Cisco Connect
Seoul, Korea
April 1-2, 2015

Understanding RF Fundamentals and the Radio Design of Wireless Networks

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Product Manager - EISG

Session Abstract

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- This session focuses on the current wireless trends & reasons for customers to move towards newer technology.
- Supremacy of Cisco 802.11ac technology over other vendors.
- RF and its properties for current day deployments.
- Some examples that are good and some examples gone bad.
- Cisco Cloud based Predictive RF Planning tool and its features
- Demo of the tool

SESSION AGENDA - Objectives

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- Current Wireless Trends

  Reasons for Customers to move to Newer Technology

  Supremacy of Cisco 802.11ac technology
- RF Matters
- Examples of Good and Bad Installation
- Cisco Cloud Based Predictive RF Planning tool

  Demo of the tool

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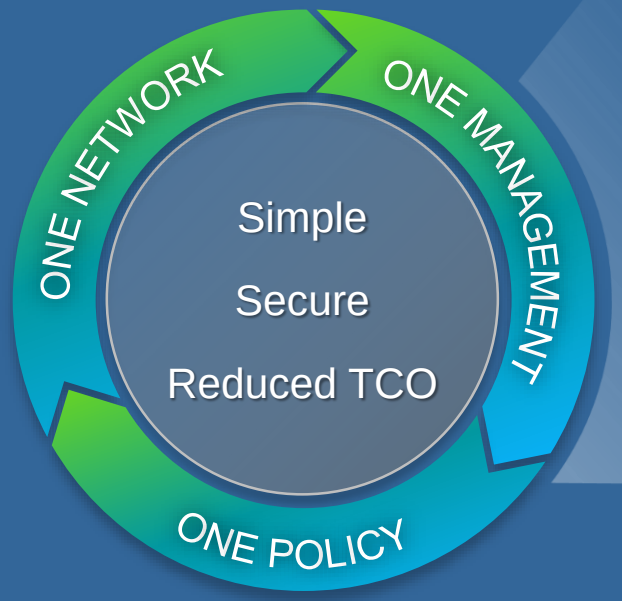
“Wireless Trends”

Cisco Enterprise Networks Vision

Cisco ONE Enterprise Architecture

Unified Access Vision & Strategy

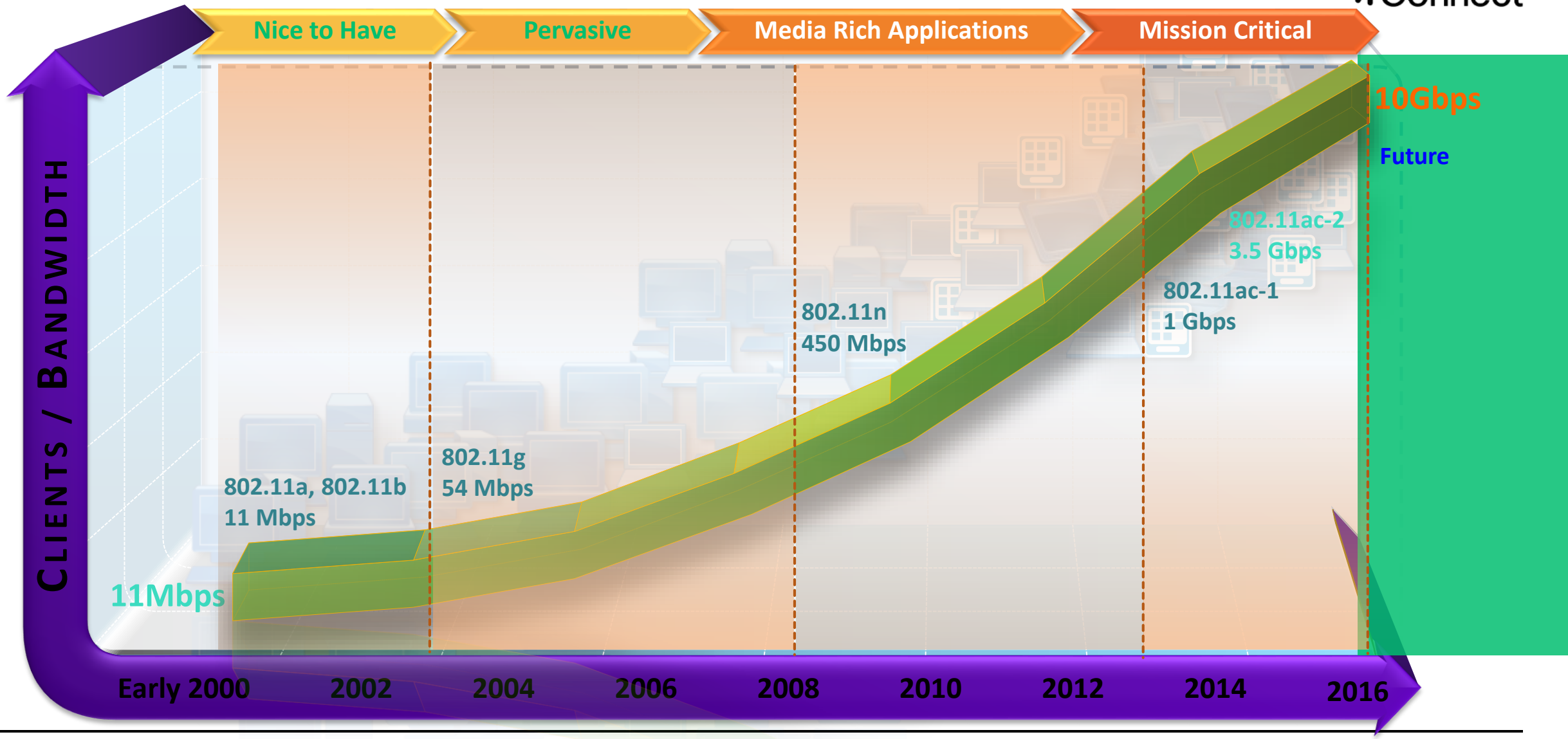
- Deployment Modes
  - Wired
    - Traditional Access
    - Instant Access
  - Wireless
    - Centralized
    - Flex
    - Autonomous
  - Wired-wireless
    - Converged Access
  - Cloud Managed



One Place to Define Policy
Multiple Policy enforcement points

- One pane of glass
  - Wired
  - Wireless

Wireless Standards – Past, Present, and Future



Why Gigabit Wi-Fi

802.11ac

3X the Performance of 802.11n

2X End User Device Battery Life

Further Range Compared to 802.11n

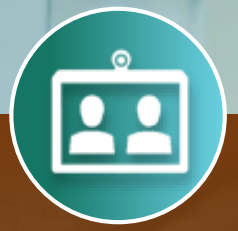
Why Gigabit Wi-Fi…*Now!*

802.11ac

Wireless: Primary Means of Access

Wireless (53%) Bypass Wired Traffi c (40%)by 2017[1]

50% New Devices will be 802.11ac by End of 2014, 75% b y 2015[2]

