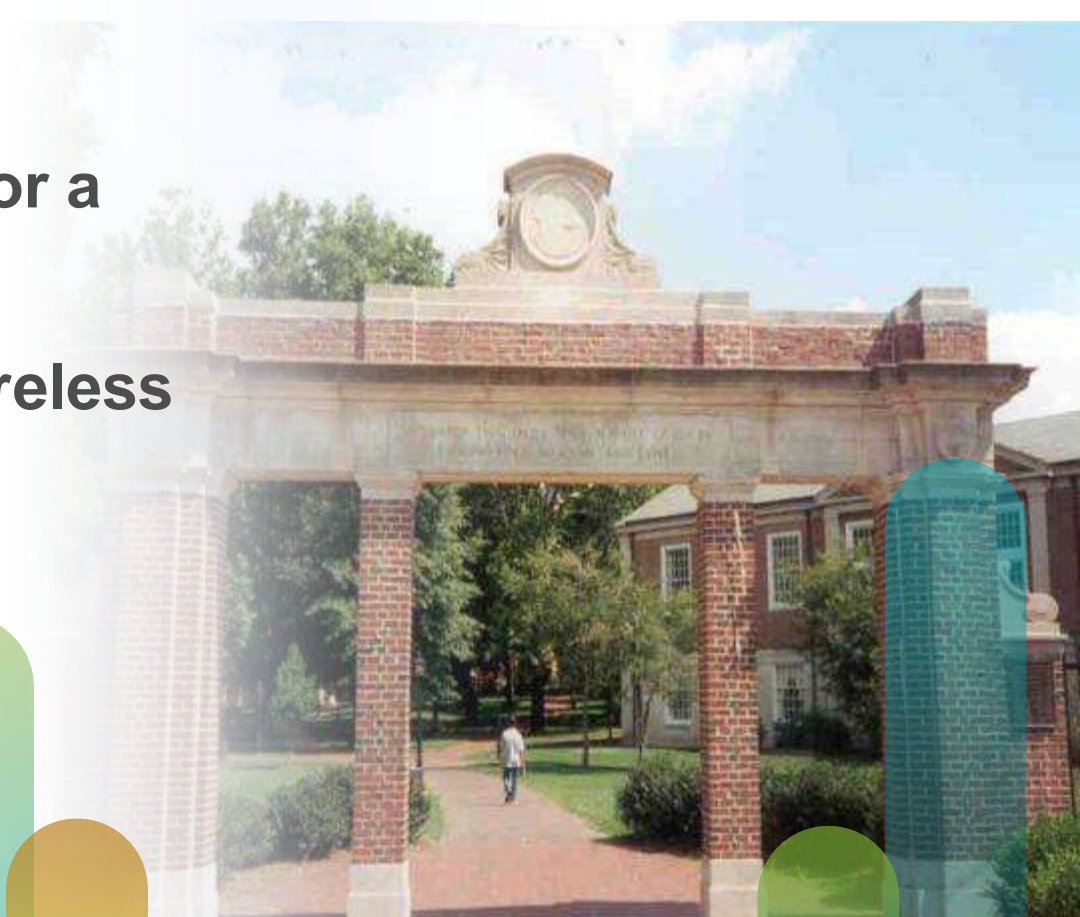


# Designing Wireless for BYOD devices in Stadiums

# Agenda

- **Market Trends**
- **“Pie in the Sky” needs for a BYOD Program**
- **Challenges of Dense Wireless and BYOD devices**
- **The Cisco Solution**
- **Stadium Deployments**



# Users Are Driving Demand for Rich Mobile Experiences

7B additional Mobile Devices



2015

Global Mobile Traffic Will Grow 26x



**Video Will Be 66% of All Mobile Traffic**

Source: Cisco Visual Networking Index (VNI) Global Mobile Data Forecast, 2010–2015



# So have you Planned for This????

Students and Faculty expect to be connected wherever they are learning

Simpl  
e

Secur  
e

Reliable



ANY USER



ANY DEVICE



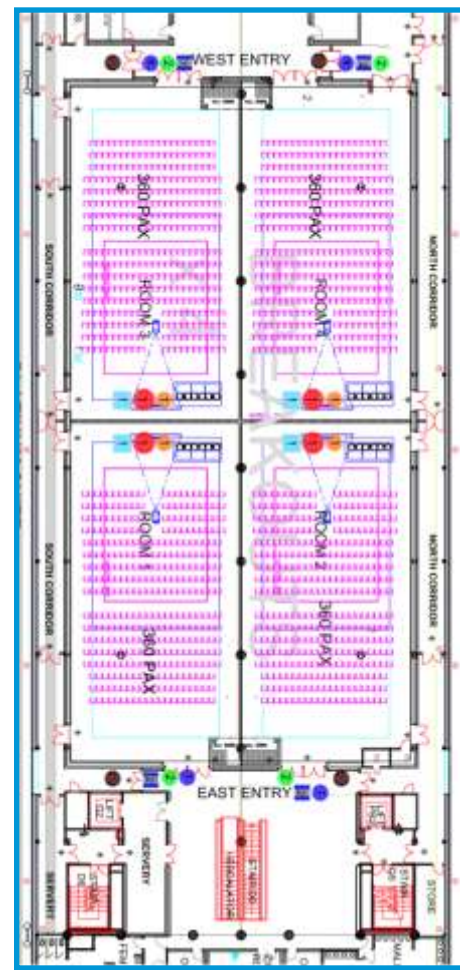
ANYWHERE



ANYTIME

# High Density Clients

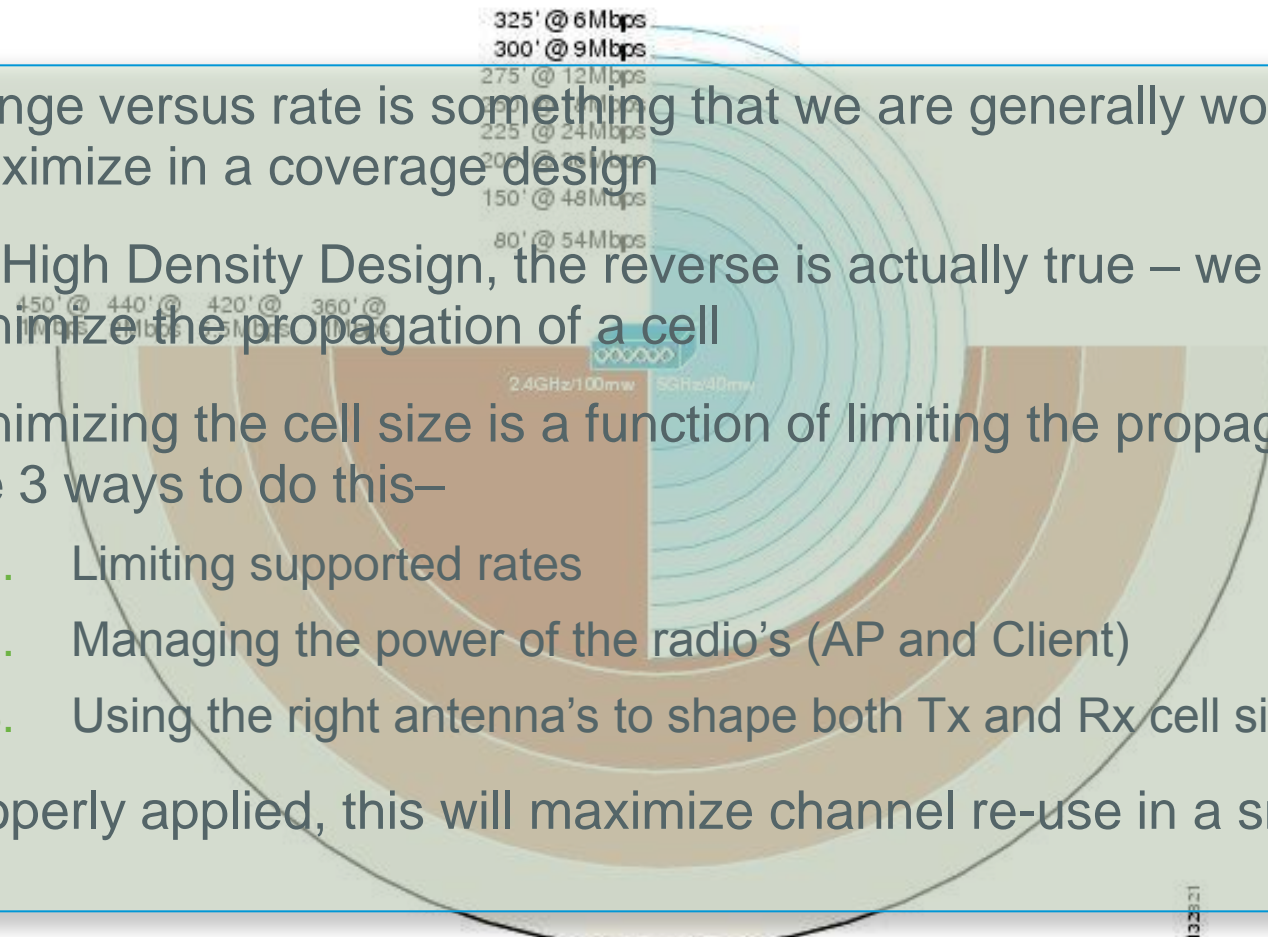
- Contrast “normal” with these assumptions
- If sitting in a theater style seat, place your hand on the back of the seat in front of you – that’s about 36 inches, 3 feet
- The average seat width is 24 Inches
- 3 ft x 2 ft, lets assume 1m x 1m or 1 m<sup>2</sup>
- In the user seating – that’s 1 device per 1m<sup>2</sup> 1/9-1/3 dev/sq ft



**The “New Normal” is more than 1 device/Mac per User**



# Channel Efficiency

- 
- Range versus rate is something that we are generally working to maximize in a coverage design
  - In High Density Design, the reverse is actually true – we want to minimize the propagation of a cell
  - Minimizing the cell size is a function of limiting the propagation, there are 3 ways to do this—
    1. Limiting supported rates
    2. Managing the power of the radio's (AP and Client)
    3. Using the right antenna's to shape both Tx and Rx cell size and isolate
  - Properly applied, this will maximize channel re-use in a small space

# Characteristics of BYOD Devices

Different Devices require Different Levels of Wi-Fi Support

- iPads, Smartphones, Tablets, and many PCs are bad WiFi clients and likely to always be bad!
  - Long battery life implies Single Stream
  - Very poor WiFi devices
    - Gain is as bad as -7dB as measured in Cisco Labs  
~1/4 the distance for a given power level compared to a laptop. Laptop typical -3dB => +3dB
- iPads Smartphones and Tablets are hard to manage, Hard to troubleshoot
- iPads Smartphones and Tablets Very poor security....
  - Until the industry makes these devices as secure as a PC we have to enforce security on the network side.
    - Eg control where they go, control what they can access....
  - Cached passwords, trivial passwords... do you want this to have the keys to the kingdom? Teachers do grades on their iPhone???

