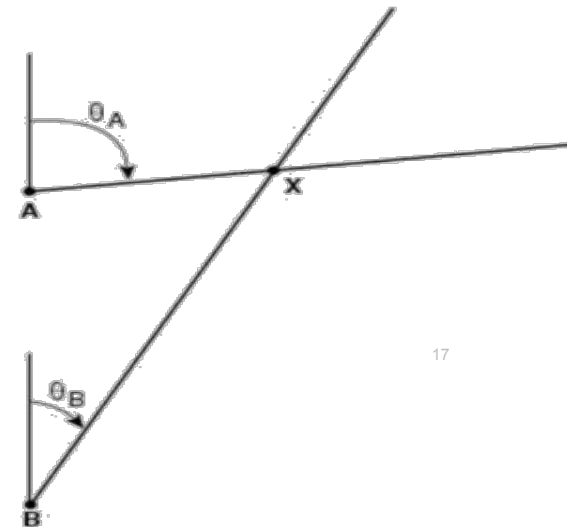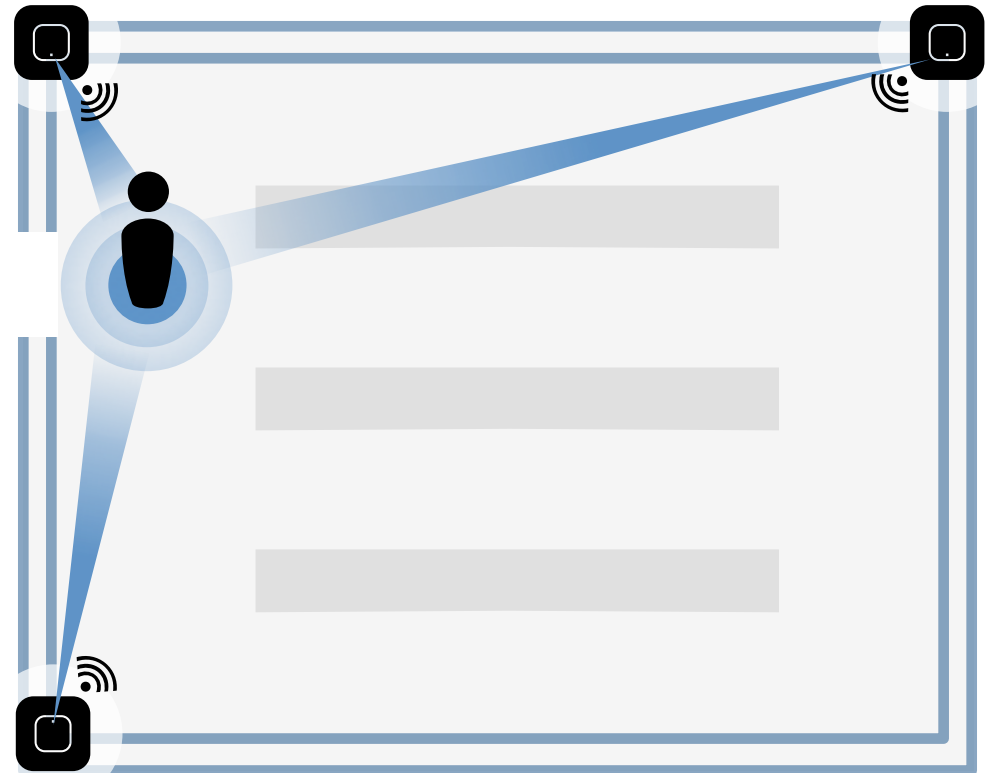
Angle of Arrival(AOA)

- ~ +/- 1 meter location accuracy
- 32 different antenna elements hear the signal a little earlier/later than others, measured by the phase of the signal
- Favors line-of-sight with high degree of accuracy in cone under AP

Each antenna element is a fraction of a wavelength closer/farther to the client than its neighbor, and the exact value depend on the client location (if underneath => 0, if side on => element spacing)

AP antenna array

90 degree cone

Wavefront (rays with a common distance)

