



a Hewlett Packard  
Enterprise company

# Advances in Wi-Fi and the Application of Machine Learning to the Network

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# The Road to MOBILE, CLOUD & IOT

**2003**

Intel Introduces  
Centrino



**2007**

Apple iPhone  
Drives BYOD



**2009**

802.11n Enables  
Network Right-sizing



**2010**

Apple iPad Enters  
Board Rooms



**2013**

Microsoft Introduces Lync;  
Gigabit Wi-Fi w/.11ac



**FUTURE**

**20B+**

Connected Wired  
and Wireless "Things"



**Pioneering Workplace Mobility  
with Secure Enterprise Wi-Fi**

**Enabling and Safeguarding  
BYOD Access**

**Redefining Digital Workplaces with  
Mobile UC, Location and IoT**

# The last 10 Years



**2007**

54Mbps max assoc rate  
100Mbps Ethernet Uplink  
20Mhz Channel Width  
OFDM  
SISO 1x1x1:1

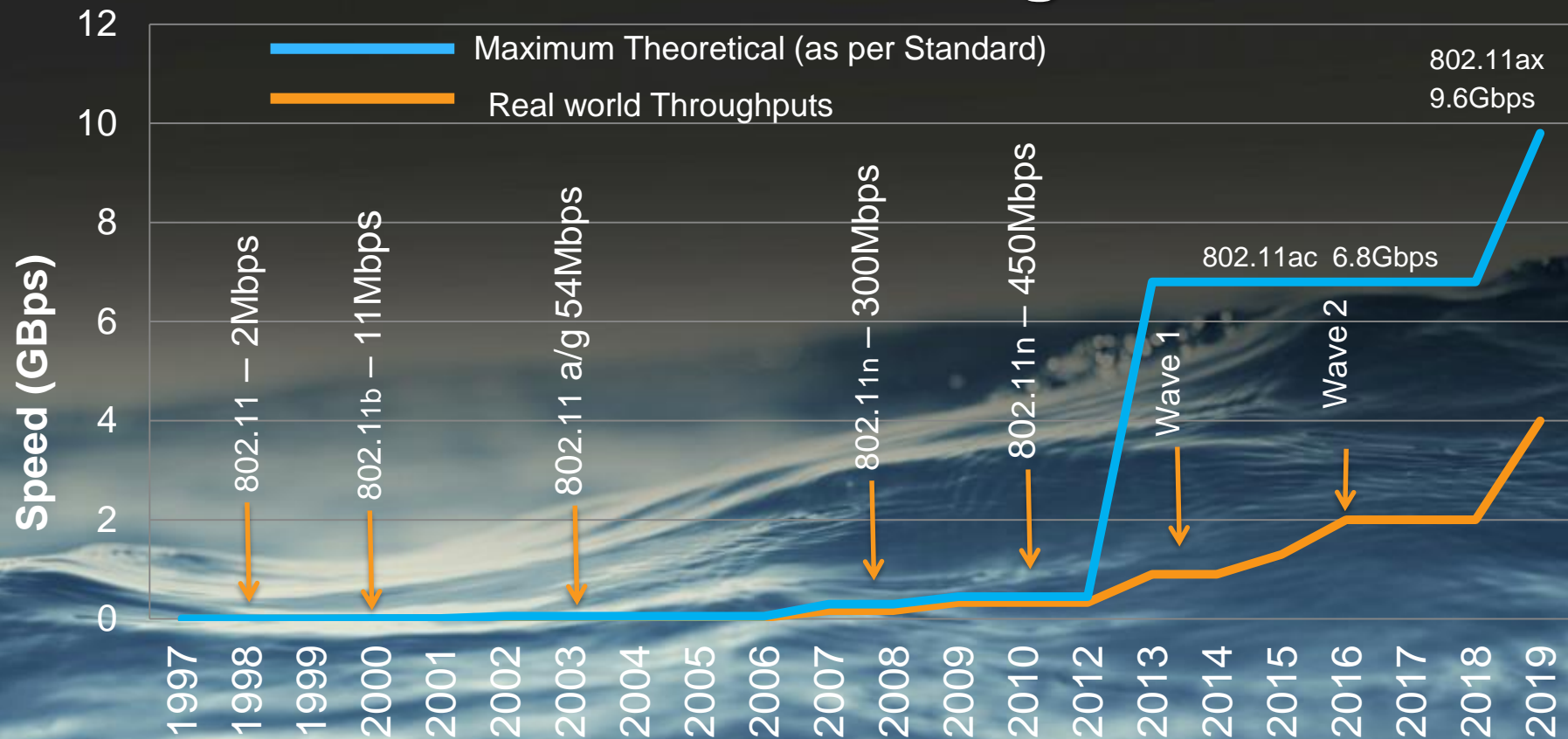


**2017**

1.7 – 3.4\*Gbps max assoc rate  
5Gbps Ethernet Uplink  
160Mhz Channel Width  
256 QAM  
MuMIMO 4x4x4:3

\* Only 2 SS @ 160MHz currently supported

# Wi-Fi Standards Progression





# Wi-Fi on Campus circa 2009



# Wi-Fi on Campus 2017



**Prioritize critical  
apps, ensure  
student success**



**Reliable Wi-Fi for  
100's of student  
devices at once**

# Performance Gains through Wi-Fi standards evolution

**802.11n**

130Mbps  
(multi client)

2009

**3.3X**

**802.11ac**

430Mbps  
(multi client)