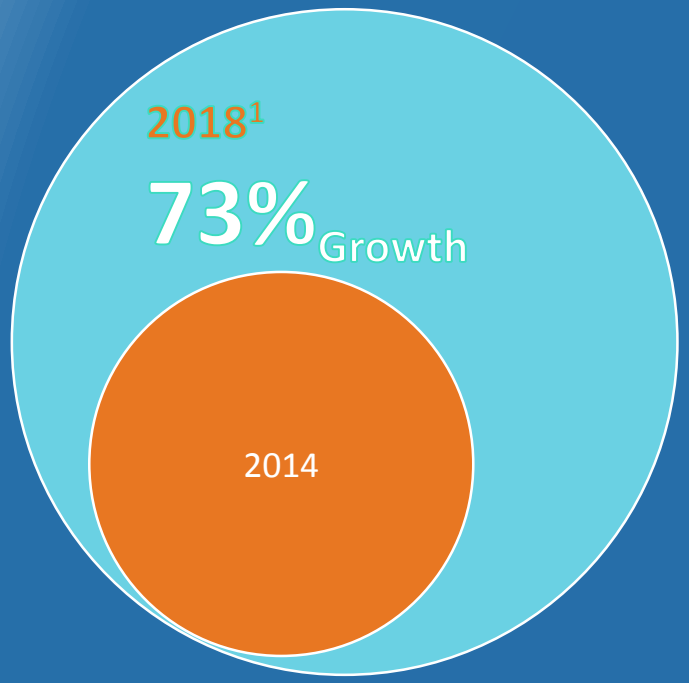


50% of Traffic will be Voice & Video by 2015[3]

1 Cisco VNI Global Mobile Data Forecast 2012-2017, 2 ABI Research, 3 Nemertes Research Global Mobile Research 2013

Need for 802.11ac Driven By Device and Application Growth

Mobile Device Growth



App. Access by Mobile Device[2] (2014 to 2017)

Email / Calendar 28% Growth

Collaboration 45% Growth

Productivity 53% Growth

Custom Business 63% Growth

UC / IP Telephony 64% Growth

Virtual Desktop 79% Growth

Why Cisco for Gigabit Wi-Fi

802.11ac

Improved Experience on all Devices

Built for High-Density Environments

Industries' Only Modular / Future Proof Access Point

Broadest Portfolio- no Price Premium over 802.11n

Not All Gigabit Wi-Fi Solutions are Created Equal

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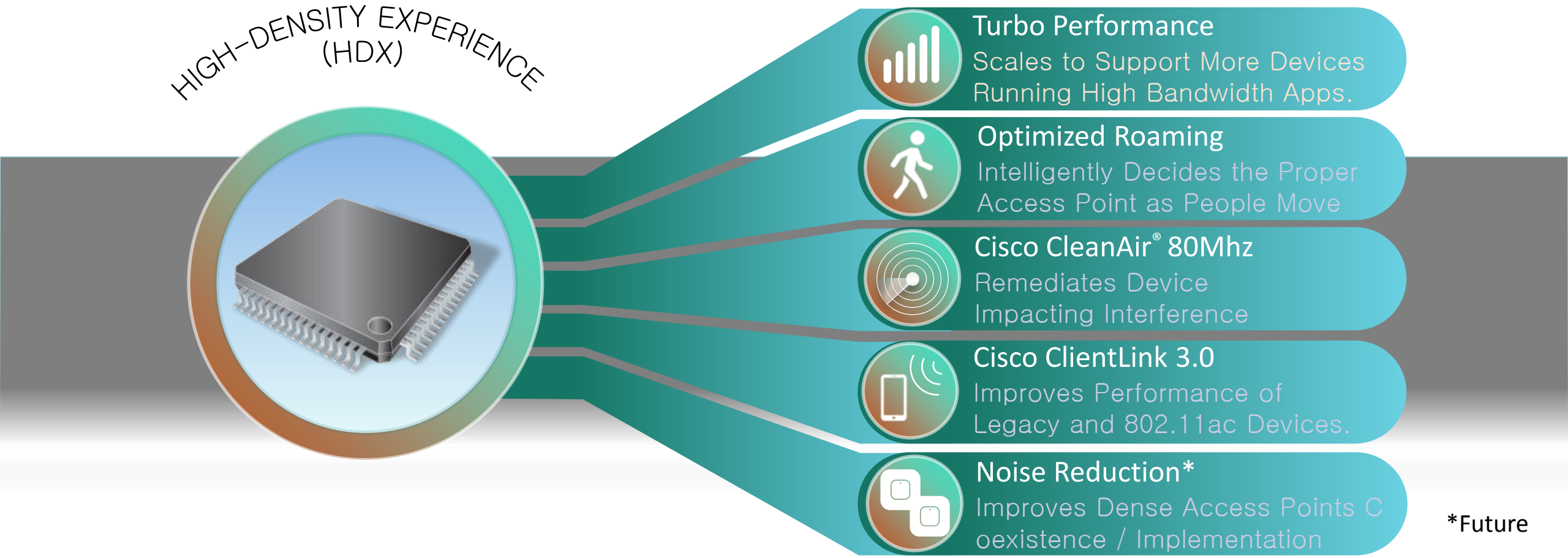
Cisco is the ONLY SOLUTION with High-Definition Experience Technology (HDX)

	All Gigabit Wi-Fi Vendors	802.11ac	802.11ac with HDX
Optimized Wi-Fi Network			
Improved Experience on ALL Devices			
Increased Scale and Coverage			
Support Bandwidth Intensive Apps.			
Support More Devices Than 802.11n			
Improved Device Power Efficiency			

Optimizing Network Performance & End-User Experience

Made Possible by Purpose Built Chip Set



*Future

Cisco Delivers Investment Protection

Future Proof Your Network with Industries' Only Modular Design

Supported on Cisco Aironet 3600 & 3700 Series

802.11ac Wave 1 & 2*:
Support for Next-Gen Wireless Standard

Wireless Security Module:
Always On Intrusion Protection

3G Small Cell:
Cellular Blind Spot Coverage with Wi-Fi

Others:
Future Technologies to Meet New Demand

*Future

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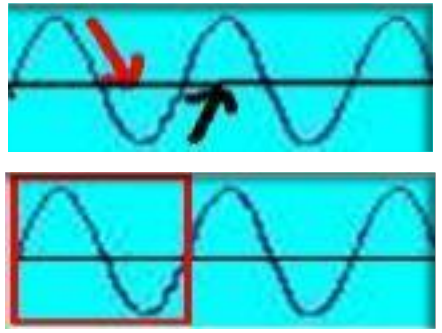
What is **R**adio?
Why these **F**requencies?

“RF Matters”

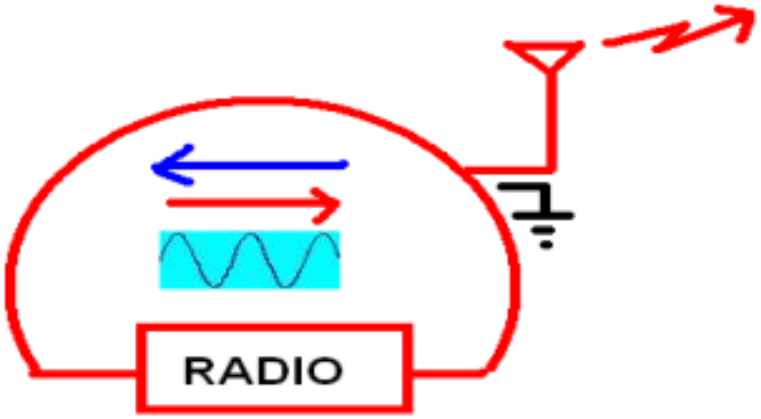
Basic Understanding of Radio…

Battery is DC
Direct Current

Typical home is
AC Alternating Current



AC Frequency 50 Hz or 50 CP
S – Cycles Per Second



Waves travel back and forth so fast they actually leave the wire

How fast the AC current goes, is its "frequency"
AC is very low frequency 50 Hz (Cycles Per Second)

Radio waves are measured in kHz, MHz and GHz

The lower the frequency, the physically longer the radio wave – Higher frequencies have much shorter waves, and as such, it takes more power to move them greater distances.
This is why 2.4 GHz goes further vs. 5 GHz
(given same amount of RF power).