Client

Hyperlocation – One-Meter Location

- Advanced military technology – Enterprise application

- 32 array antennas

Best of **INTEROP**
2015 Mobility Winner
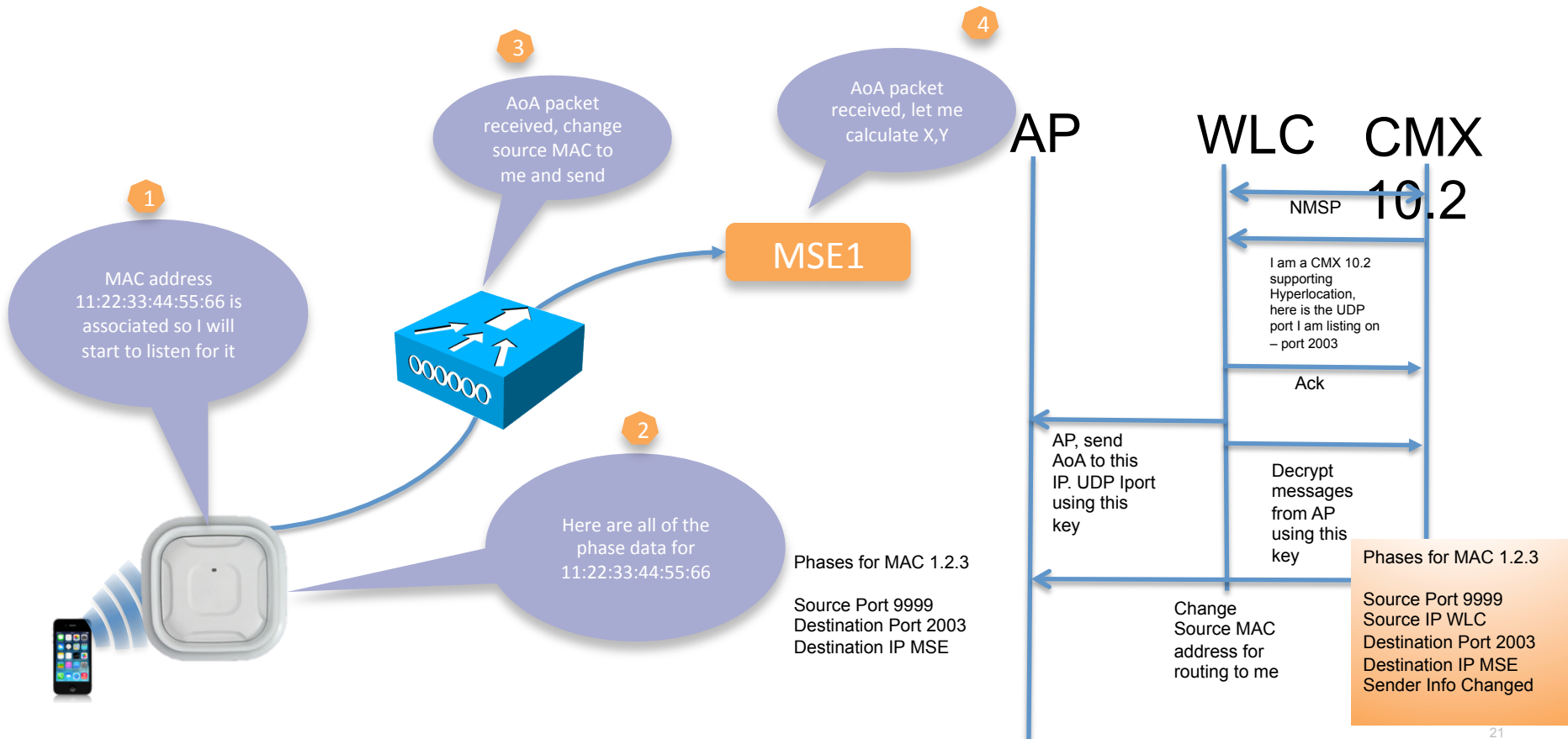
FastPath/Angle of Arrival (AoA) Packet Processing Flow