2014





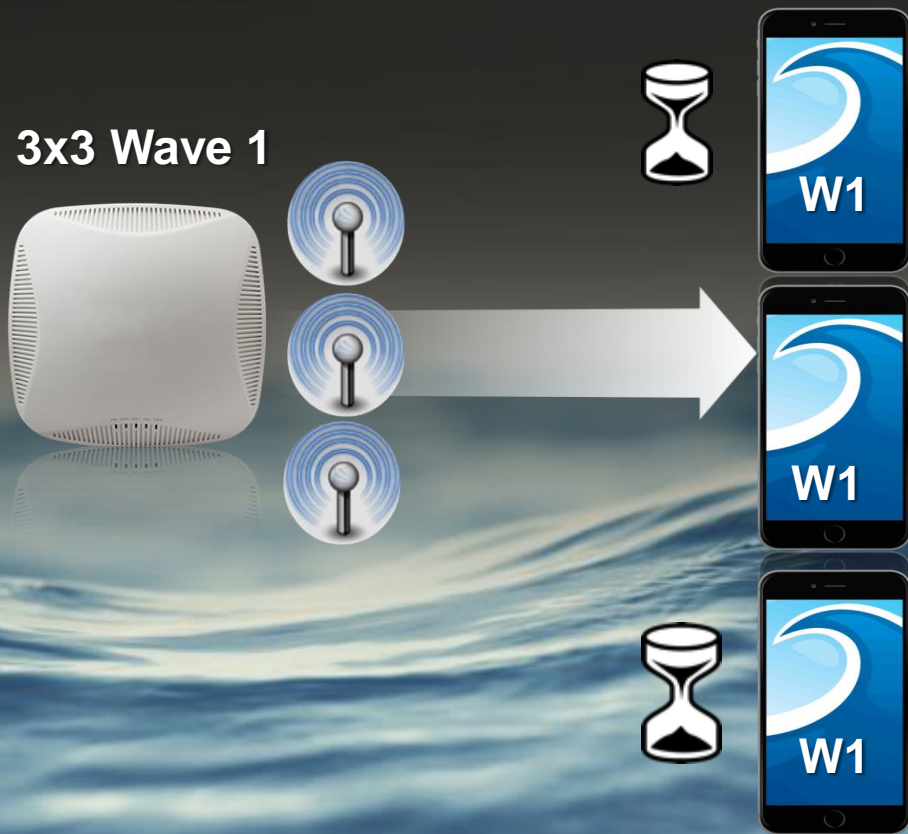
# Devices are not all Equal



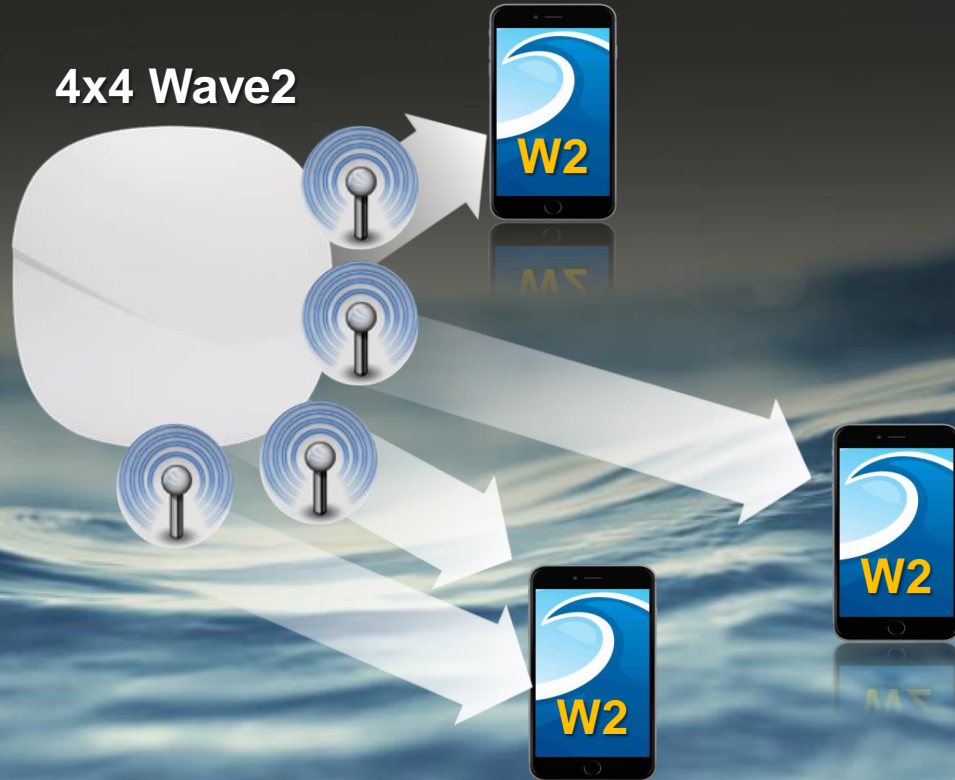


# The one user at a time issue

3x3 Wave 1



# Improvements with Multi-User MIMO



Up to 3 individual  
devices using  
4 stream multi-user  
MIMO

**Possible 1Gbps+  
throughput**

# What's next - 802.11ax



Up to 37 individual  
Bidirectional  
Simultaneous  
conversations using  
802.11ax\*