Popular Radio Frequencies:

AM Radio 520-1610 KHz
Shortwave 3-30 MHz
FM Radio 88 to 108 MHz
Aviation 108-121 MHz
Weather Radio 162.40 MHz
GSM Phones 900 & 1800 MHz
DECT Phones 1900 MHz
Wi-Fi 802.11b/g/n 2.4 GHz
Wi-Fi 802.11a/n 5 GHz

Spark transmitter

Basic Understanding of Radio…

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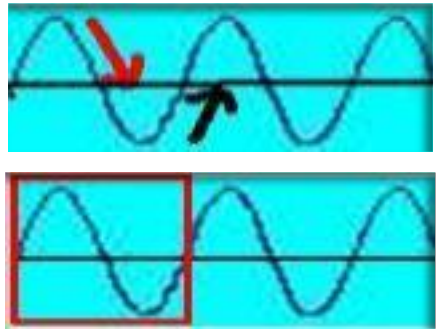

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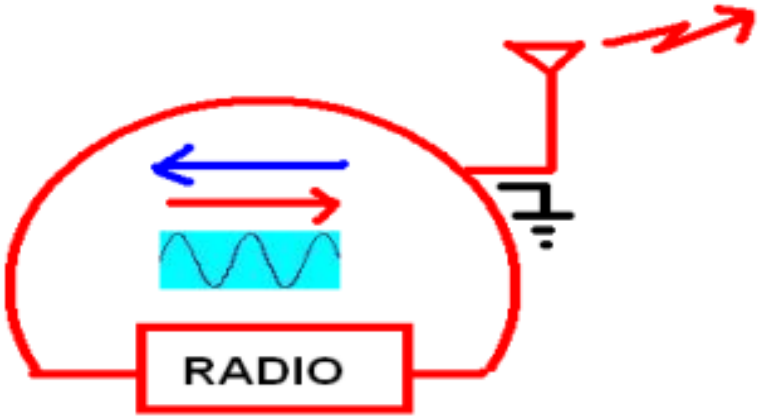

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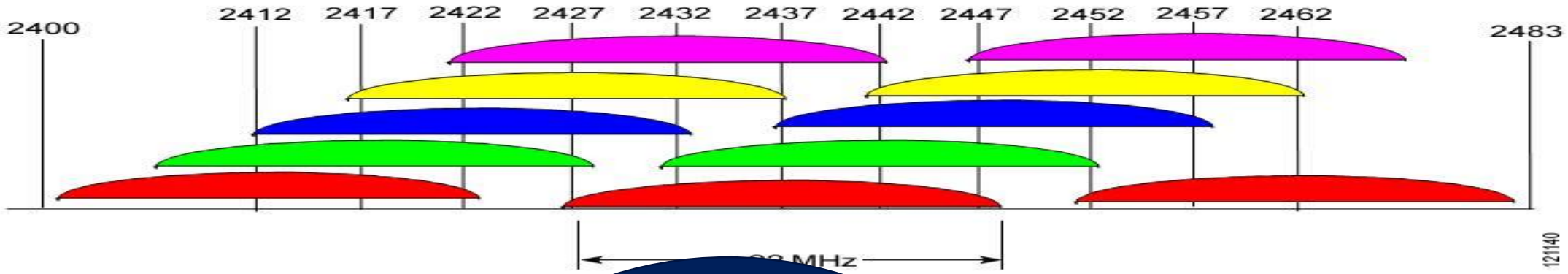
Wi-Fi 802.11a/n 5 GHz