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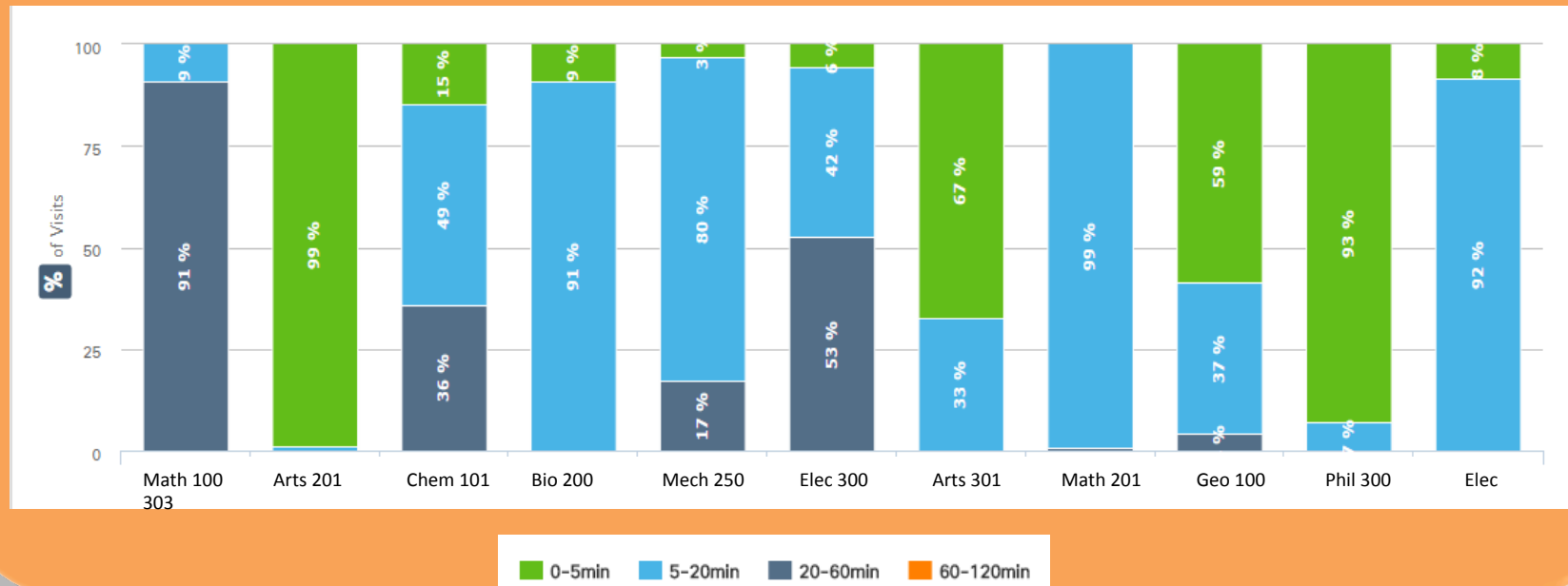- Conclusion