**Possible Multi Gbps  
throughput**

\*Assumes 80MHz Channel width





# Capacity is the key metric to measure Wi-Fi performance

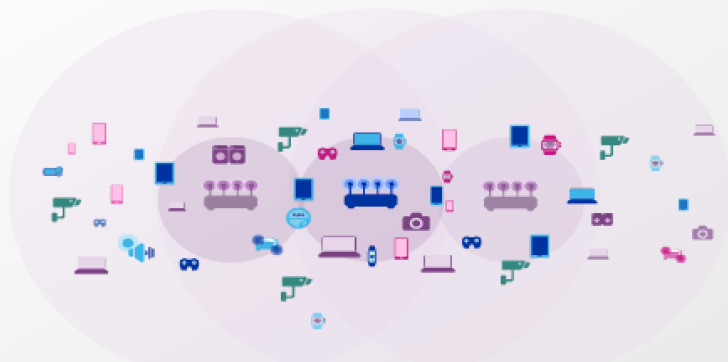
Moving away from simplistic theoretical peak speeds

Traditional approach  
“theoretical peak speed”



- Works for single AP with few devices

New approach  
Overall “capacity”



- Relevant for dense usage scenarios

2.4GHz/  
5GHz

802.11 g/n

802.11 ac

11ac MU-MIMO

802.11 ax

60 GHz

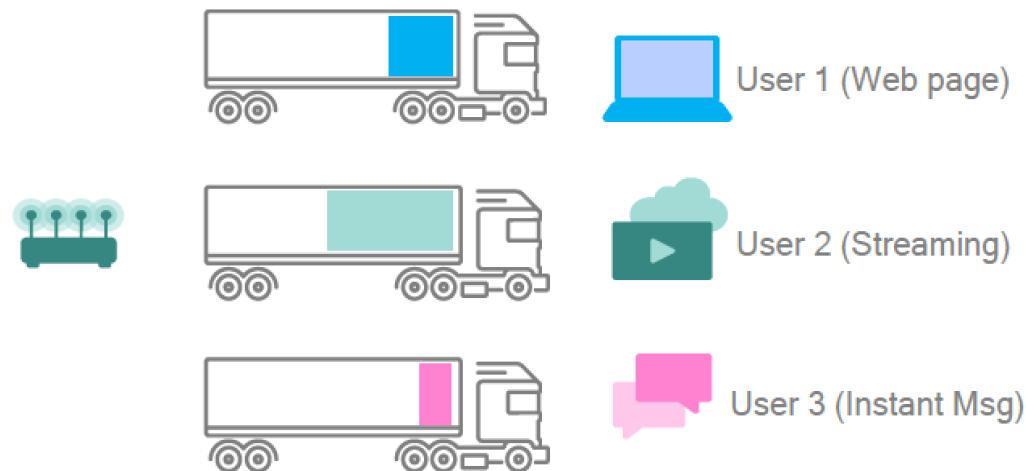
802.11 ad

802.11 ay

# OFDMA: Proven technology for efficient access

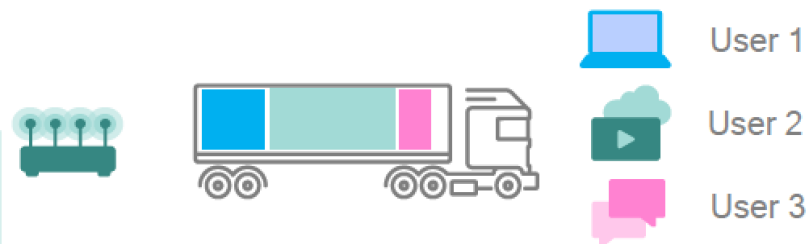
Foundation of global 4G LTE standard

## OFDM



- Fixed overhead independent of payload size
- Uses full channel bandwidth per user

## OFDMA



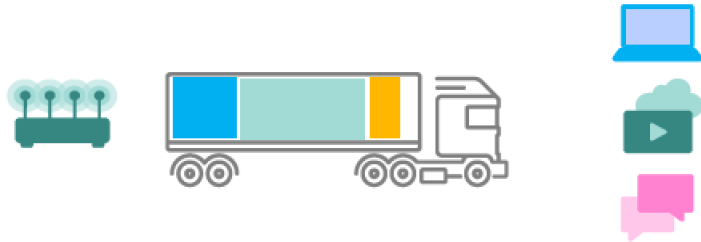
- Overhead amortized among users
- Efficient use of resources
- Scales resources for different types of traffic (e.g. IM vs large download)
- Increases overall efficiency



# OFDMA and MU-MIMO are complementary

Utilized based on the type of application being served

## OFDMA



- OFDMA increases efficiency
- OFDMA reduces latency
- Ideal for low-bandwidth applications

## MU-MIMO



- MU-MIMO increases capacity
- MU-MIMO results in higher speeds per user
- Ideal for high-bandwidth applications