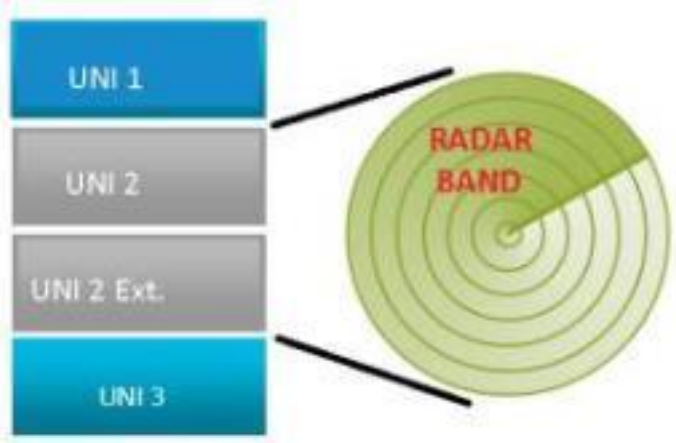
Spark transmitter

Wi-Fi Radio Spectrum 2.4 GHz

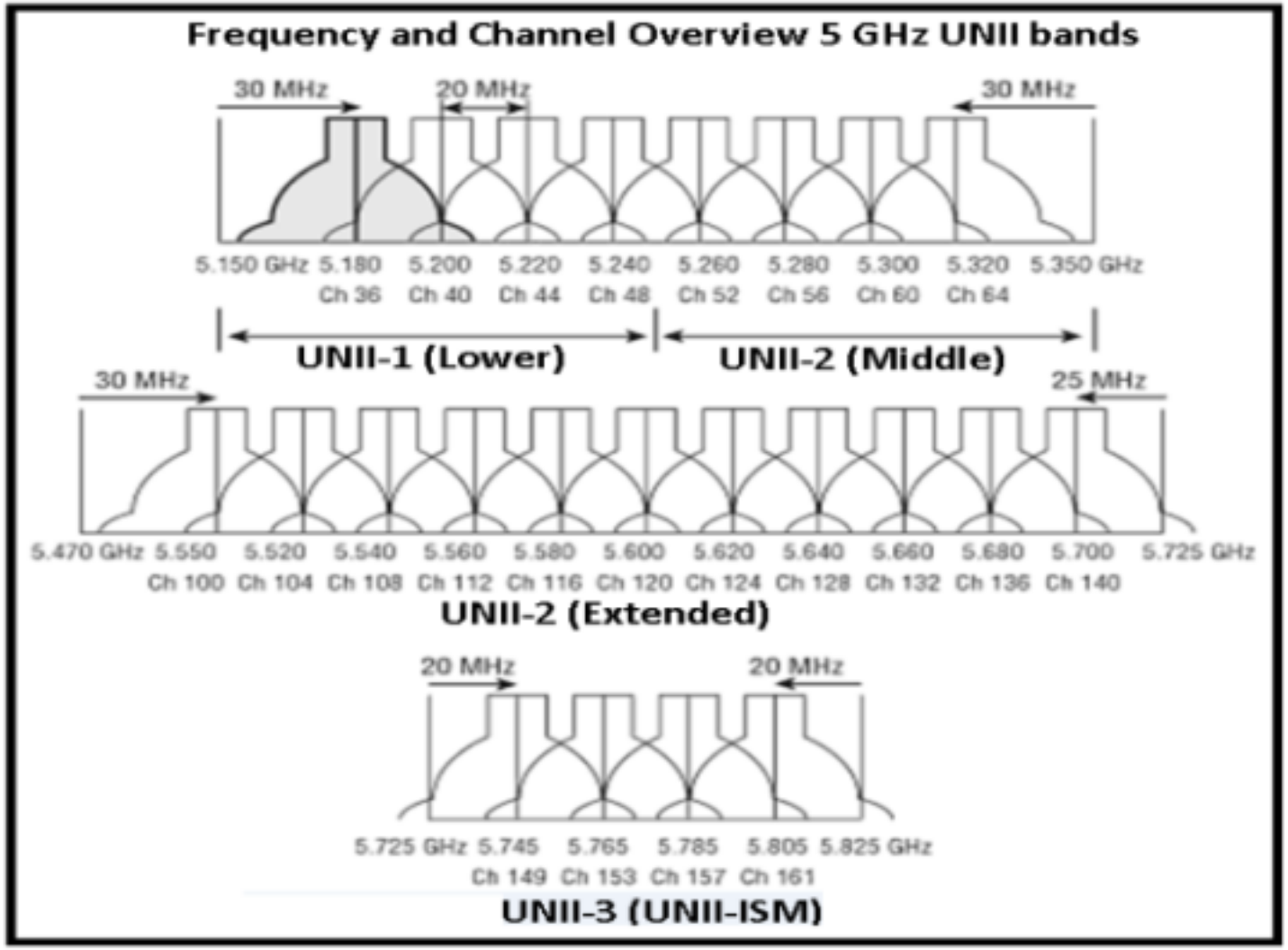


Don't do it!

Wi-Fi Radio Spectrum 5 GHz



Note: 5 GHz channels do not have the severe overlap that 2.4 GHz channels have but they use DFS to enable sharing of the band



A Radio Needs a Proper Antenna

Antennas are identified by color
Blue indicates 5 GHz
Black indicates 2.4 GHz
Orange indicates both

Omni-Directional antennas like the one on the left, radiate much like a raw light bulb would everywhere in all directions

Directional antennas like this “Patch” antenna radiate forward like placing tin foil behind the light bulb or tilting and directing the lamp shade

Note: Same RF energy is used but results in greater range as it is focused towards one direction, at the cost of other coverage areas

Antennas are custom made for the frequency to be used.
Some antennas have two radiating elements to allow for both frequency bands (2.4 and 5 GHz) in one antenna enclosure.
Cisco AP-3700 3600/2700/2600/1600 use such antennas.

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Antenna Basics

Antenna Basics

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- **Antenna - a device which radiates and/or receives radio signals**
- **Antennas are usually designed to operate at a specific frequency**
- **Some antennas have more than one radiating element (example Dual Band)**

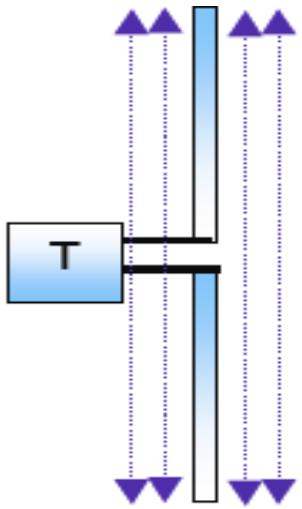
- **Antenna Gain is characterized using dBd or dBi**
  - Antenna gain can be measured in decibels against a reference antenna called a dipole and the unit of measure is dBd (d for dipole)
  - Antenna gain can be measured in decibels against a computer modeled antenna called an “isotropic” dipole <ideal antenna> and the unit of measure is

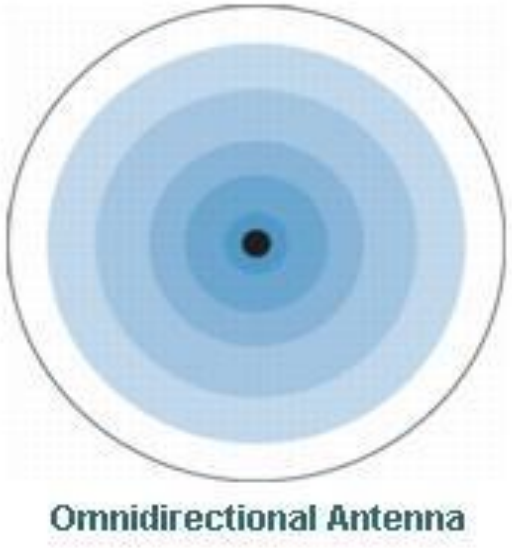
  dBi the “i” is for isotropic dipole which is a computer modeled “perfect” antenna

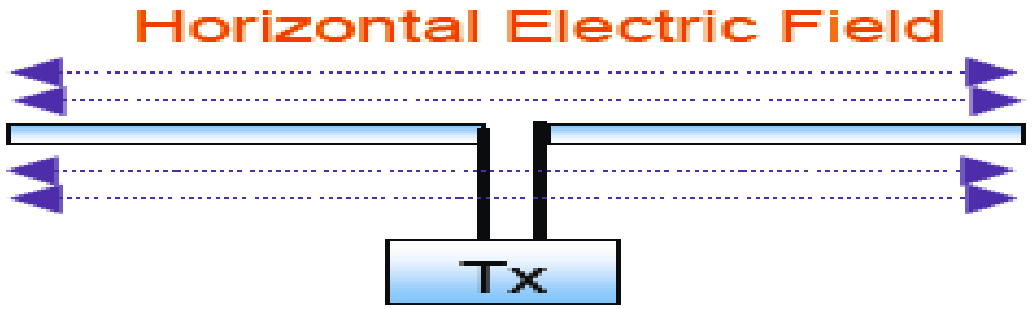
- **WiFi antennas are typically rated in dBi.**
  - dBi is a HIGHER value (marketing folks like higher numbers)
  - Conventional radio (Public safety) tend to use a dBd rating.
  - To convert dBd to dBi simply add 2.14 so a 3 dBd = 5.14 dBi

How Does a Omni-Directional Dipole Radiate?

The radio signal leaves the center wire using the ground wire (shield) as a counterpoise to radiate in a 360 degree pattern