Higher Education

Business Capabilities

- Digital classroom
- Higher student service utilization
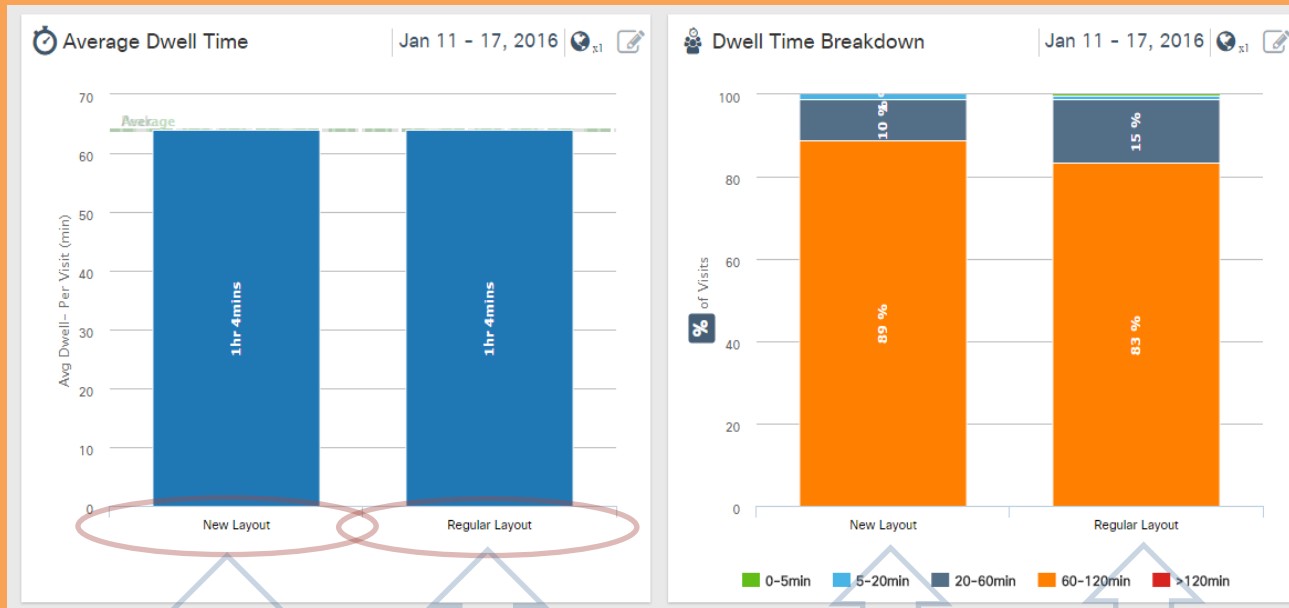- Safety and security

Success Measures

- Better student outcomes (higher engagement and satisfaction, improved learning and test scores)
- Efficient access to student services
- Improved instructor productivity with enhanced learning
- Personalized instruction based on student needs

Which Classes do Students Attend and Spend Time in?

AB Testing – is the New Building Layout Effective?