MU-MIMO is similar to multiple trucks serving users simultaneously

# UL OFDMA & UL MU-MIMO

## Scheduled UL access for increased capacity and efficiency

### Contention based resource allocation (11ac)



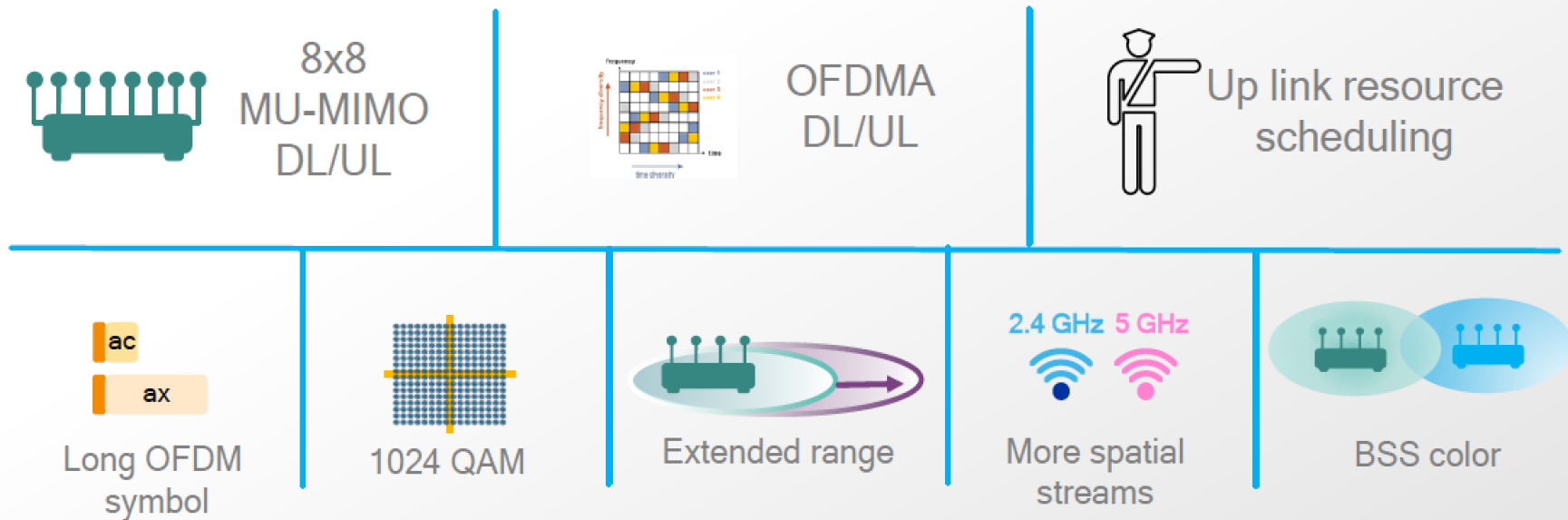
- Un coordinated resource management
- Devices all compete and try to get resource till they succeed
- Works well in single AP scenario

### Scheduling based resource allocation (11ax)



- Up link resource allocation managed by AP
- A must for dense scenarios
- Increased capacity and better user experience

# Technology building blocks of 11ax



**MU-MIMO and OFDMA expertise are key for success in 11ax**



# Analytics based on device location

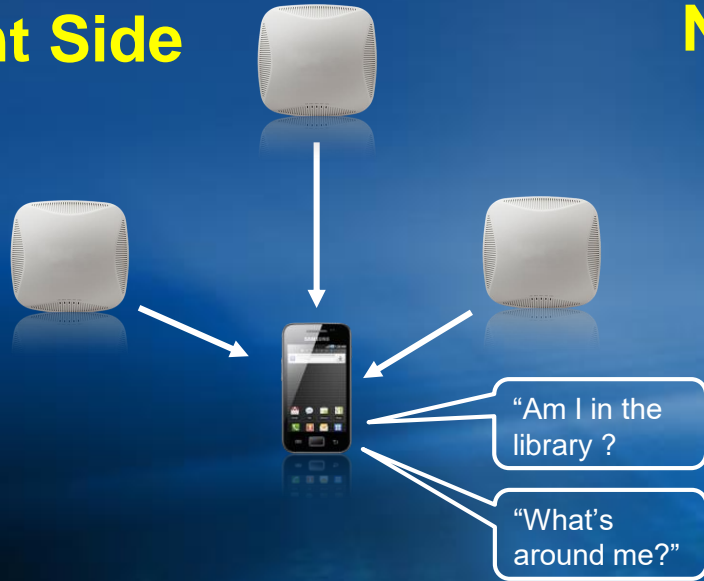


# Potential Uses for Student Location and Analytics

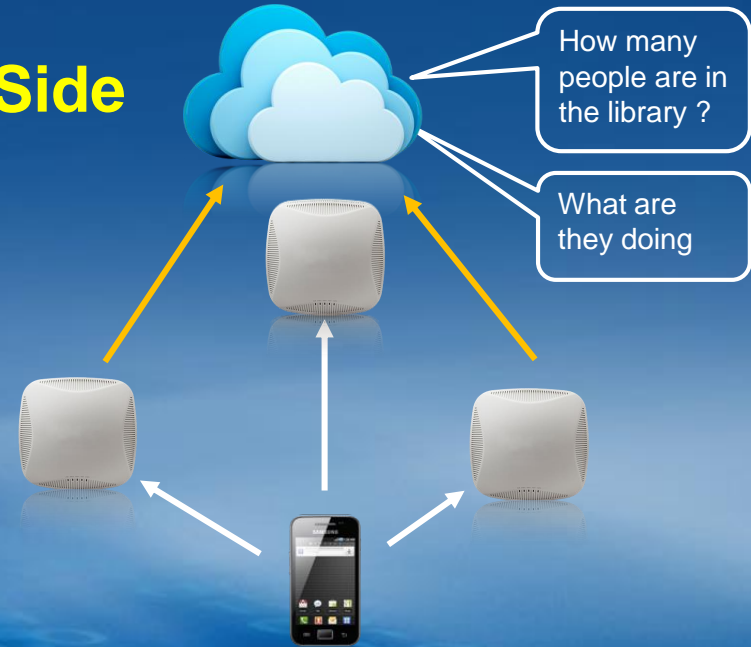
- How the space across campus is used
- How different demographic student groups use the campus space
- What are highly successful student space usage patterns?
- What are less successful student space usage patterns?
- Where is my fellow student
- How long do students remain in the same area
- Turn by Turn directions to a room or facility