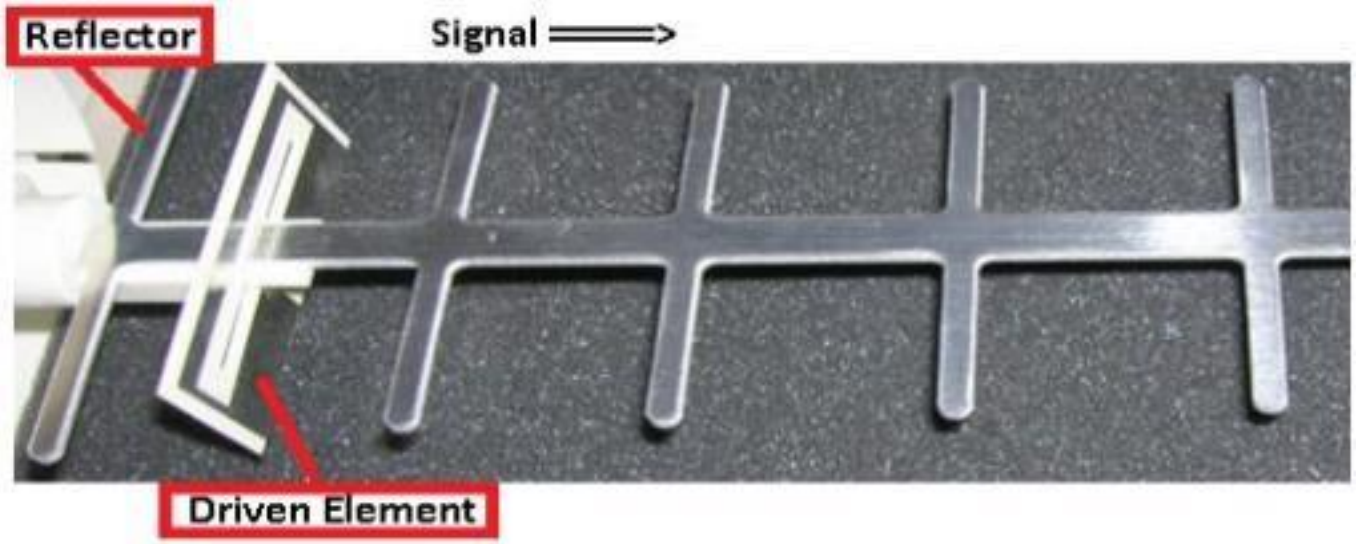


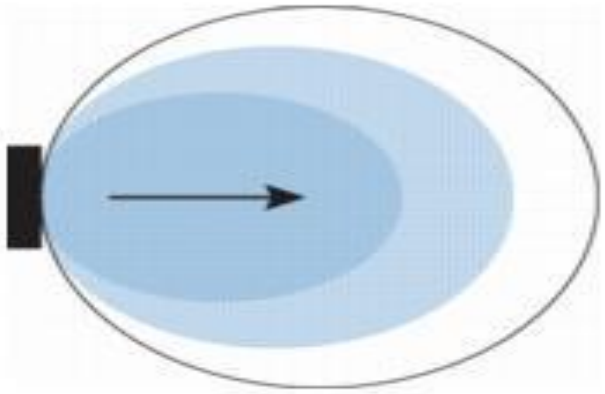
Low gain Omni radiates much like a light bulb " 360" degrees

How Does a Directional Antenna Radiate?

Although you don't get additional RF power with a directional antenna, it does concentrate the available energy into a given direction resulting in greater range.

Also a receive benefit - by listening in a given direction, this can limit the reception of unwanted signals (interference) from other directions for better performance





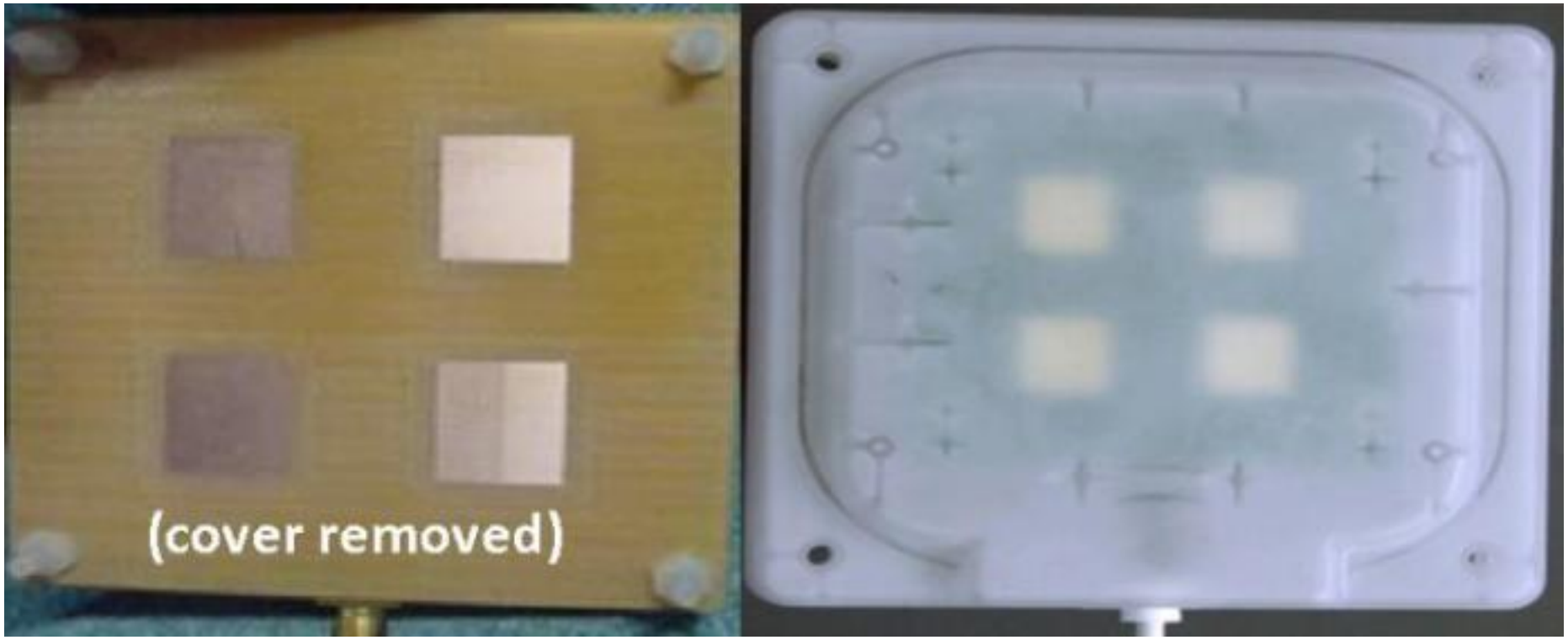
YAGI Antenna

A dipole called the "driven element" is placed in front of other elements. This motivates the signal to go forward in a given direction for gain.

(Inside view of the Cisco AIR-ANT1949 - 13.5 dBi Yagi)

Patch Antenna: a Look Inside

Patch antennas can have multiple radiating elements that combine for gain. Sometimes, a metal plate is used behind the antenna as a reflector for more gain.



The 9.5 dBi Patch called AIR-ANT5195-R

Patch and Yagi antennas favor the direction the antenna is pointed – like a flashlight

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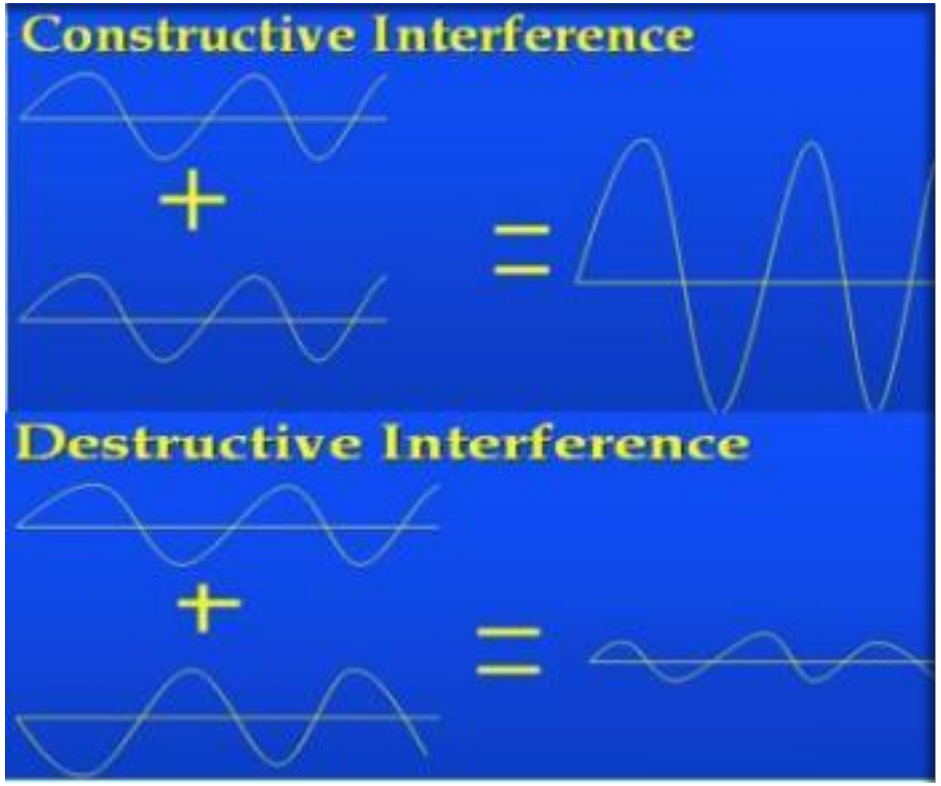
Understanding Multipath, Diversity and Beamforming