Average Dwell Time — Jan 11 - 17, 2016

New Layout: 1hr 4mins
Regular Layout: 1hr 4mins

Dwell Time Breakdown — Jan 11 - 17, 2016

New Layout: 89%, 10%
Regular Layout: 83%, 15%

Legend: 0-5min, 5-20min, 20-60min, 60-120min, >120min

Building where we are testing the new layout

Building that are still on the regular layout

A much higher percentage (89%) of visitors to building with the new layout spend more than an hour!
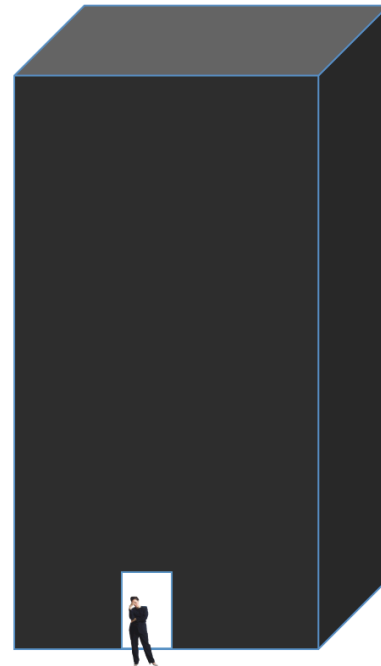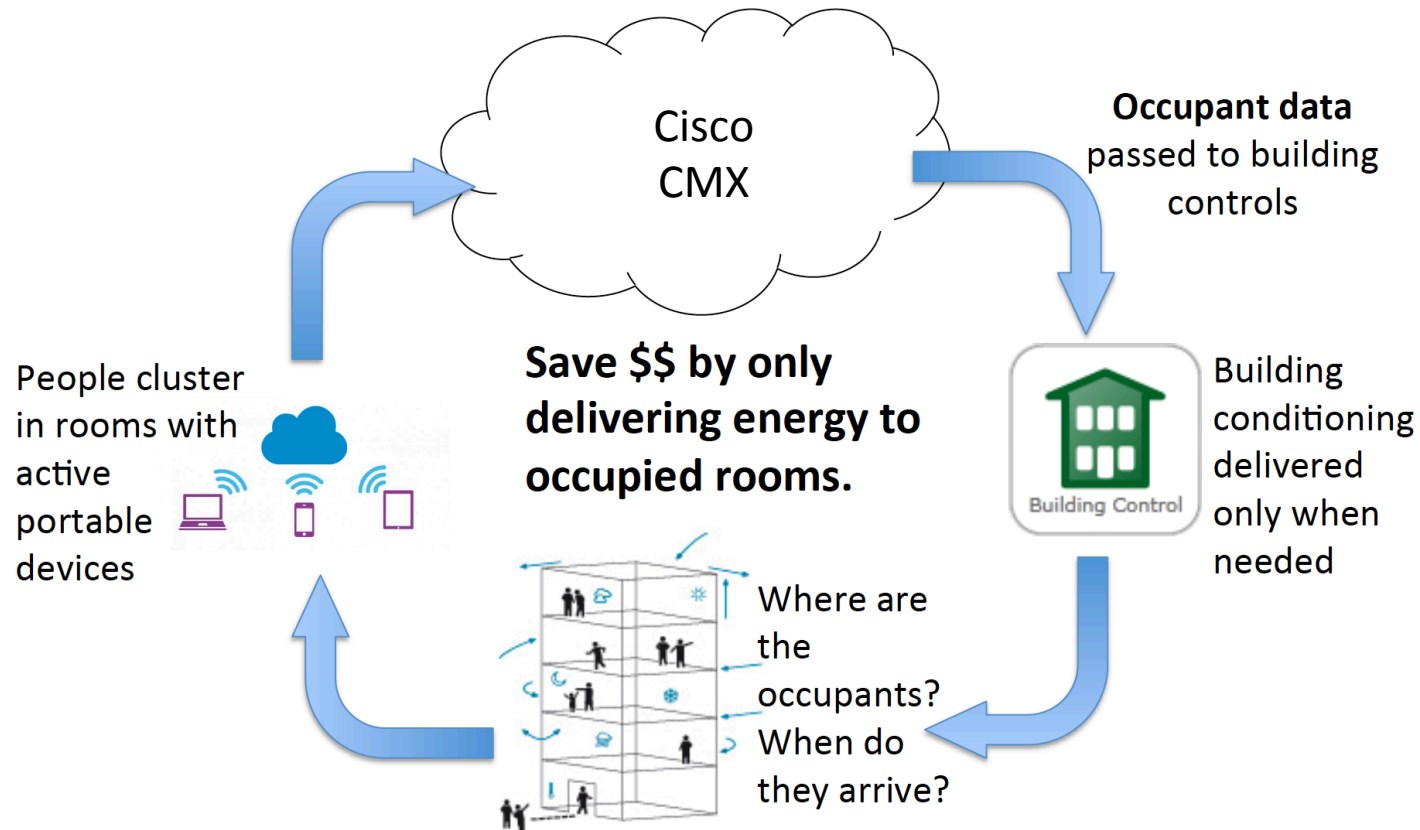
Which
Rooms
to Heat?

Which
rooms to
ventilate?