# How can I calculate Location ?

## Client Side



## Network Side



- **Very Fast**
- **Very Accurate**
- **Needs App, Map and AP / Beacon Locations**

- **High Volume**
- **Slower calculation and accuracy**
- **Map and AP Locations are known**
- **No Client involvement**
- **Requires Location Engine**

# Bluetooth v Wi-Fi for Location Calculation





Live

Playback



00:00

10:00

23:00

Atmosphere - Jupiters - Ballroom

07/12/2016

+

-



1

206

530

1037

1830

*Jupiters*  
GOLD COAST

PAVILION BALLROOM  
ARUBA ATMOSPHERE ANZ  
CONFERENCE  
MONDAY 5<sup>TH</sup> - THURSDAY 8<sup>TH</sup>  
DECEMBER, 2016



Number of visits: **1,828**

Average dwell time: **1h:42m**

New/Returning split: **26% / 74%**

# Heatmap Reporting

## Reports

General Campaigns Devices Location Sharing Goals Heatmap

DATE & TIME

12/07/2016 12am



LEVEL

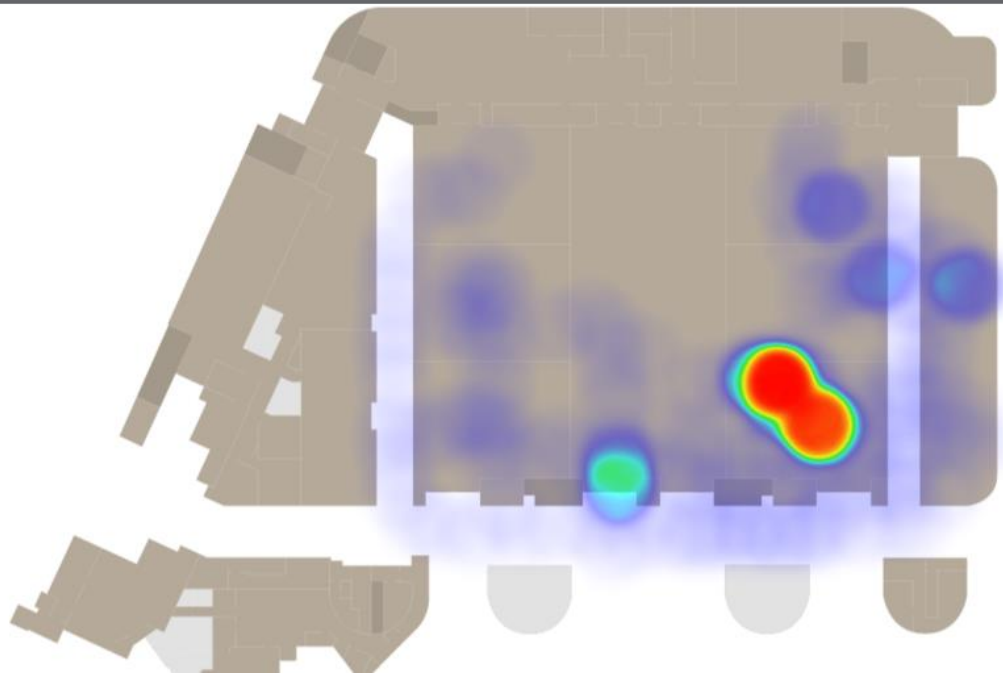
Pavilion



Pavilion

+

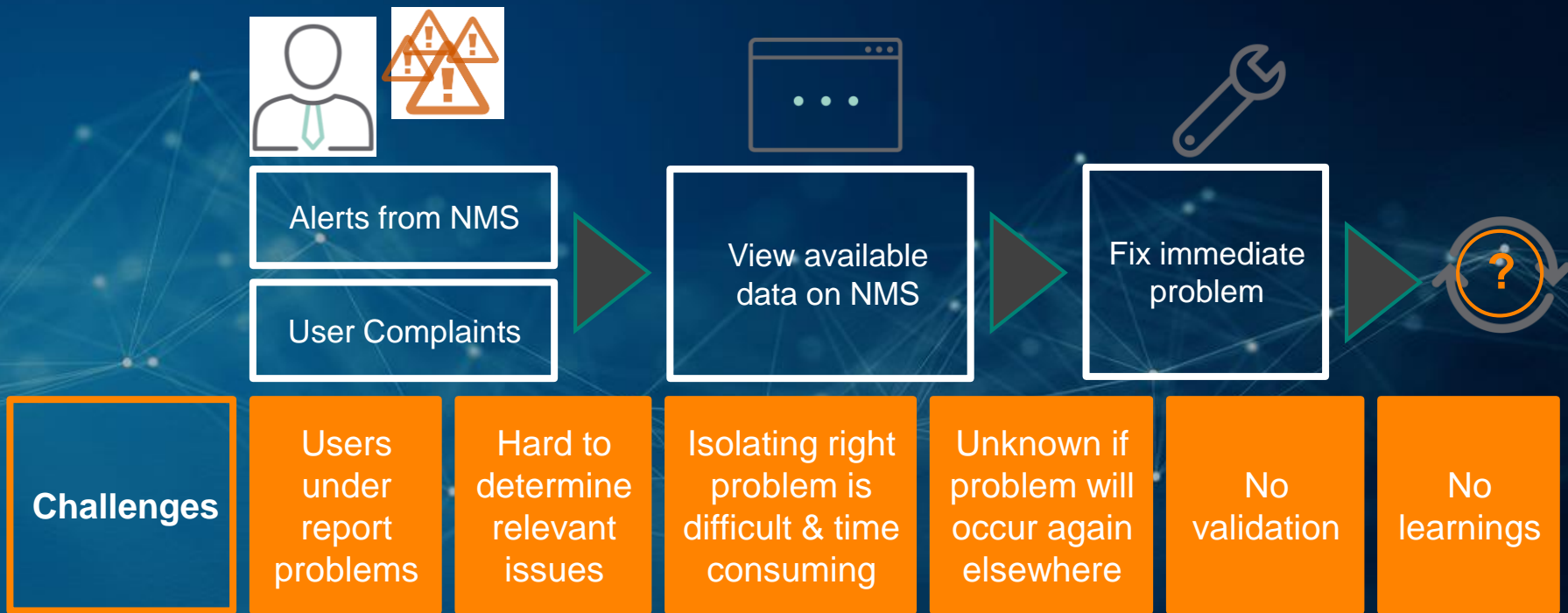
-



The background of the slide features a dark blue gradient with a faint, abstract network diagram. This diagram consists of numerous small, light-blue dots (nodes) connected by thin, light-blue lines (edges), creating a complex, web-like structure that spans the width of the slide. The nodes and lines are more densely packed in some areas and more sparse in others, giving it a dynamic, digital feel.

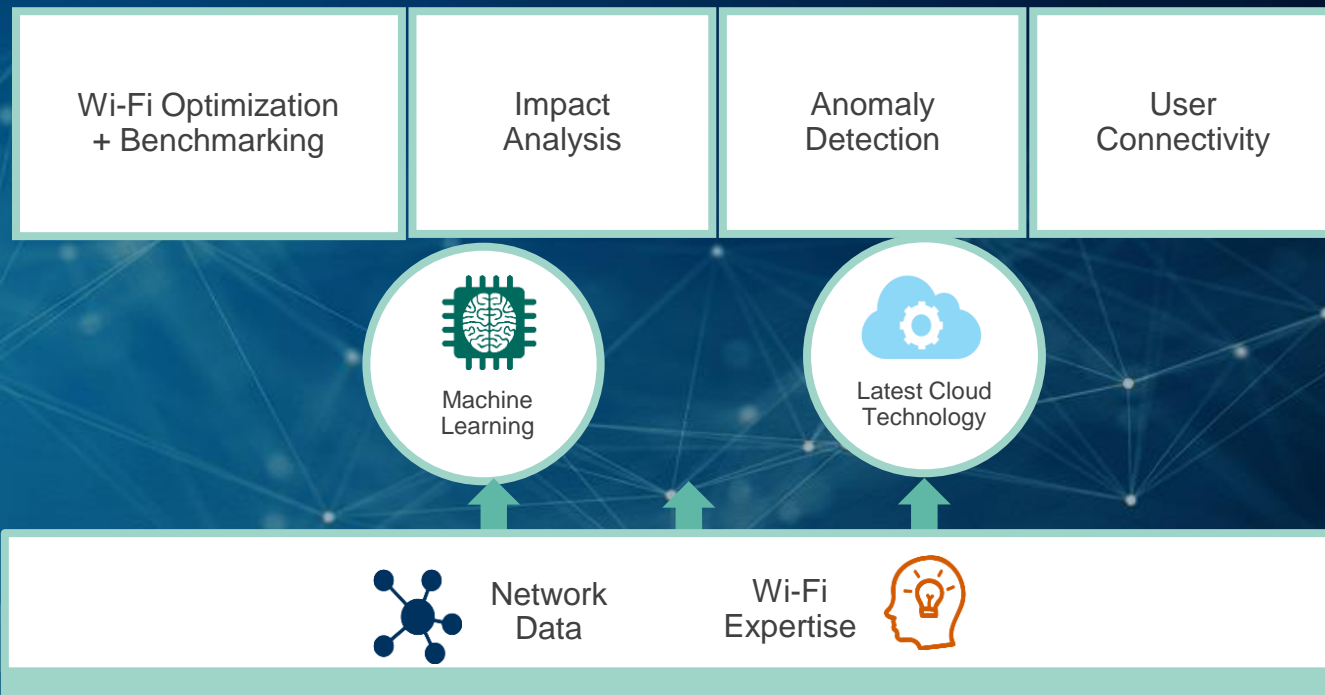
# Machine learning applied to network optimization and security