Understanding Multipath

Multipath can change Signal Strength



- **As radio signals bounce off meta l objects they often combine at the receiver**
- **This often results in either an improvemen t "constructive" or a "destructive"type of interference**

Note: Bluetooth type radios that "hop" across the entire band can reduce multipath interference by constantly changing the angles of multipath as the radio wave increases and decreases in size (as the frequency constantly changes). The downside is that throughput using these "hopping" methods are very limited but multipath is less of a problem

Evolution to MIMO Technology

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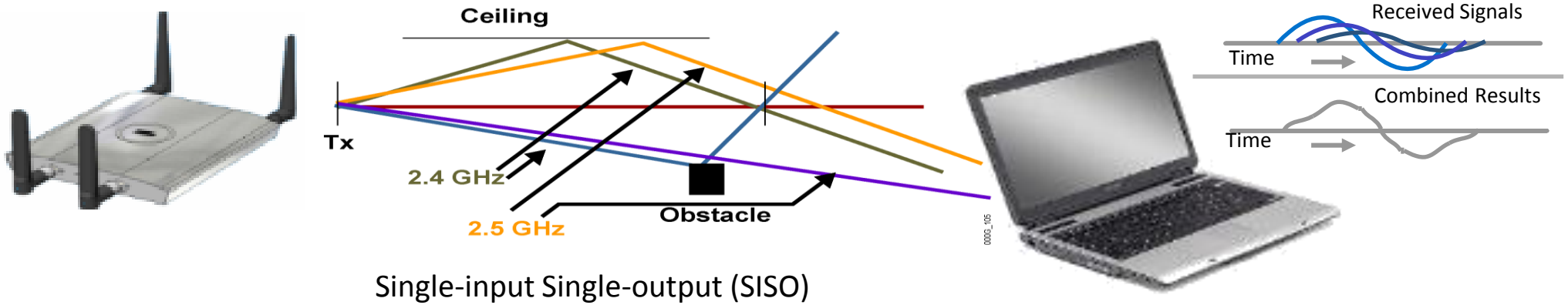
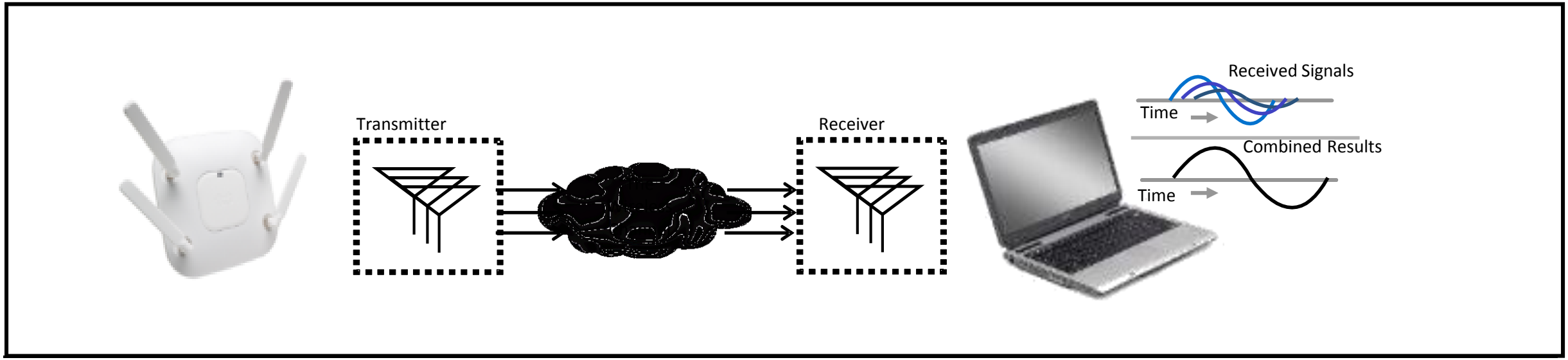
- **Old WiFi systems used Single Input Single Output (SISO) technology**
  - Single transmit stream
    - Single transmit antenna
    - Single receive antenna
  - Severely impacted by multipath signals
    - Performance marginally improved by diversity



Single-input Single-output (SISO)

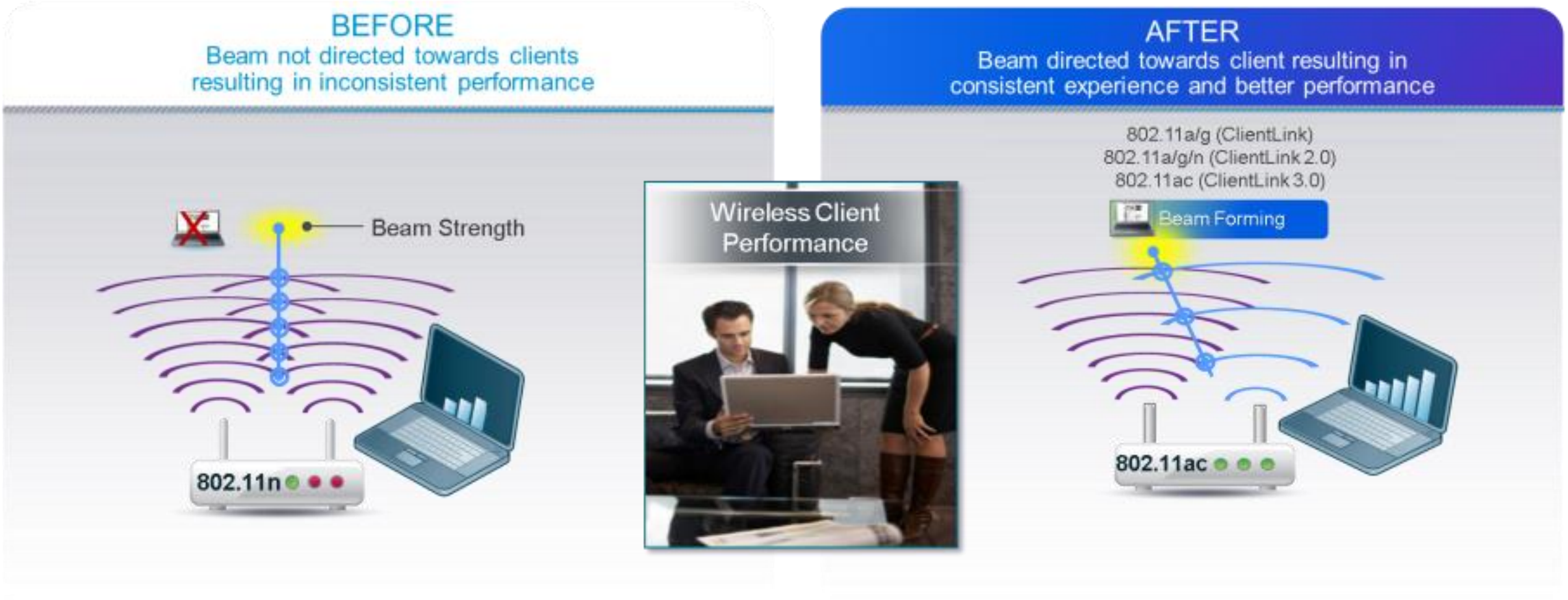
Evolution to MIMO Technology (Cont.)