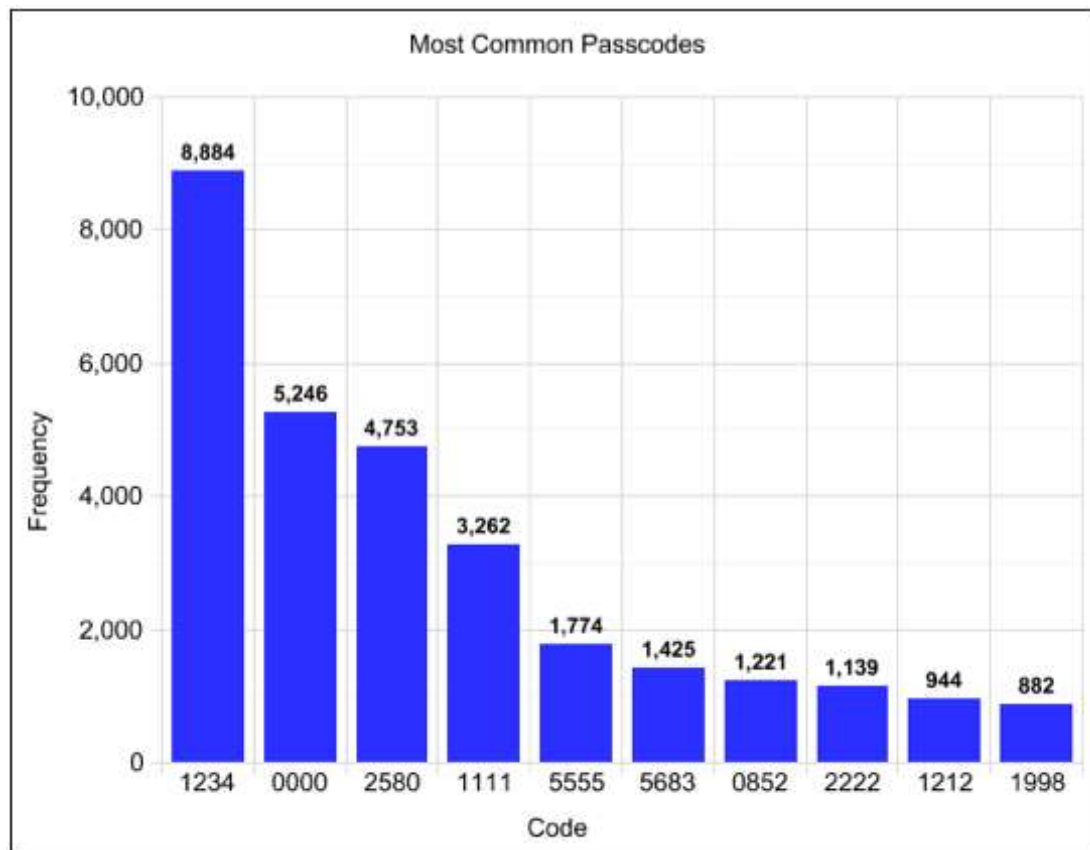
**They Don't Behave the Same on Your Campus Network**

# Results-

	Ipad - 1	Iphone-4	Moto-Xoom	Galaxy S2	Galaxy Tab
					
Measured - best	-33 dBm	-39 dBm	-34 dBm	-31 dBm	-33 dBm
Pathloss	46 dB	46 dB	46 dB	46 dB	46 dB
RSSI	13 dBm	7 dBm	12 dBm	15 dBm	13 dBm



# Security? Most Common Passcodes on iDevices



- 15% of all passcode sets were represented by only 10 different passcodes
- A thief could safely try 10 different passcodes on an iPhone without initiating the data wipe.
- With a 15% success rate, about 1 in 7 iPhones would easily unlock
- Even more if the intruder knows the users' years of birth, relationship status, etc.

# Gartner says, “iPad requires 300% more APs!”

...but not with Cisco!

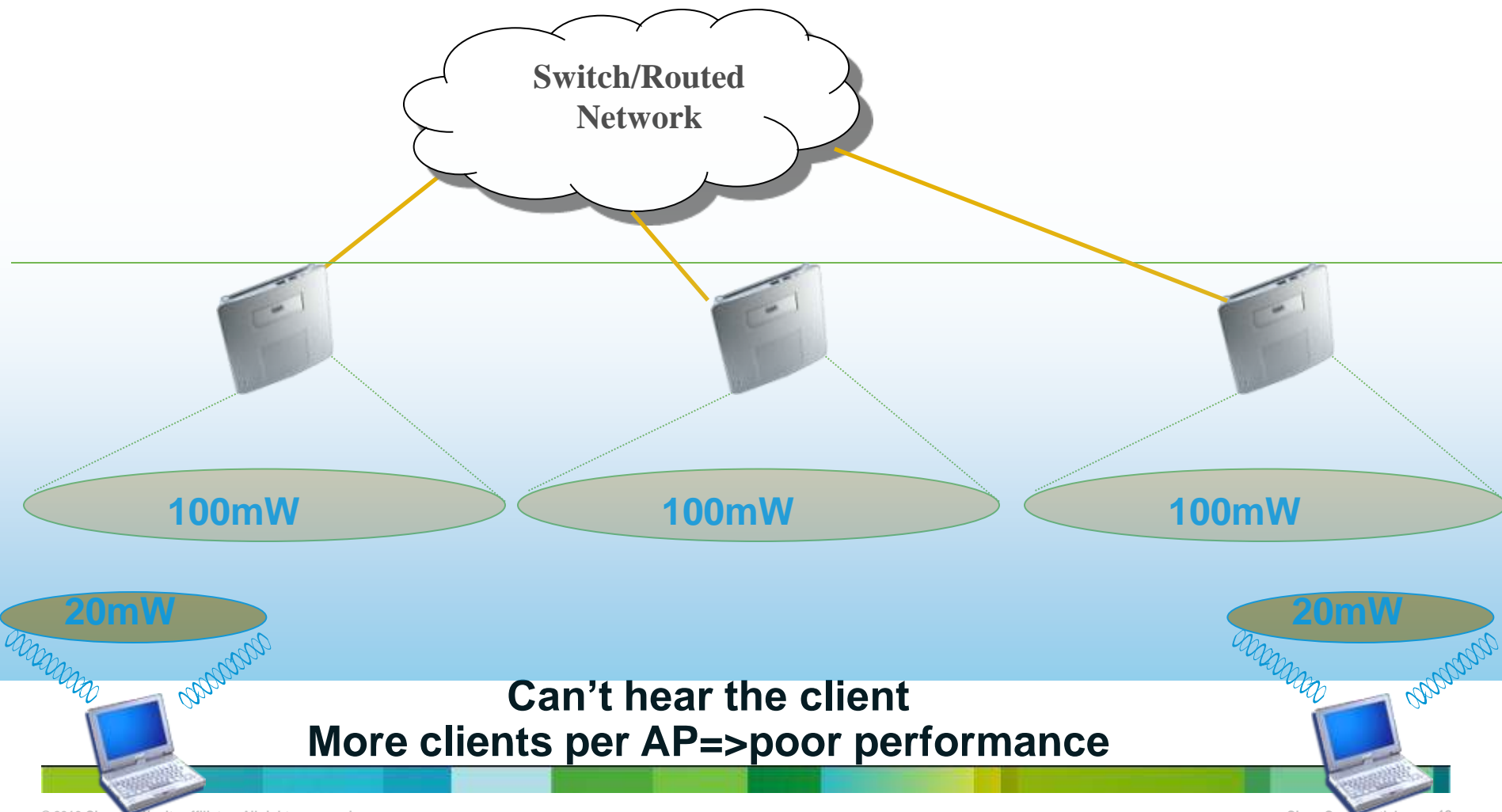
- “...while the iPad may connect, performance will fall off much more quickly than laptops as the user moves away from the access point”
- “...(iPad) may find itself in a coverage hole at the edge of the coverage area where other devices are able to operate.”
- 2.4GHz is not acceptable. Must implement dense 5GHz coverage
- Cisco 3600 has superior coverage as the industries only 4X4 MIMO and is the only AP set for the future.

Most important thing for iPads  
and BYOD is stable RF!!!!

Can't do this anymore.....

# Loud APs and Quiet Clients

Clients at the edge drop to low data rates!!!