# How we fix network issues today





# Applying Machine Learning



# Security Landscape : Current Defenses Failing. Security Teams Overwhelmed



**PREVENTION & DETECTION  
NOT ENOUGH  
INCREASINGLY POROUS**



**MONITORING SYSTEMS  
FALLING SHORT  
CANNOT DETECT UNKNOWN THREATS  
AND UNABLE TO SCALE**

# Automated Detection of Threats Inside the Organization



**ATTACKS AND  
RISKY BEHAVIORS**  
on the inside

Compromised  
Users & Hosts

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Negligent  
Employees

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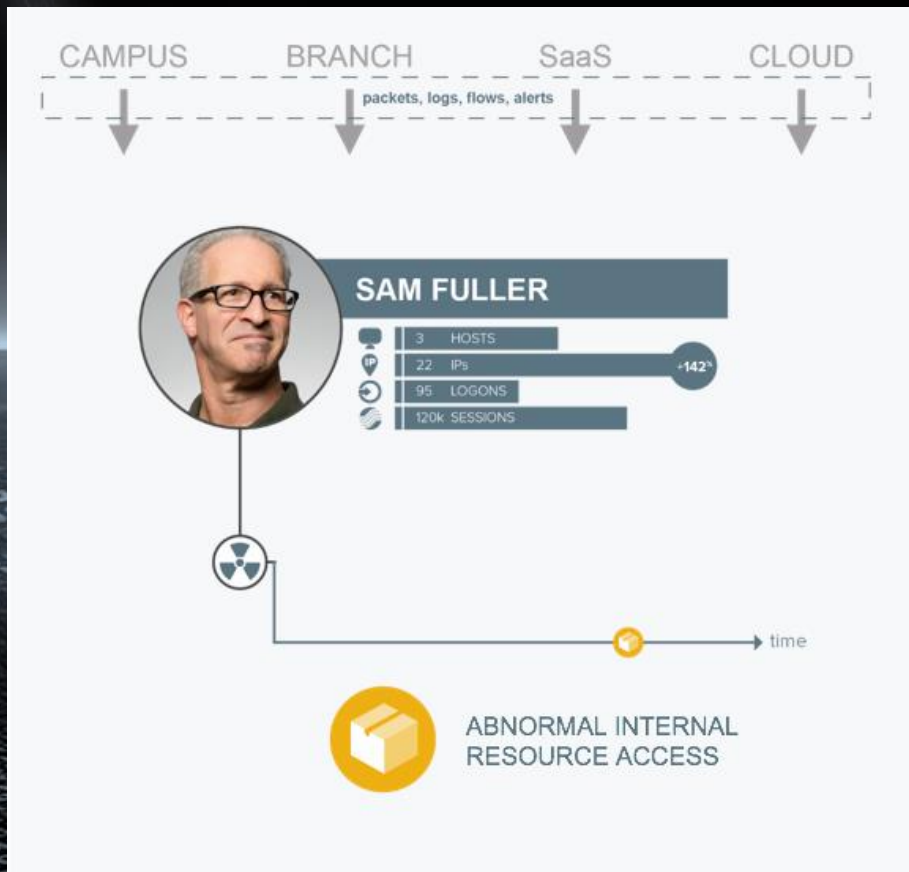
Malicious  
Insiders