- **MIMO requires at least 2 receivers or 2 transmitters per band**
  - Uses advanced signal processing to coordinate multiple simultaneous signals from multiple antennas
    - Improved link reliability



Cisco's ClientLink Technologies

Advanced Beam Forming Technologies Improve Wireless Client Performance



Cisco ClientLink—Improves Predictability and Performance

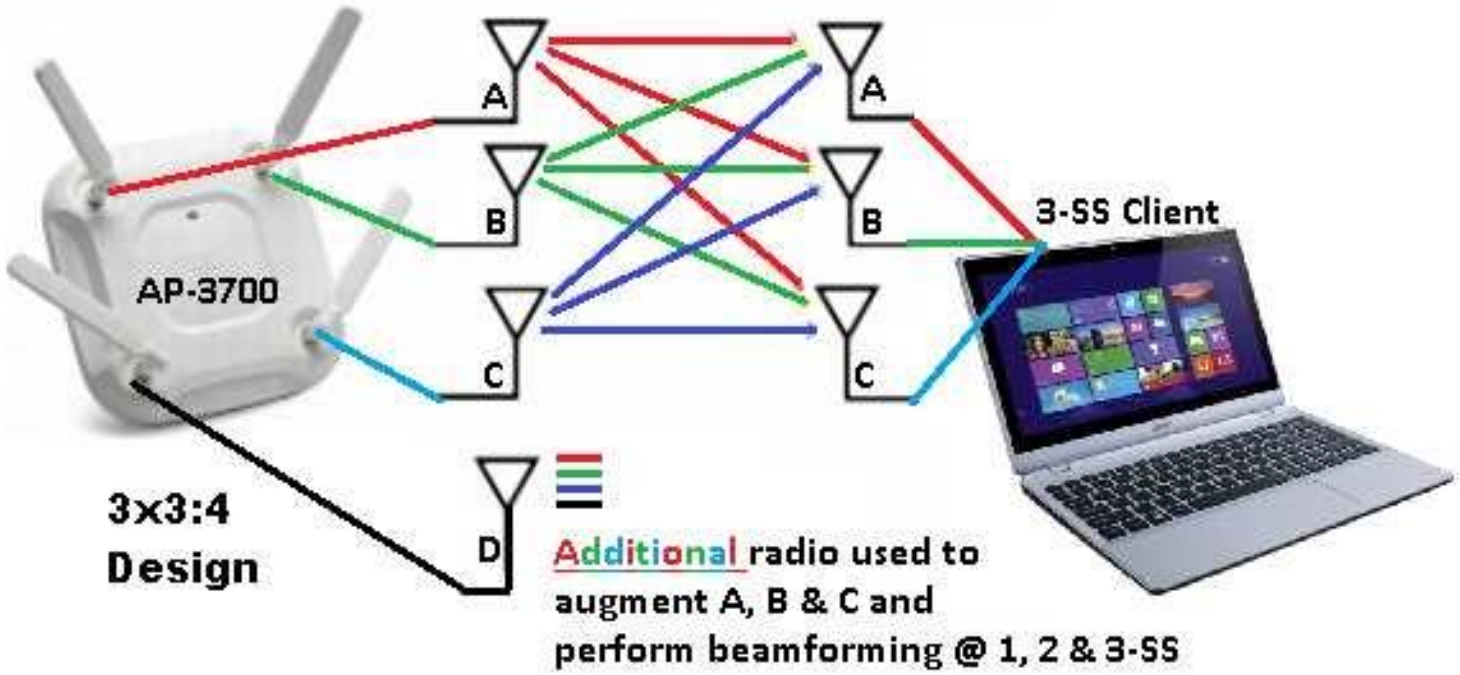
Beam-forming Spatial Streams (ClientLink 3.0)

All the features of ClientLink 2.0 + 3-ss 11ac Clients

The extra radio "D" is used to augment spatial stream data and is used in beam-forming

Note .11n had support for beam-forming <u>but was never adopted</u> so there was no TxBF without ClientLink

Client-Link performs beam-forming on legacy 11a/g/n clients <u>as well as 802.11ac clients 3-ss clients.</u>



Note: Only Cisco APs can beam-form a 3-SS signal as it requires <u>4</u> transmitters - most APs on the market don't have this additional radio for reliability and performance

The additional radio assists in both transmit and receive.

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Understanding 802.11ac

Why is 802.11ac important today?

802.11ac comes in 2 waves: Wave-1 (now) et Wave-2 (end of 2015+)

Many 802.11ac equipments exist on the market t oday (tablets and smartphones).

There is a big ask for more density and more performance from the end-users already.

iPad Air 2

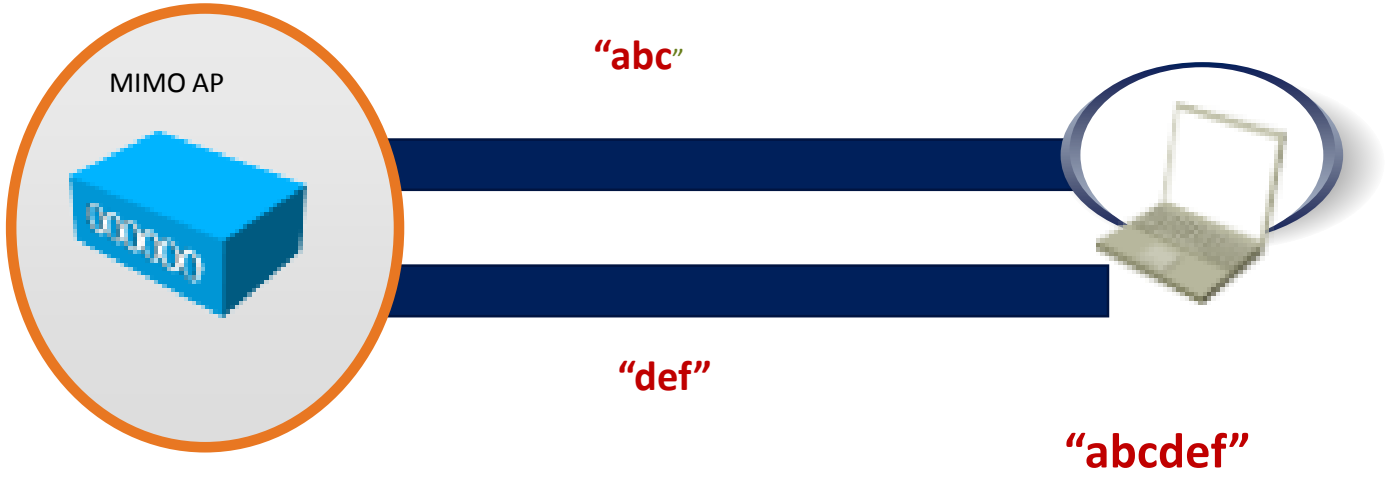
iPhone 6/6+

IDENTIFY 802.11AC EXISTING CLIENTS here:
https://wikidevi.com/wiki/List_of_802.11ac_Hardware#Mobile_general_purpose_computers_.28non-PC.29