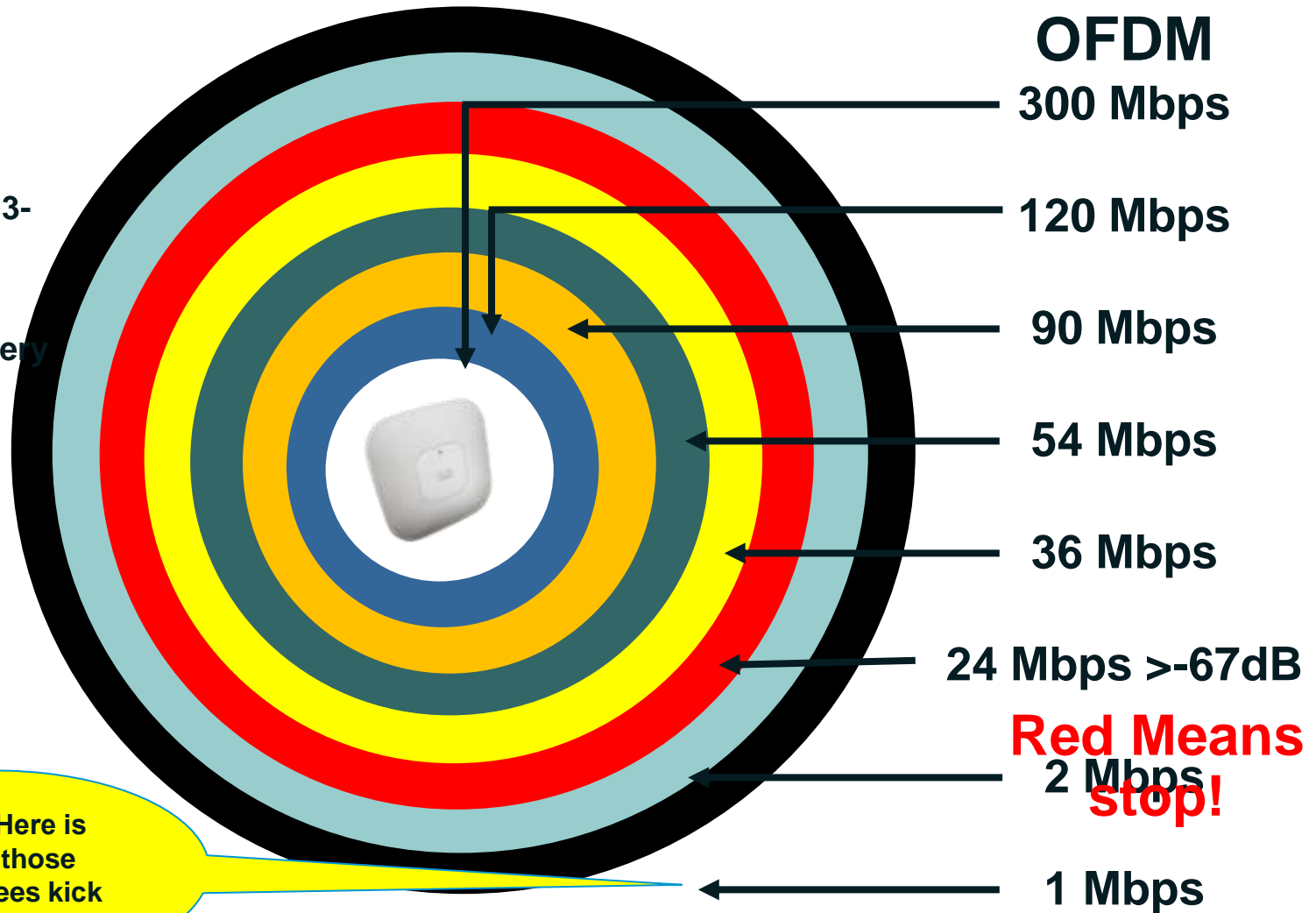




# iPads and BYOD Requires smaller cells!

## •Rules of Thumb

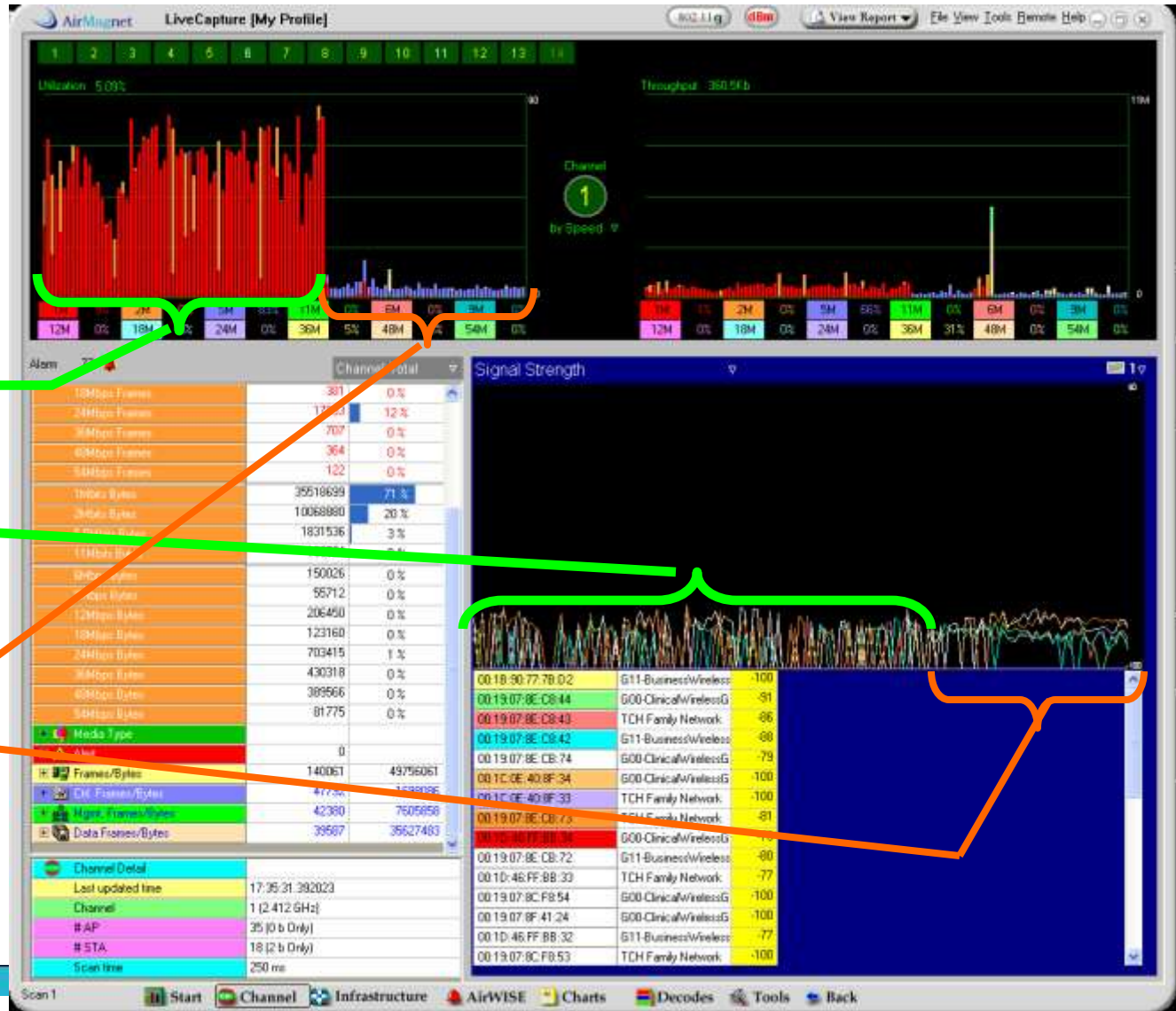
- 1 AP for ever 3-5000 sq ft
- 67to -70dB
- ~2 APs for every 3 Classrooms



BTW...Here is where those Guarantees kick in....

# Shut off 802.11b!!! Channel Utilization –

## What Made the Difference?



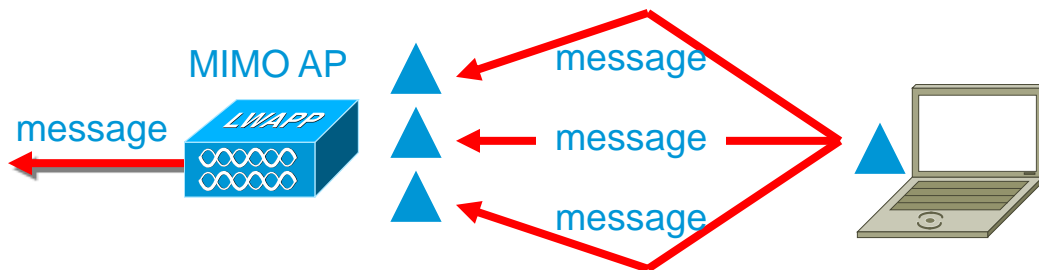
What made  
this  
dramatic  
change?  
Before

5% After

# MIMO Overview

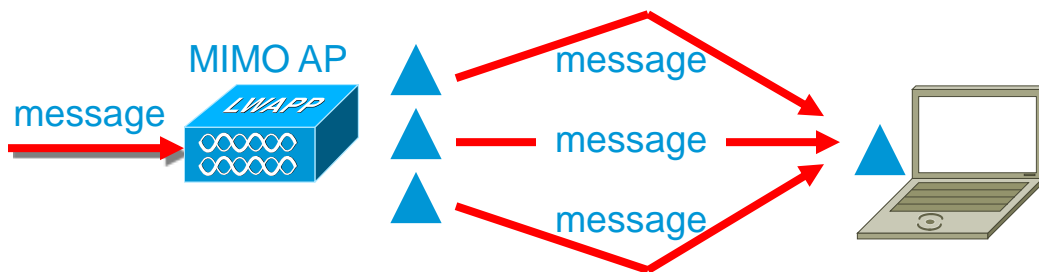
## Maximal Ratio Combining

- Performed by receiver
- Combines multiple received signals
  - Increases receive sensitivity
- Works with non-MIMO and MIMO clients



## Transmit beam forming

- Performed by transmitter
- Ensures signal received in phase
  - Increases receive sensitivity
- Works with non-MIMO and MIMO clients



## Spatial Multiplexing

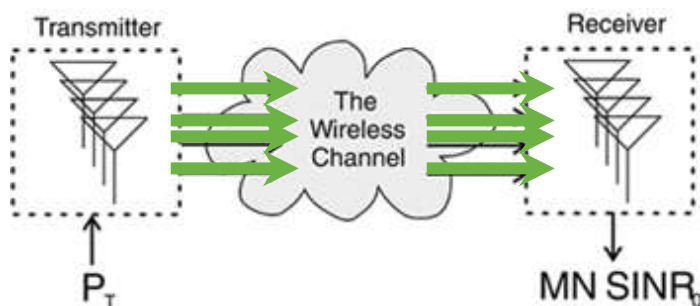
- Transmitter and receiver participate
- Multiple antennas txmt concurrently on same channel
  - Increases bandwidth
- Requires MIMO client



# 802.11n Operation

## Multiple Input Multiple Output (MIMO)

- Multipath used to improve signal fidelity
- Line-of-sight becomes baseline
- Requires multiple transmitters and receivers
- Multiple streams of data



Multiple Input Multiple  
Output (N x M)



# 802.11n Operation

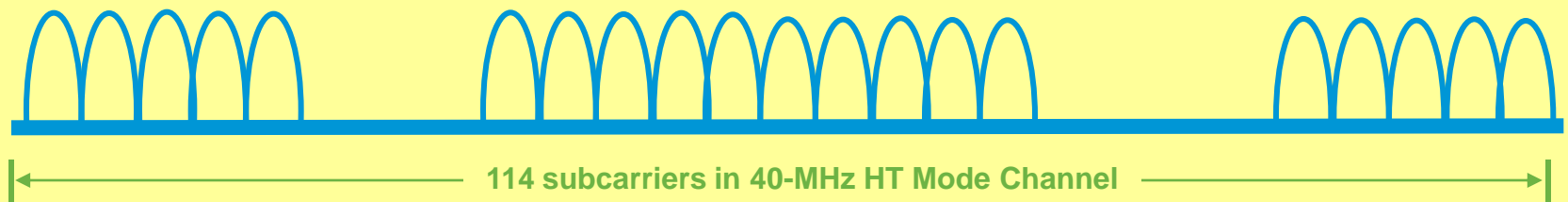
## PHY Efficiency – Additional OFDM Subcarriers