Making Builds Smart is Expensive

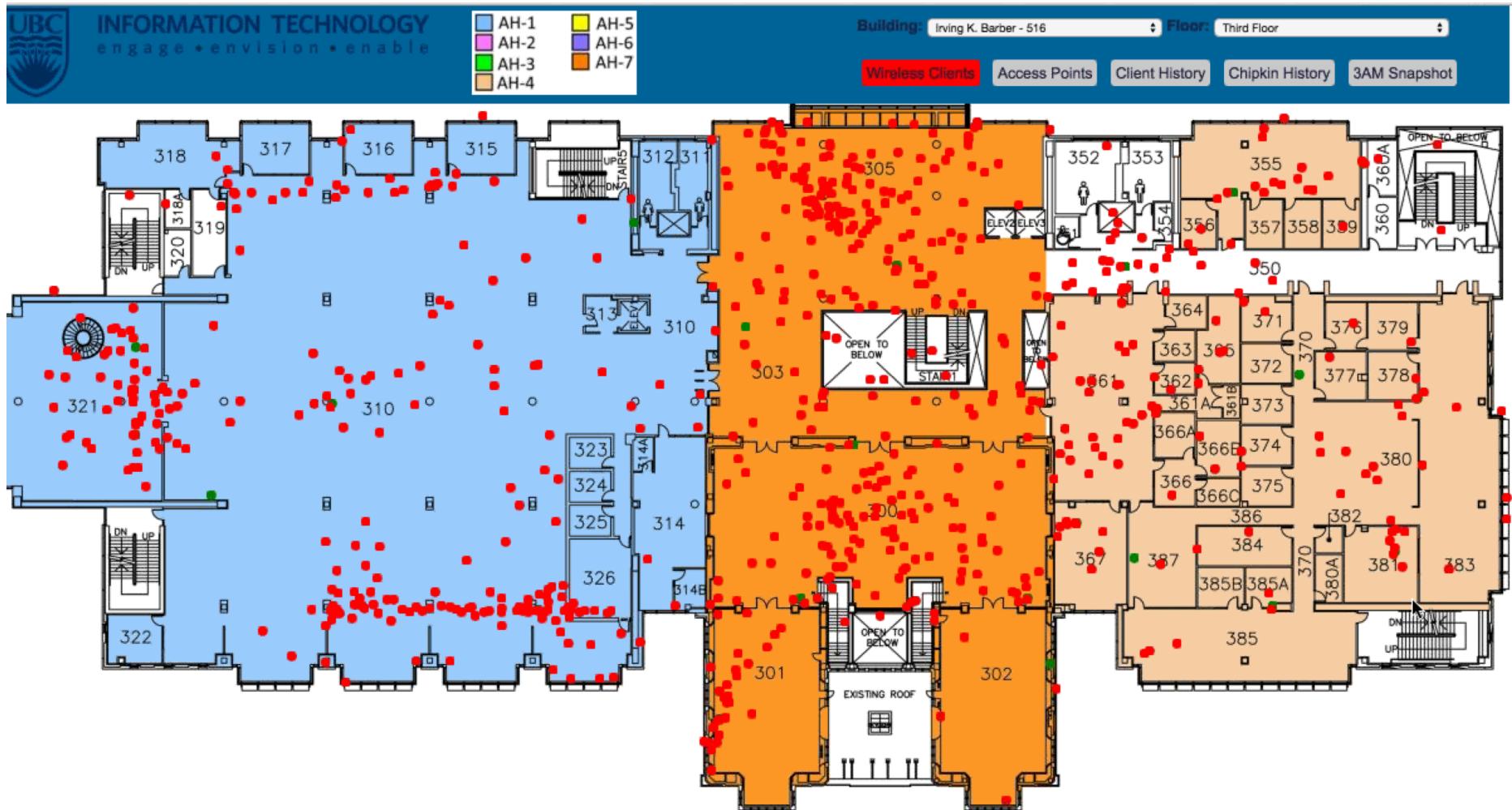Building Sensors (motion, video, thermal). Typical cost for sample buildings ~ $40K

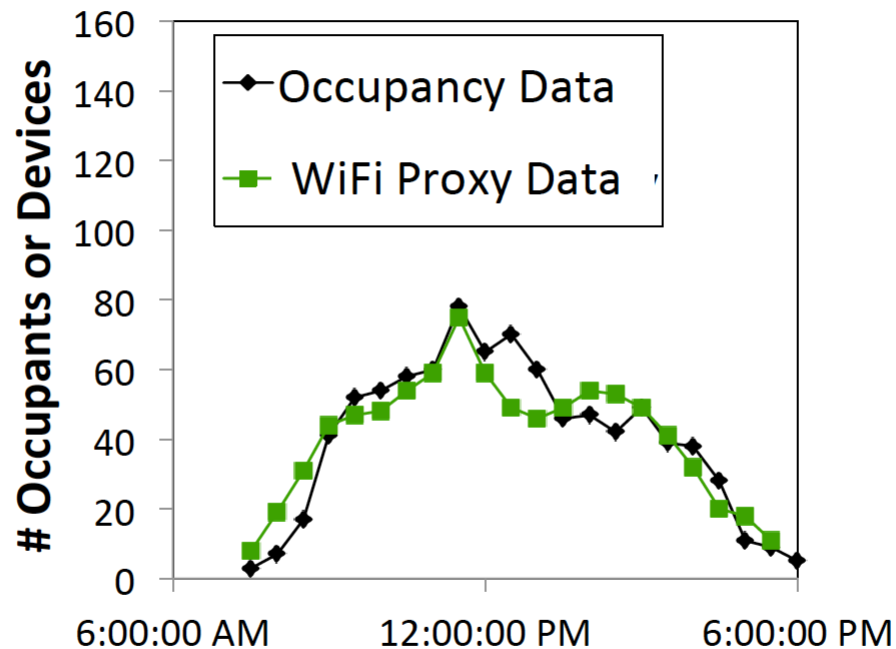# Solution: Use CMX Location Data to Dynamically Adjust HVAC Controls