# Looking for Small Changes That May Indicate Attack

MACHINE LEARNING  
UNSUPERVISED

Behavioral  
Analytics

BASELINES  
HISTORICAL  
+  
PEER GROUP





# Finding the malicious in the anomalous

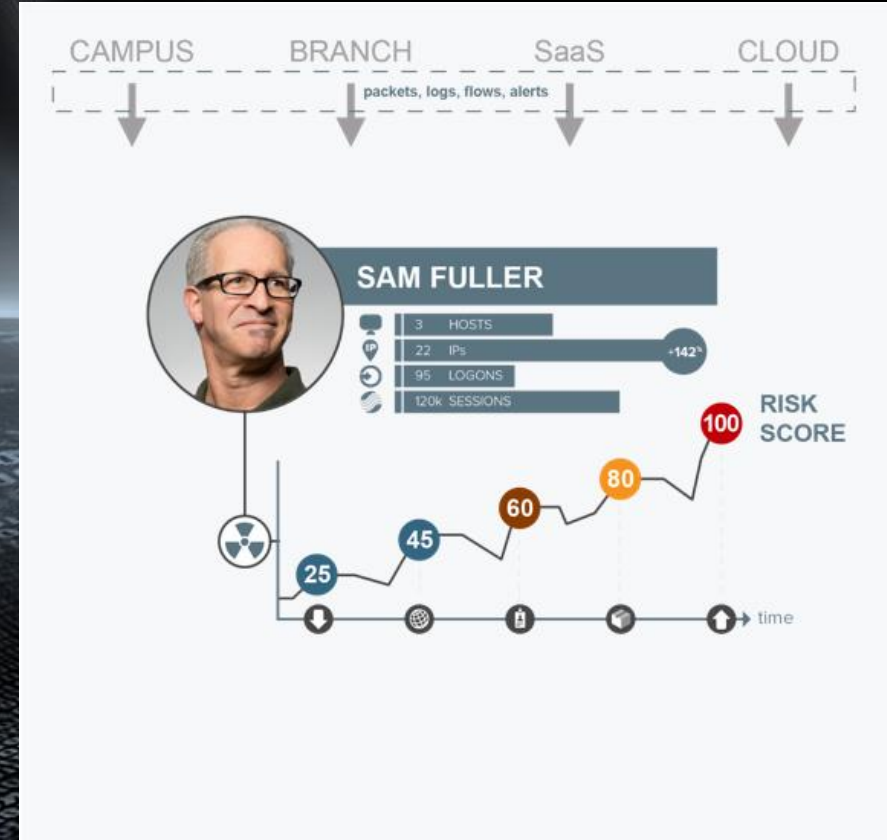


## MACHINE LEARNING

SUPERVISED  
UNSUPERVISED

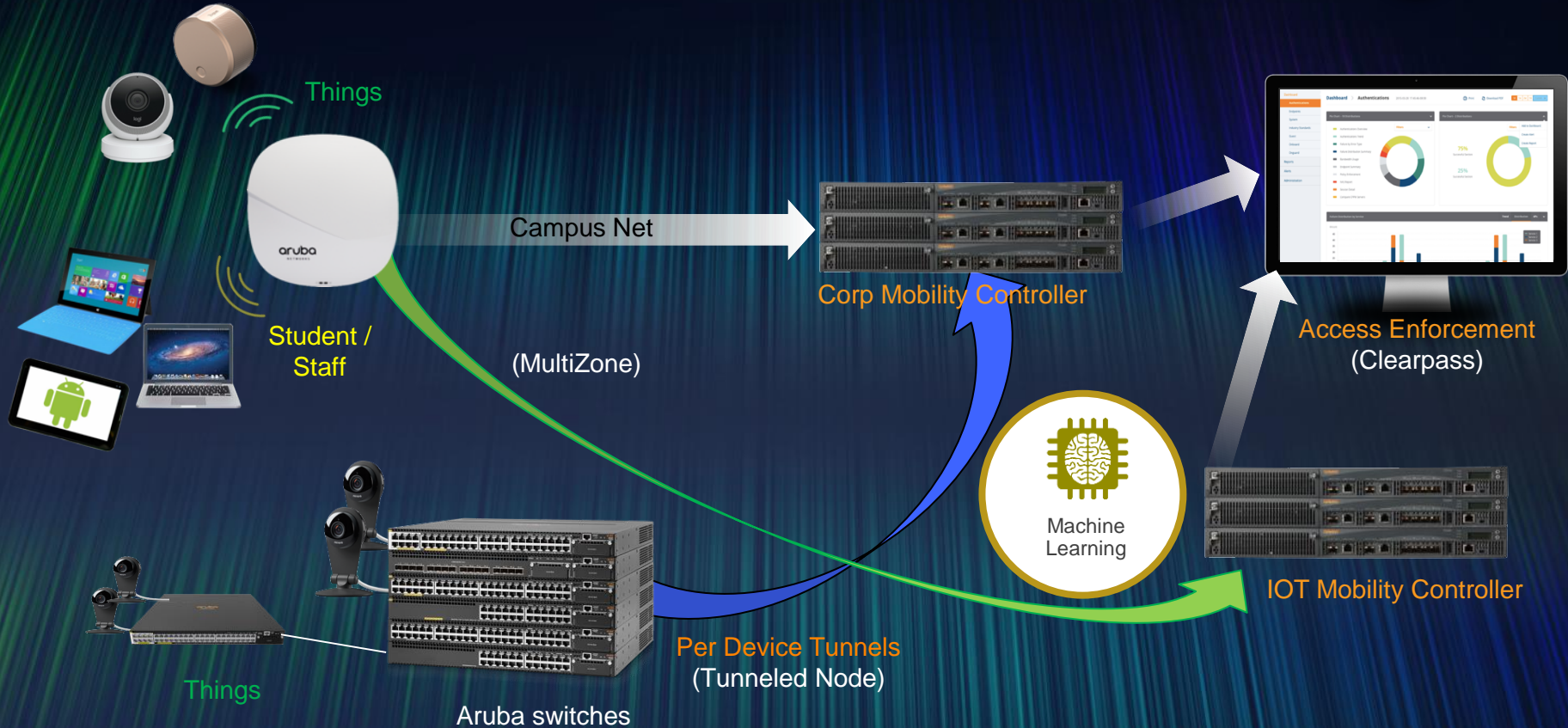
## THIRD PARTY ALERTS

DLP  
Sandbox  
Firewalls  
STIX  
Rules  
Etc.





# Campus IOT Access Security Framework



# The Aruba Community

Join Airheads

Become an expert

The screenshot shows the Airheads Community website. The top navigation bar includes the Airheads logo, a search bar, and links for Register, Sign In, Help, and Menu. The main content area is divided into several sections: 'FEATURED' with links to Airheads Technical Webinars, 2017 Community MVPs, and a blog post about leveraging Aruba Advanced Security; 'DISCUSS' with a link to a 3200M ROW on AOS 6.4.3.6; and a 'Search Airheads' section with a search bar and a 'Global Discussions' sidebar. The bottom section shows a list of posts under the 'Education - Australia / New Zealand' group, including topics like 'More on IOT and possible impact to your school', 'Securing Mobility in Education - YouTube video', and 'Updated CLI comparison guide (Provision/Comware/Cisco) now available: V3.2'.

The screenshot shows the Aruba Central Training website. The top navigation bar includes the Aruba logo, a search bar, a language selector (English (US)), a Contact Sales button, and a Menu icon. The main content area is titled 'Central Training' and lists four modules: 'Module 1 - Introduction', 'Module 2 - Setup', 'Module 3 - Configuration', and 'Module 4 - Guest Access'. Each module has a brief description and a 'Watch now' link. The right side of the page features a vertical navigation menu with icons for each module.

**57,000+ Airheads!**  
[community.arubanetworks.com](http://community.arubanetworks.com)

**How-to Videos**  
[www.arubanetworks.com/products/networking/central-training/](http://www.arubanetworks.com/products/networking/central-training/)



# How does Wi-Fi energy compare to a mobile phone energy

## Based on dBm Math

Max Transmit power from GSM mobile handset

(some can do 2 watts)

This is placed next to your head

$$\begin{array}{rcl} 1 \text{ watt} & & 1 \\ 1000 \text{ mw} & & \hline 30 \text{ dBm} & & 1 \end{array} \text{ of a watt}$$

A normal design for RF delivery to all locations in a WLAN design

The level of Received RF - RSSI

This is RF power at your laptop or tablet

$$\begin{array}{rcl} -66 \text{ dBm} & & 1 \\ 0.00000000025 \text{ watt} & & \hline 0.00000025 \text{ mw} & & 4,000,000,000 \end{array} \text{ of a watt}$$

*RF from Wi-Fi – 4 **Billion** times less*

An aerial view of a city at dusk or dawn, with a network overlay of glowing nodes and connecting arcs. The nodes are positioned at various points across the city, with arcs connecting them in a web-like pattern. The background shows a dense urban landscape with numerous buildings and a highway on the right side.

# aruba

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