802.11g/a



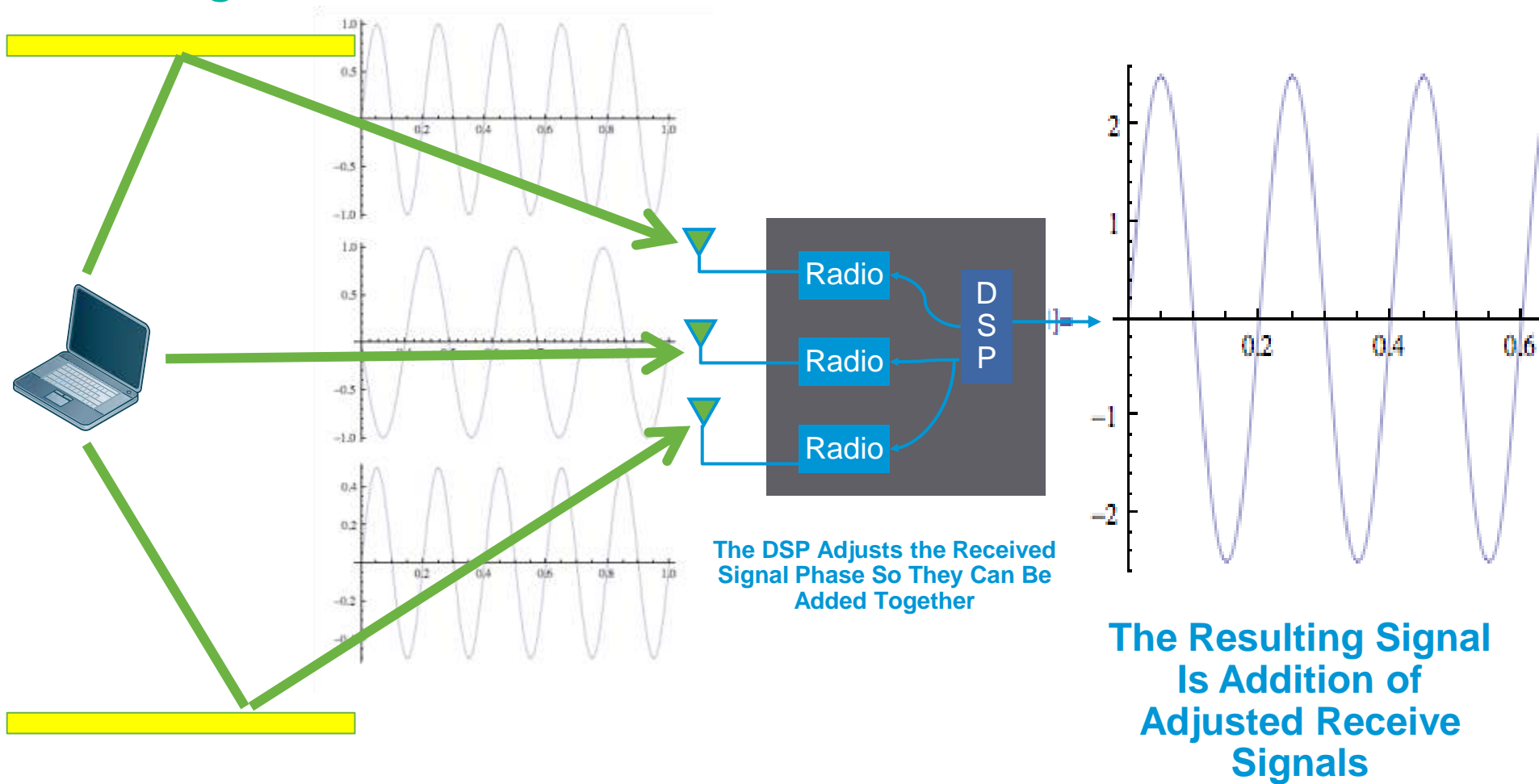
802.11n



# Implementing Dense Wireless

1:1 and above computing...