Cisco CMX

Occupant data passed to building controls

People cluster in rooms with active portable devices

Save $$ by only delivering energy to occupied rooms.

Building conditioning delivered only when needed

Building Control

Where are the occupants? When do they arrive?

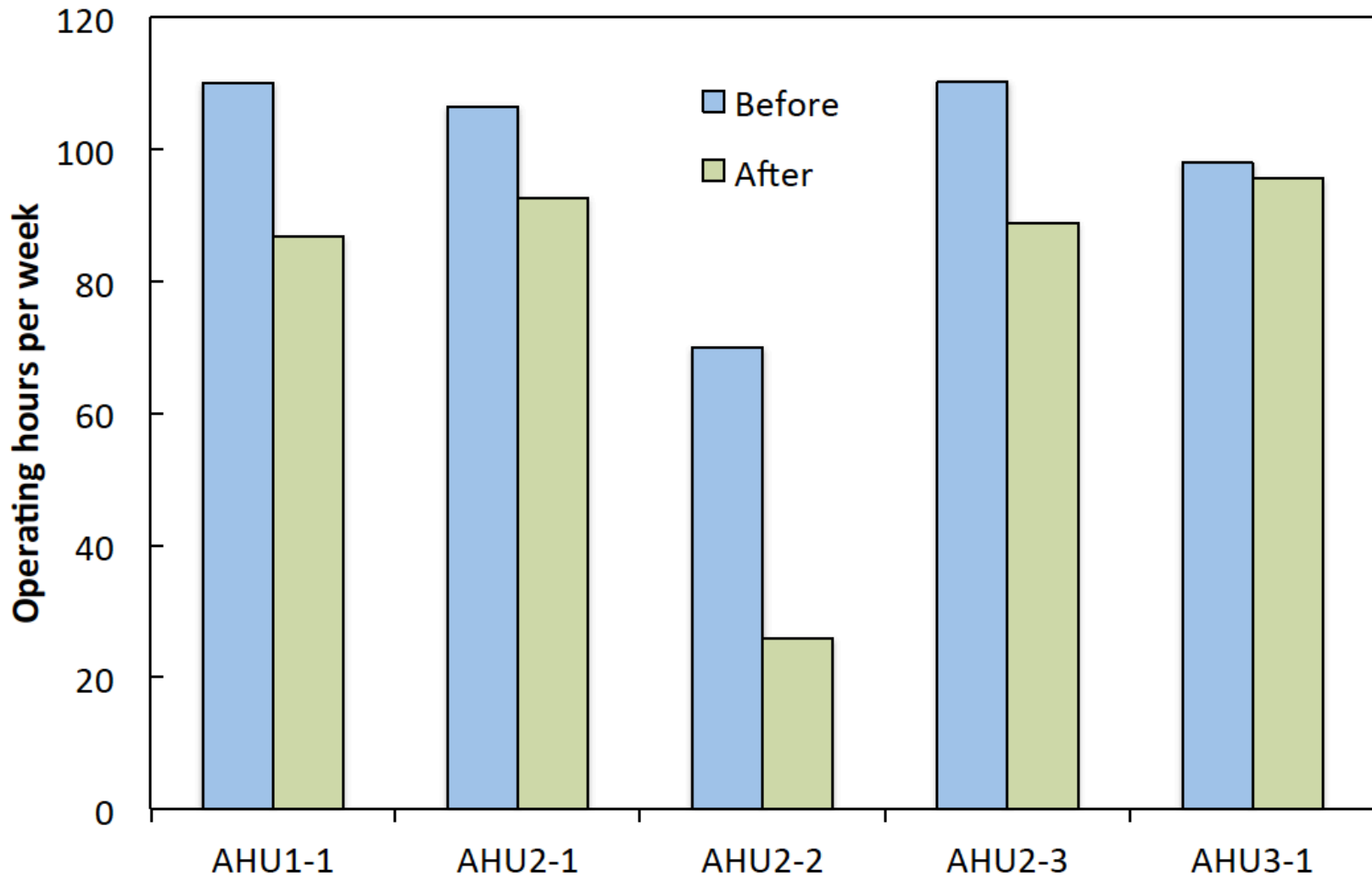# Wireless Location Tracking Example UBC Angus Hub