# MRC Maximal Ratio Combining: *Hearing the Quiet Client*

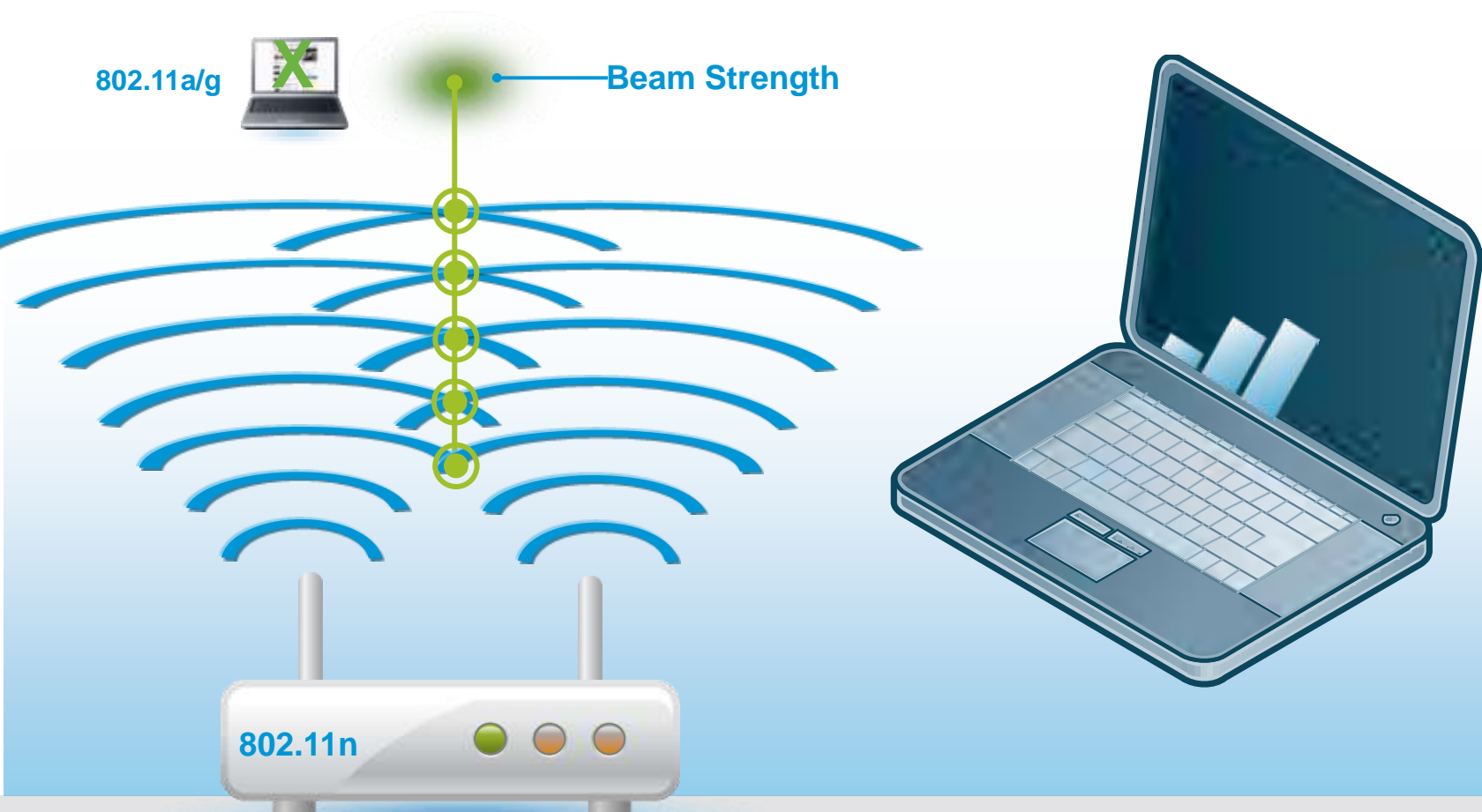


**Multipath Reflections  
of Original Signal**

**More receivers mean better wireless**

# Existing 802.11n Solutions

## Beam Strength Not Directed to Client

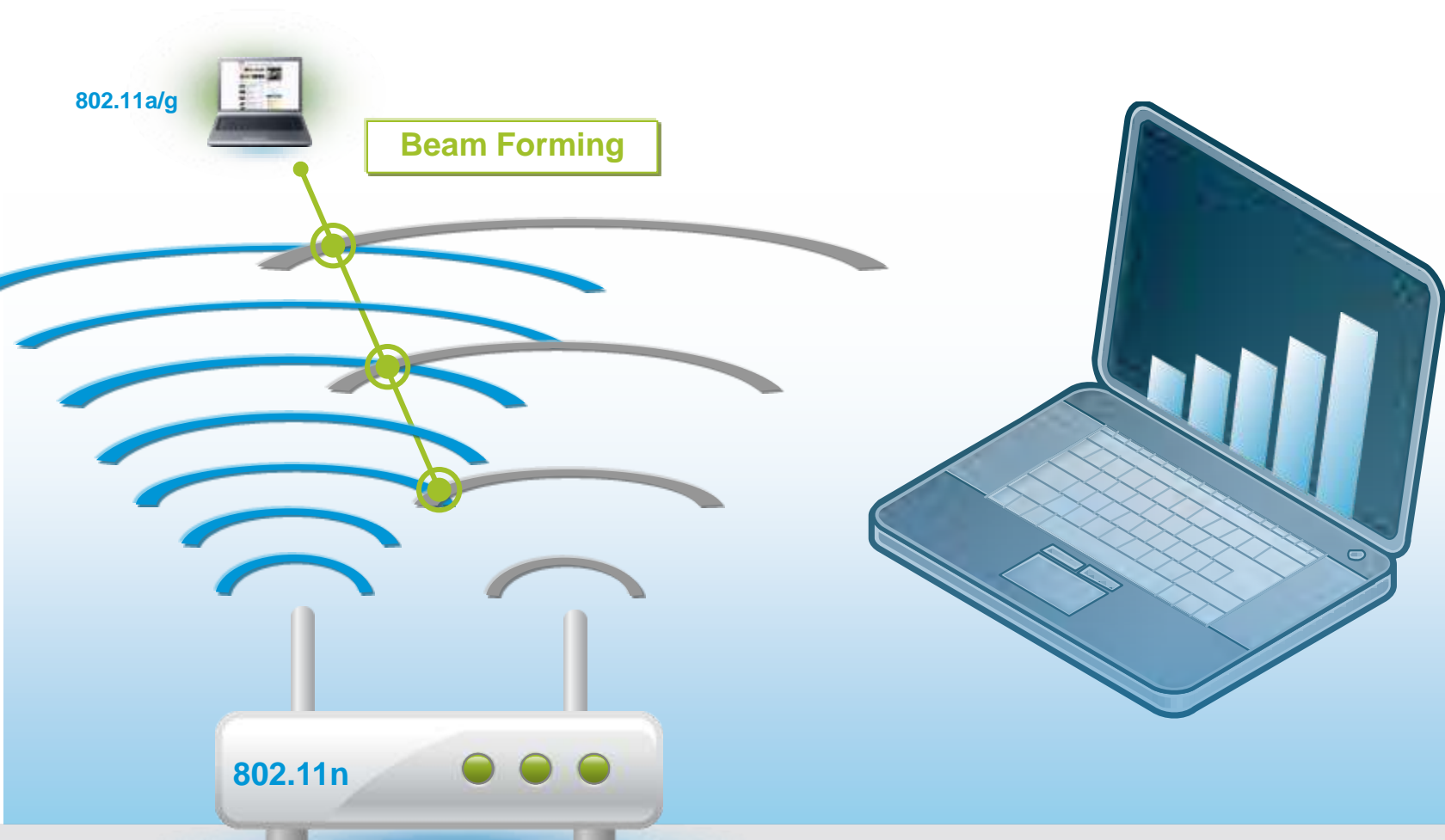


**802.11a/g/n Client Connection Not Optimized,  
Creates Coverage Hole**



# Cisco ClientLink 2.0

Cisco Innovation: Beam Forming Intelligence

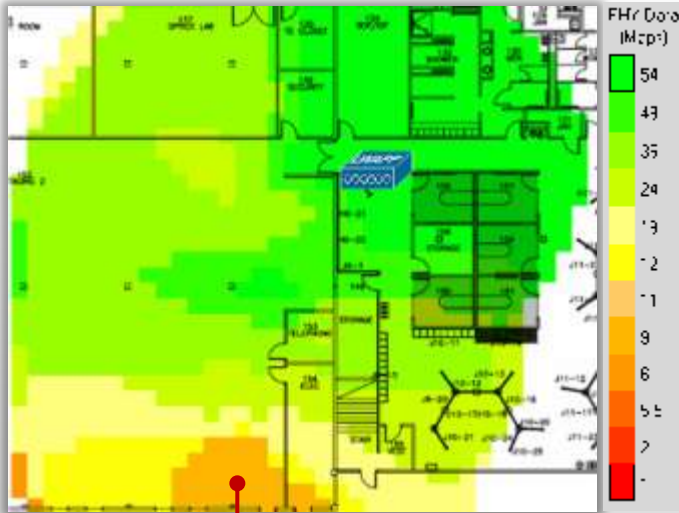


**ClientLink uses Beam Forming to Direct Signal to Improve Performance and Coverage for 802.11a/g/n**

# Why Is Cisco's ClientLink so Unique?

Reduces coverage holes and improves client performance

**BEFORE**  
Client-link disabled

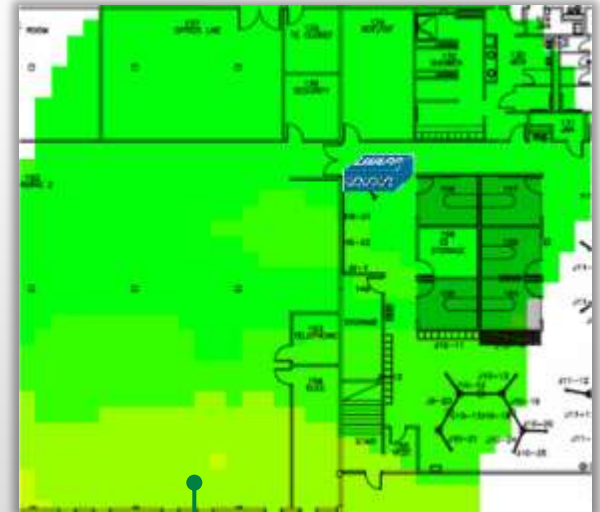


**Lower Data Rates**

**Wireless Client Performance**



**AFTER**  
Client-link enabled



**Higher Data Rates**

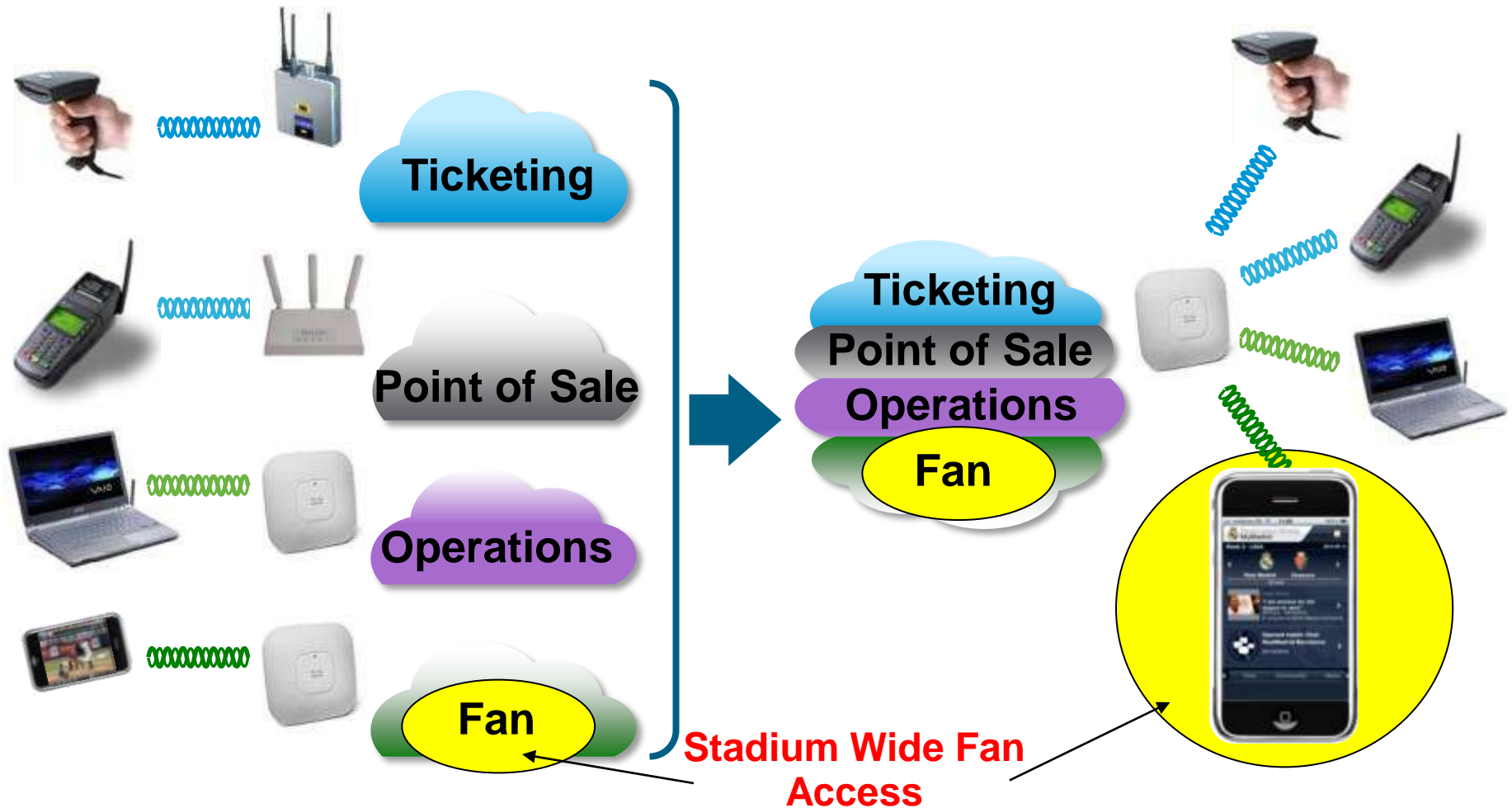
**Miercom**

## Up to 65% Improved Throughput for iPads

# Deploying High-density WLANs in Complex RF Environments

# Connected Stadium Wi-Fi

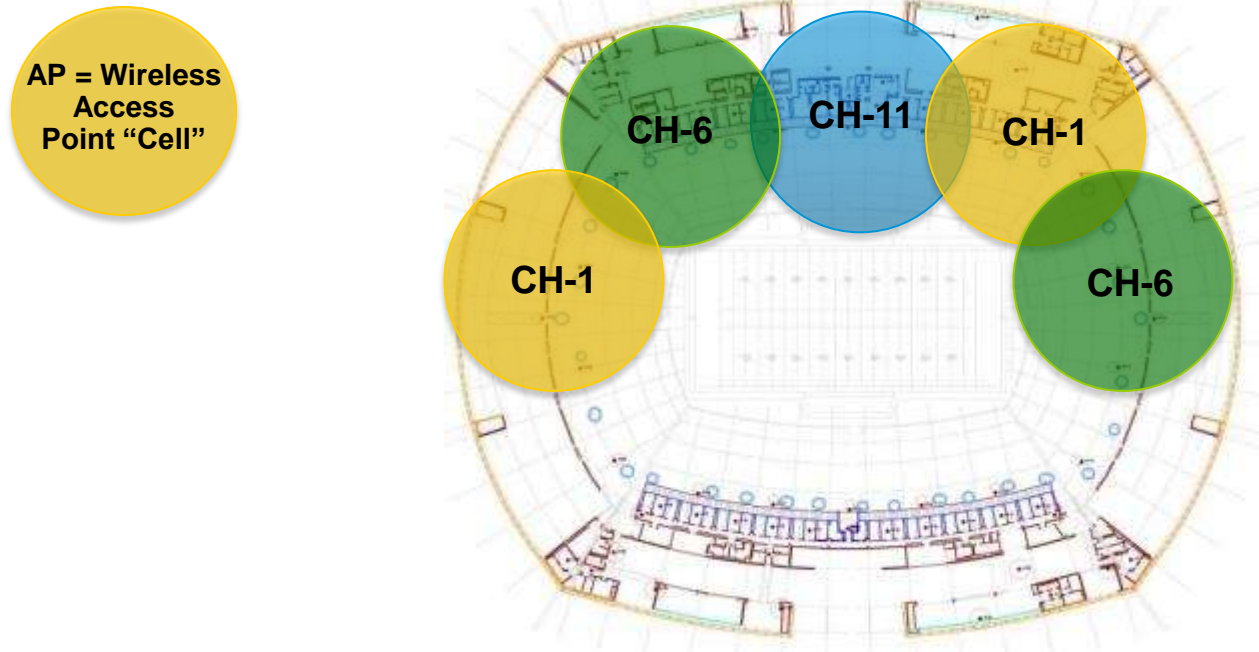
**Purpose:** One Wi-Fi Network for All Venue Needs



Converging traditionally separate Wi-Fi networks into a single network with stadium-wide fan access while maintaining security through virtual separation



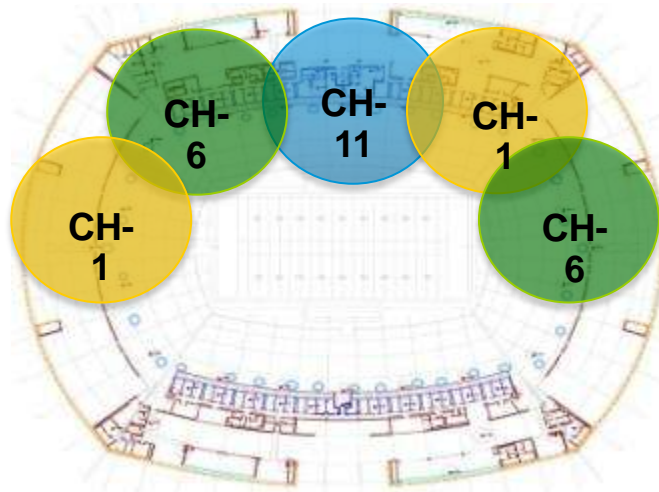
# Traditional Stadium Wi-Fi Deployment



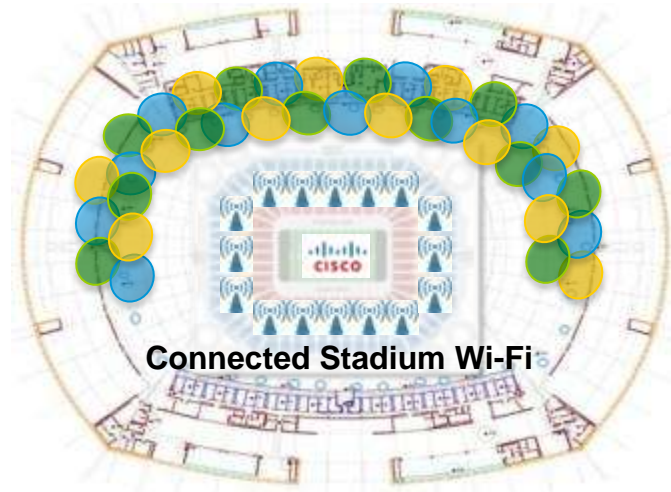
- Large Wi-Fi “cells” cover more physical area
- Traditionally for Team/Venue Back Office applications  
Limited number of Wi-Fi devices
- Results in Wi-Fi coverage with limited capacity for fan access

# Connected Stadium Wi-Fi

## Coverage and Capacity



**Before**  
Coverage with “Limited Capacity”

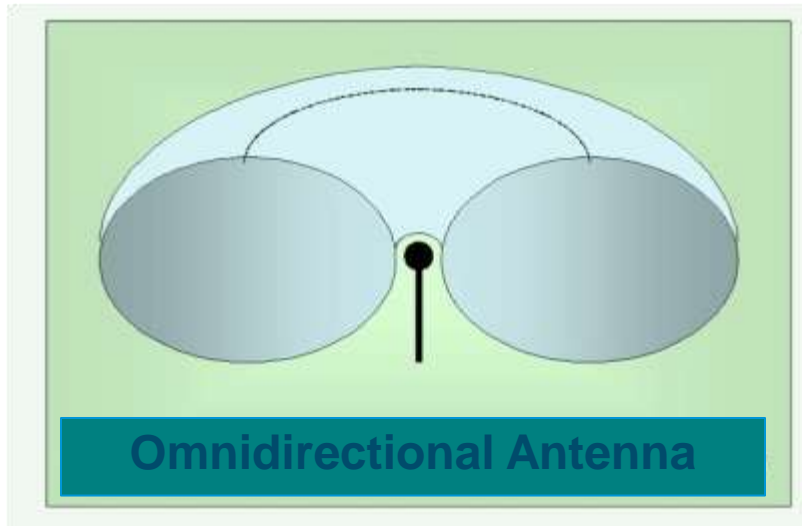


**After**  
Coverage with “High Capacity”

- Smaller cell size enables devices and AP to operate at higher data rates
- High Gain Directional Antennas reduces co-channel interference
- Cisco Radio Resource Management automatically adjusts AP channel assignment and radio power for optimum cell coverage and capacity
- More Cells = More Capacity (BW)

# Connected Stadium Wi-Fi

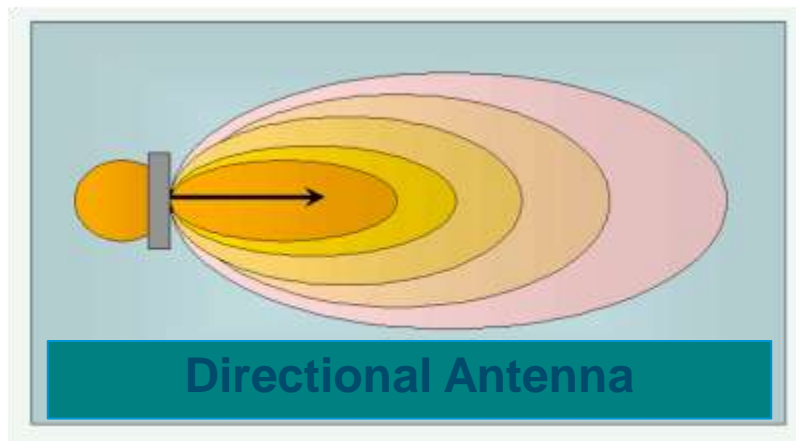
## Antenna Radiation Patterns



- Antenna placement and orientation become increasingly important with high gain.

Gain can vary from low (*like a standard light-bulb*) to highly directional (*like a car headlight*)

- Omnidirectional antennas are typically used in common areas.

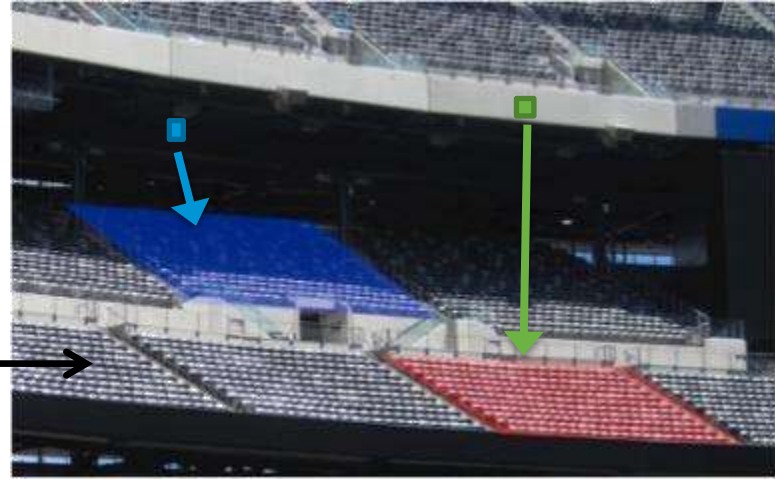


- Directional antennas are typically used in general seating areas and other high-density areas.

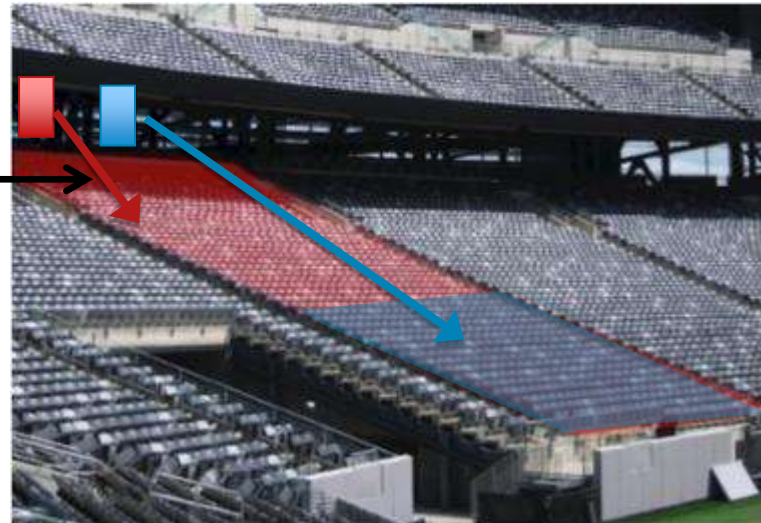
# Bowl Coverage Examples

- High gain antenna with down-tilt mounting contains coverage

- Single Tier
  - 322 seats (red)
  - 480 seats (blue)
  - One AP per section



- Two Tier
  - 1020 Seats
  - 96' deep by 47' wide
  - Two APs per section



# Connected Stadium Wi-Fi Components

## New High-Density Products



**AIR-CAP3502P-x-K9**  
**Cisco Aironet 3500 Series Access Point**

- Optimized for external antennas
- 802.11n dual-band 2x3 MIMO
- CleanAir technology for spectrum intelligence
- Special, customizable power settings and configuration
- VideoStream for optimized video

**AIR-ANT25137NP-R=**  
**Cisco High Density Directional Antenna**

- Single antenna with both 2.4 GHz and 5 GHz elements
- High Gain and Narrow Beam width  
Beam width: 36 degrees @ 2.4 GHz and ~50 degrees @ 5 GHz  
Peak Gain: 13 dBi @ 2.4 GHz and 7 dBi @ 5 GHz
- Ruggedized, paintable exterior to blend in with the background