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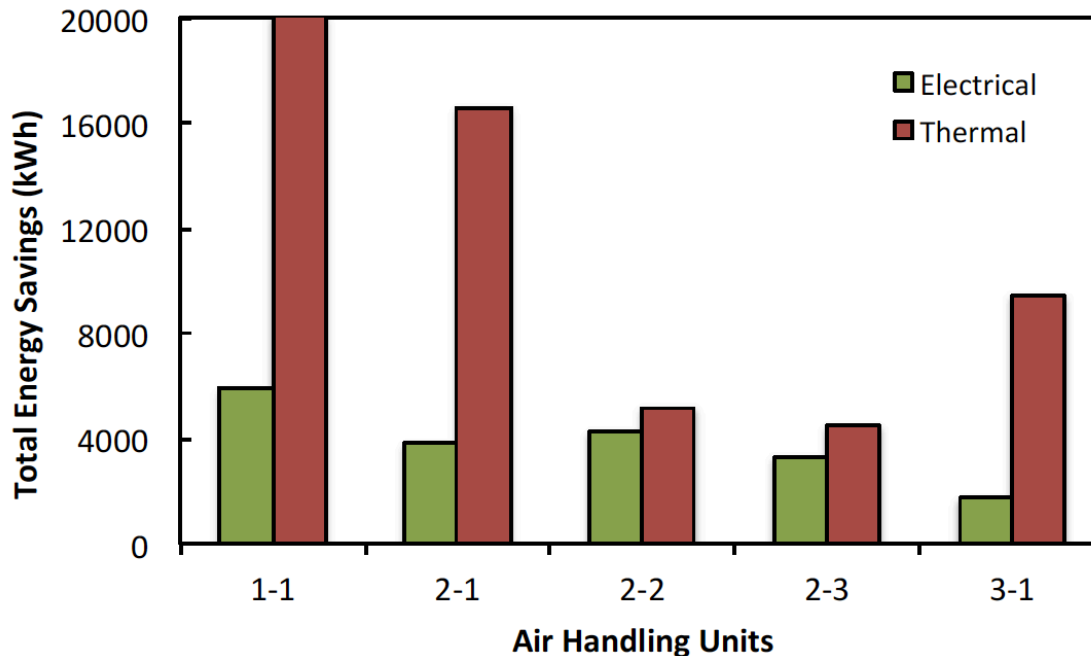# Comparing CMX Wi-Fi Data to Actual People Count

Average Correlation (5 days of data): 0.94

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Pilot Study Findings

Hyperlocation Solution

- Total cost savings of $15K were recorded in six month pilot (representing ~5% energy cost savings)
- Newer air handling systems with variable speed fans are predicted to achieve upwards of 10-15% total energy cost savings using the same method.

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Summary

- Occupancy information is a critical asset that is absent from most modern buildings

- Hyperlocation and Fastlocate allow the Wi-Fi system to track mobile devices up to 1m accuracy

- Cisco is working closely with UBC on new use cases and welcomes more collaboration across BCNet!