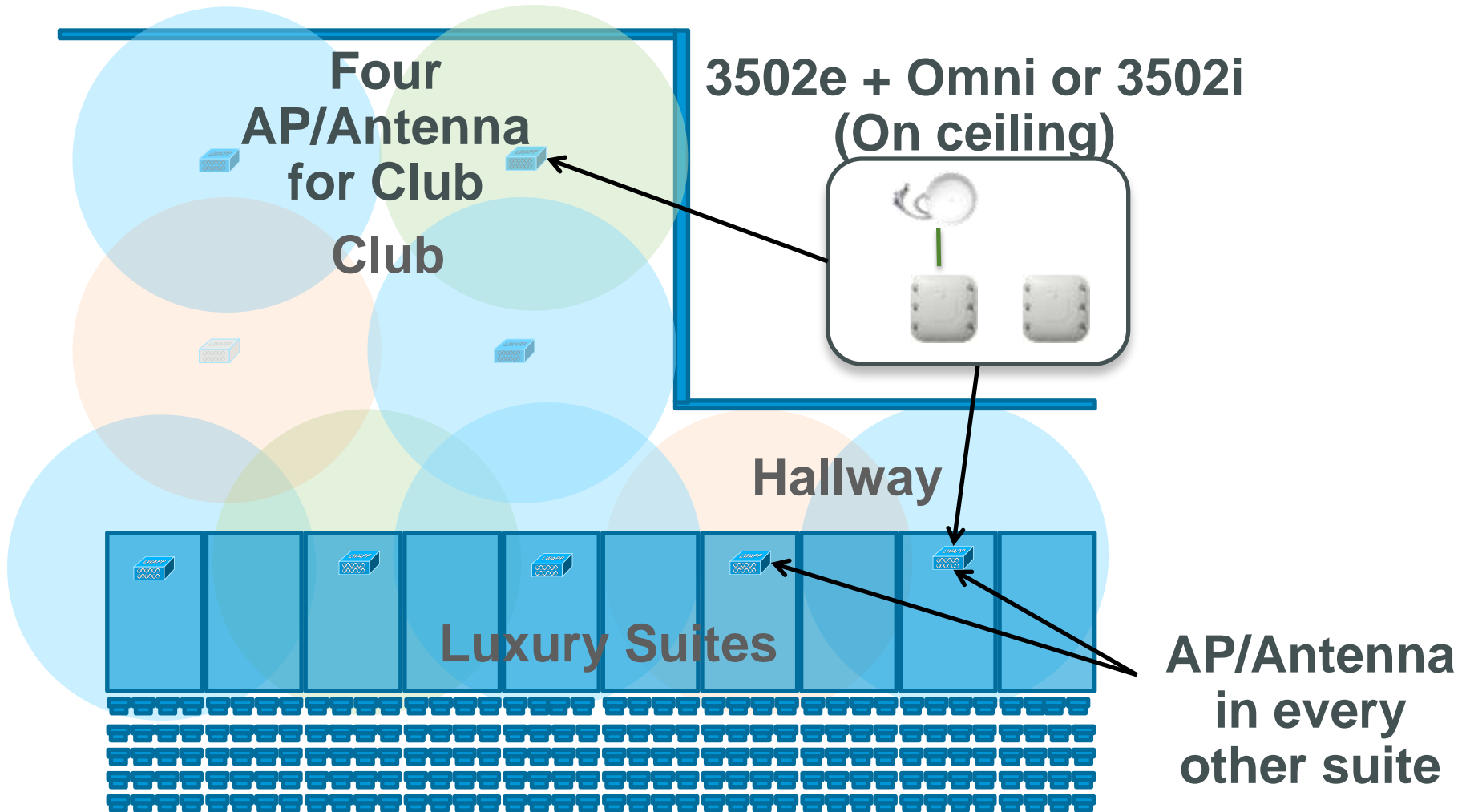




# Cisco Connected Stadium Wi-Fi AP/Antenna Placement & Estimates



# Suites & Clubs AP/Antennas



# Determining Concourse AP/Antenna Counts

1 AP per Seating Section

3502e + 2.4 & 5 GHz Patch  
(On walls or pillars)



Concourse

Antennas face  
away from  
bowl



# Determining Concession AP/Antenna Counts

1 AP per Concession Stand

3502e + Omni  
(On ceiling)





# Coachcomm Wireless Headsets

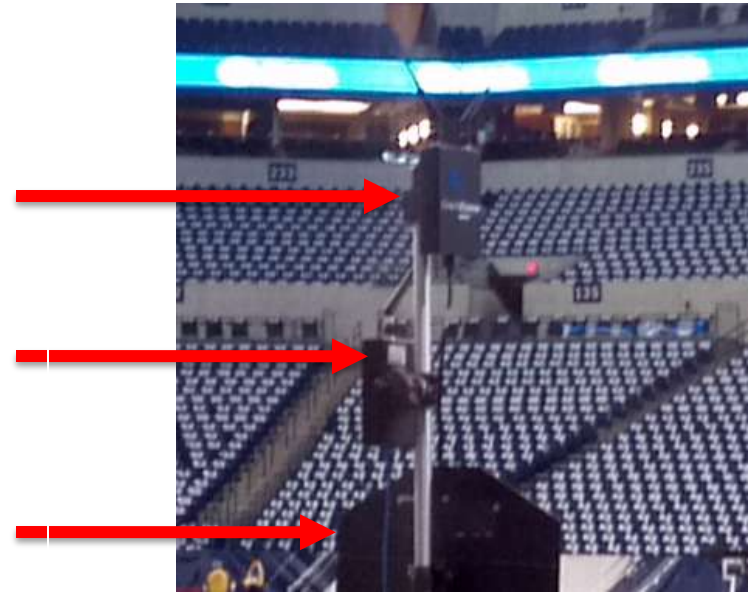


# What it looks like:

**Top antenna is 2.4Ghz  
Tempest System.**

**Middle antenna is 900Mhz  
Tempest System.**

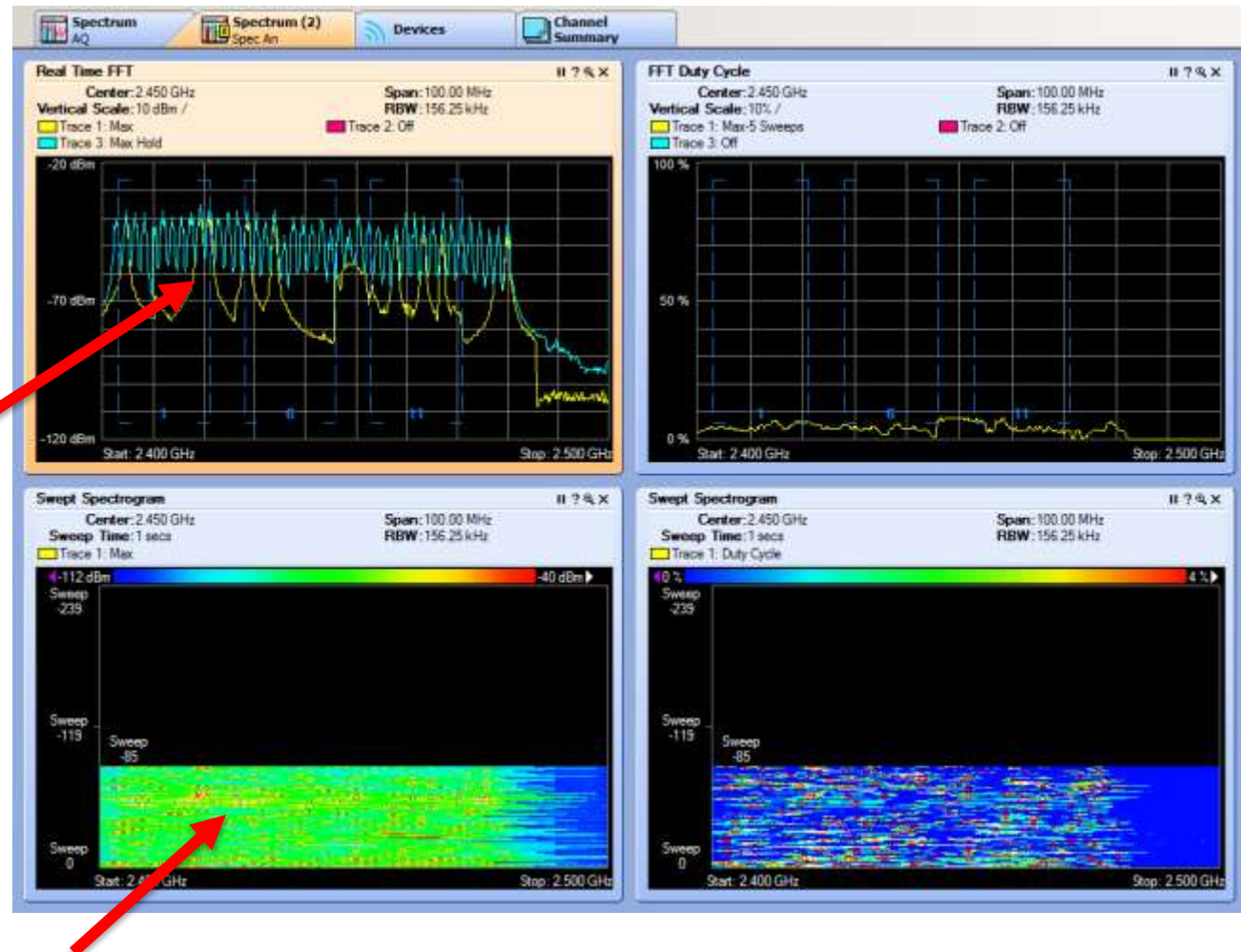
**Bottom antenna is UHF**



Tempest2400  
Available Worldwide

# What it looks like from an RF perspective

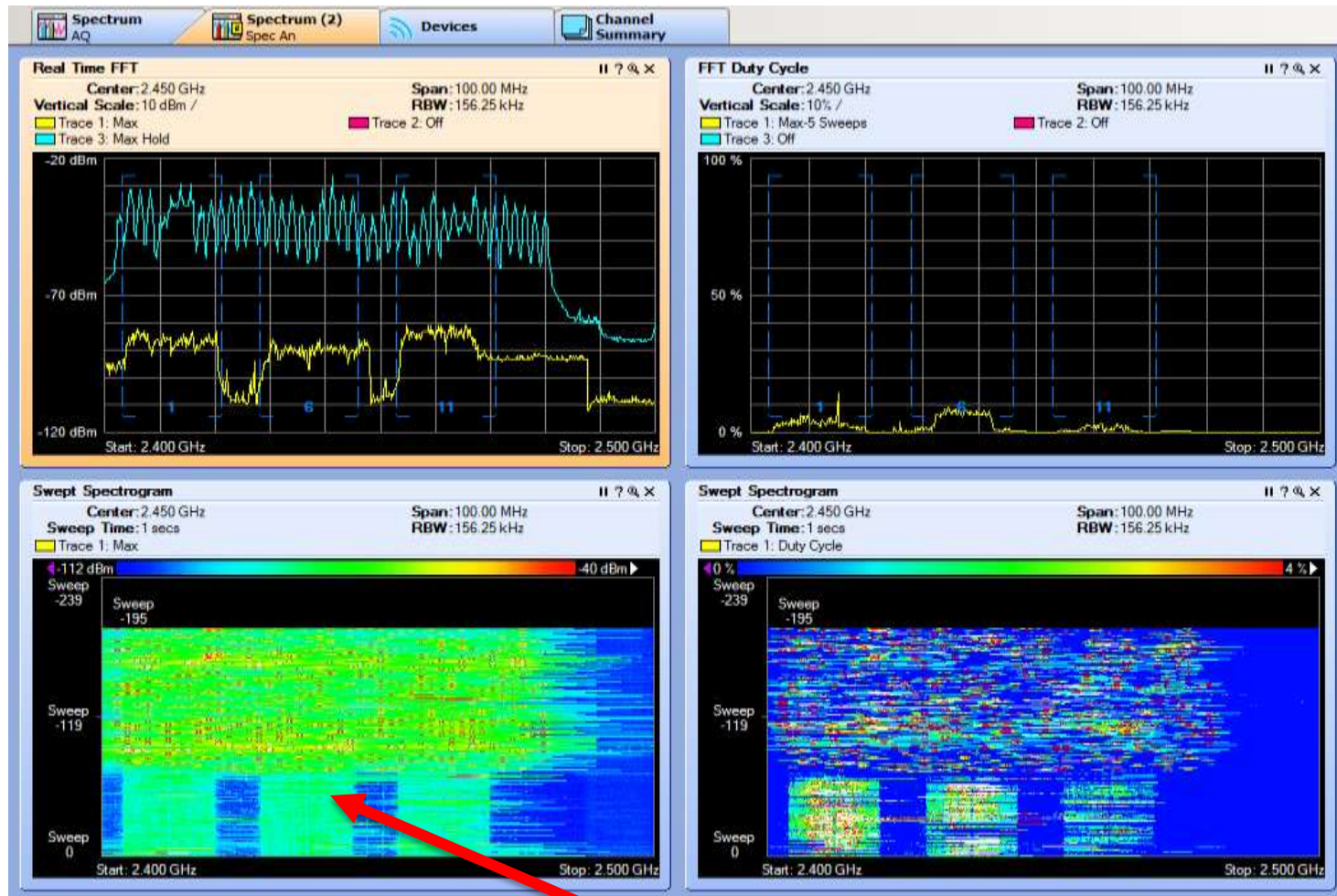
1.3Mhz  
wide.....43  
different  
frequencies



At this point channels 1, 6, and 11 aren't even distinguishable.



# Notice the difference when it's turned off



Now we can actually see our channels again.

# Example: Super Bowl XLVI Connected Stadium



- Fan facing Wi-Fi access for Super Bowl activities
- **Carrier-neutral Wi-Fi access** – free to all fans
- Provided by Verizon wireless
- **Objective: increased fan experience and 3G offload**
- High speed data as well as Voice & SMS worked well
- 604 in-stadium Access Points



Downstream  
Peak: 75 Mbps  
Total: 225.3 GB



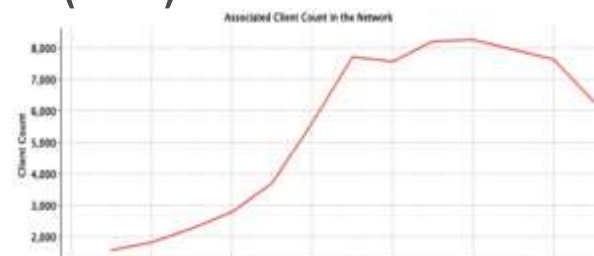
Upstream  
Peak: 42 Mbps  
Total: 144.6 GB

Total  
attendance:  
68,658



Unique  
Associations:  
12,946 (19%)

Simultaneous access:  
8,260 (12%)



# Real Madrid Club de Fútbol

Santiago Bernabéu Stadium

## The Challenge:

Provide an Immersive and interactive experience for 84,454 fans,

Allow fans to connect in entirely new ways to stay  
**"The Best Club in the Twentieth Century"**

## The Details:

275 – 3502p

240 – 3502e

515 Total Access Points (Bowl, VIP, Concourse)

4 – 5508 Controllers





# BC Place Vancouver Canada

## The Challenge:

- Create 80k unique experiences for every event
- Drive new in-person and virtual fan experiences
- Multi-purpose arena (CFL, soccer, concerts, etc)



## The Details:

- 220 – 3502p
- 425 – 3502
- 645 Total Access Points (Bowl, VIP, Concourse)
- 7 – 5508 Controllers



# WiFi 3G Offload for ATT

## Offloading up to 40,000 Cell Phones per Game

### SF Giants ATT Park

- WiFi broadband connectivity free to all 40,000 seats
- 350 x 802.11N AP Deployed
- 3G Offload for all ATT iPhone and BB devices through transparent authentication
- On-net video instant replay live during game or show



**Serving 40,000 Fans**

# SF Giants Digital Dugout



What is the Giants Digital Dugout?

The Digital Dugout is an interactive application developed by the Giants in conjunction with Birdsell Interactive, available to fans via the Giants WiFi Network or computers located in AT&T Park luxury suites.



- **“AT&T WiFi Replay”**—Video highlights
- **“Food Finder”**—If it’s served at AT&T Park
- **“FanCaptions”**—Closed captioning of PA announcements
- **Pitch Tracker**—Scores, statistics and player profiles (MLB.com)
- **Interactive Games**—Base Runner, Match Game and Buzz!
- AT&T Park history and local information





# Current StadiumVision Deployments



**Toronto Blue Jays 2008**



**Pittsburgh  
Penguins 2010**



**New York Yankees  
April 2009**



**Staples Center, Feb 2011**



**Eden Park  
New Zealand  
2010**



**NY Jets/Giants  
at NMS, Aug 2010**

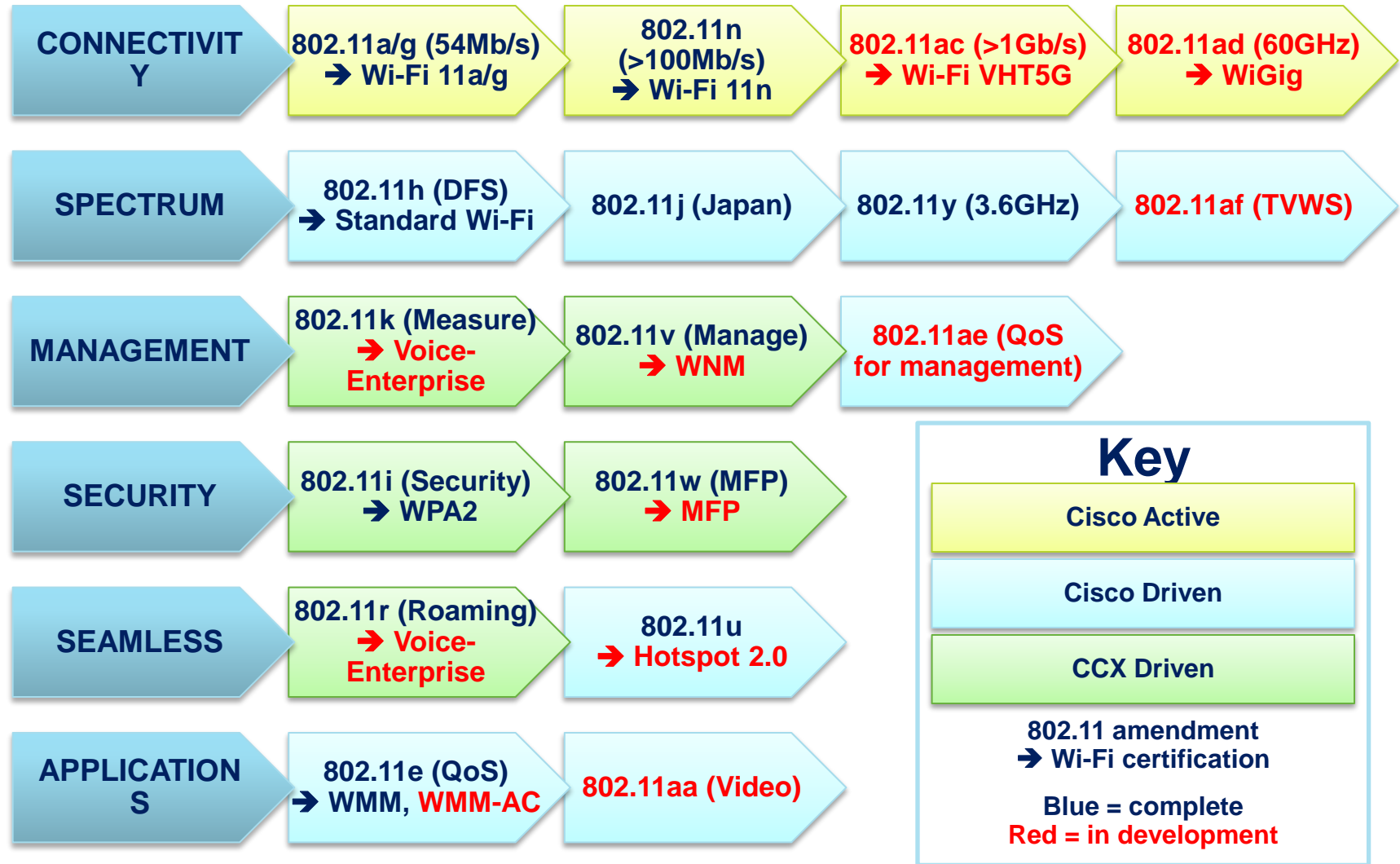


**Millennium Stadium  
Wales, 2010**



**Dallas Cowboys, Aug 2009**

# Cisco Has a Long History of Driving Wireless Innovations into IEEE 802.11 Standards & Wi-Fi Alliance Certifications



# Resources

- Cisco High Client Density Wireless LAN Design Guide:  
[http://www.cisco.com/web/strategy/docs/education/cisco\\_wlan\\_design\\_guide.pdf](http://www.cisco.com/web/strategy/docs/education/cisco_wlan_design_guide.pdf)

**Thank you.**