802.11n/ac MIMO terminology

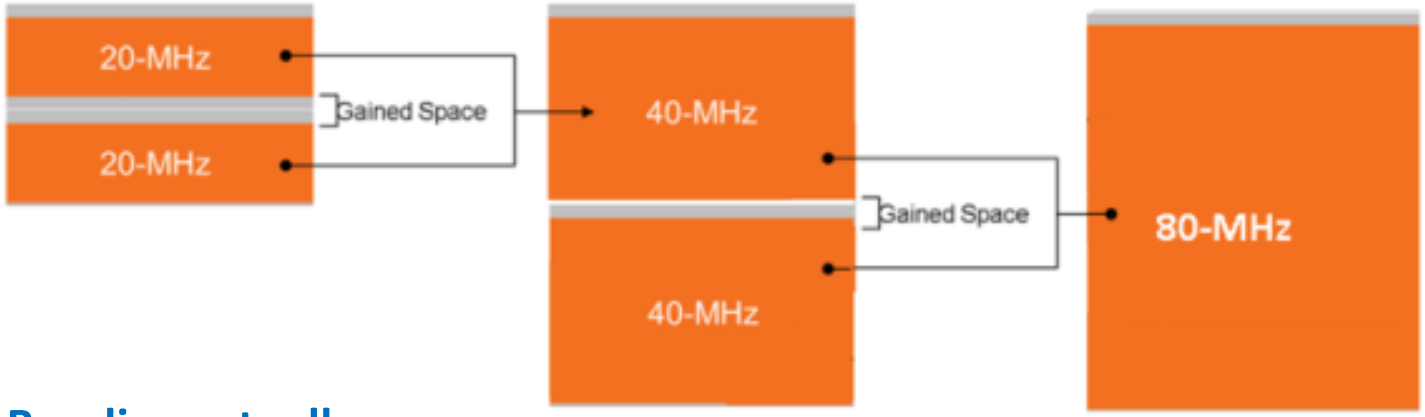
Understanding additional components (**M**ultiple **I**nput **M**ultiple **O**utput)

Spatial Multiplexing – A method for boosting wireless bandwidth by taking advantage of multiplexing which is the ability within the radio to send out information over two or more transmitters concurrently (in parallel) known as "spatial streams".



Sending side: send more symbols, in parallel (spatial multiplexing)

Understanding Channel Bonding



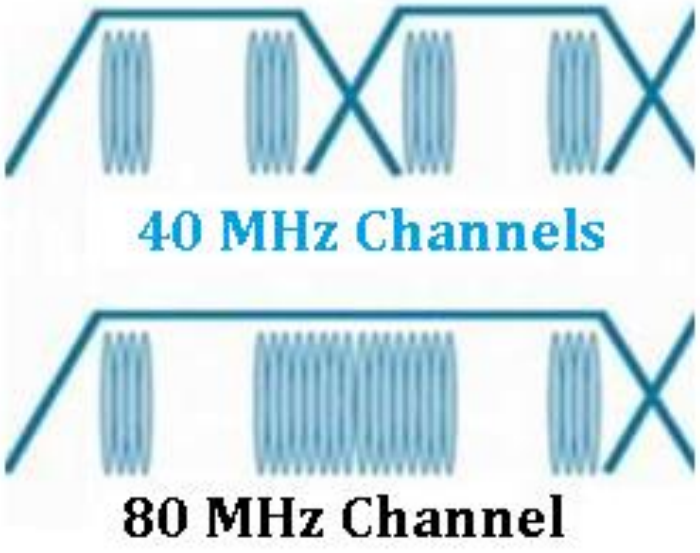
802.11ac introduced 80 MHz

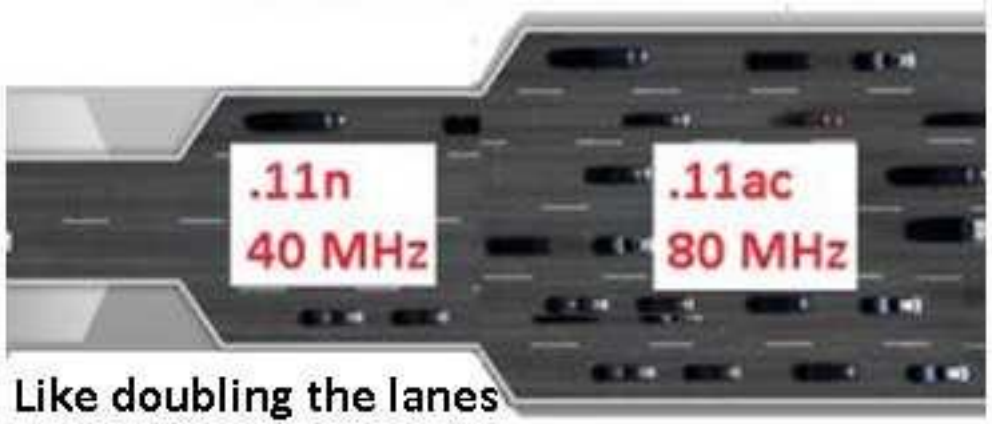
One method to gain significant throughput (2x or more) is to bond the channels using more bandwidth.

This helps 1, 2 and 3-SS clients.

Single spatial stream clients also realize physical size and battery life benefits.

Bonding actually blends the channels together so you gain a small amount of extra spectrum for data use





Guidelines when to use Channel Bonding in 5GHz

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▶ Use 20 MHz channels

- If using voice only – or the spectrum has lots of radar activity forcing channel changes
- If you have lots of non 11n/ac capable 5 GHz clients (early .11a clients)
- If you have light/medium data requirements
- You have lots of non 11ac APs already @ 20 MHz & no plans to upgrade

▶ Use 40 MHz channels

- If using interactive or streaming video
- If requirements are for moderate or heavy data usage

▶ Use 80 MHz channels

- If using a significant amount of .11ac capable clients
- If you have lots of .11ac smart phones (1-SS) and need faster throughput
- High Definition Video streaming or other multimedia rich content applications
- Heavy data usage for high throughput - Example (CAD or medical documents)

One of the real benefits of bonding is spectrum efficiency and overall system capacity. By allowing the clients to send and receive more data in a shorter period of time, the airwaves clear faster for other users and in some cases even battery life on the client device increases as it spends less time in power draining transmit mode.

Physical Layer – Type and number of cables?

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A single GbE cable is fine for (Wave-1)

- **Multiple clients (all connecting at different speeds) will not exceed GbE.**
- **Wave-2 could exceed GbE speeds as it has support for additional spatial streams and up to 160 MHz of bandwidth**
- **So you have 2 options:**
  - **You can pull two CAT6a cables**
  - **You can plan for Nbase-T future MultiGigabit ports on Cat3k switches**

•A pair of CAT6a cables allows you to fall back to using 2 GbE ports for some iterations of (Wave-2) if required. Additionally, if the second cable isn't needed it can be used to bring the console port back.

- **CAT5e cables may be used as the 2nd cable pull for cost savings but at least 1 cable should be CAT6a as CAT5 does not support 10GbE.**

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Choosing the right Access Point Model Integrated or External antennas?

Integrated Antenna? – External Antenna?

Carpeted areas

Integrated antenna versions are designed for m ounting on a ceiling (carpeted areas) where aes thetics is a primary concern

Rugged areas

Use for industrial applications where external or dire ctional antennas are desired and or applications req uiring higher temperature ranges

Outdoor–rated APs Used for Indoor Applications

- **Harsh environmental conditions (e.g. refrigerated rooms, condensing humidity…)**
- **12V DC powered or 100-480V AC**
- **ATEX Class I Division 2 (potentially explosive areas)**

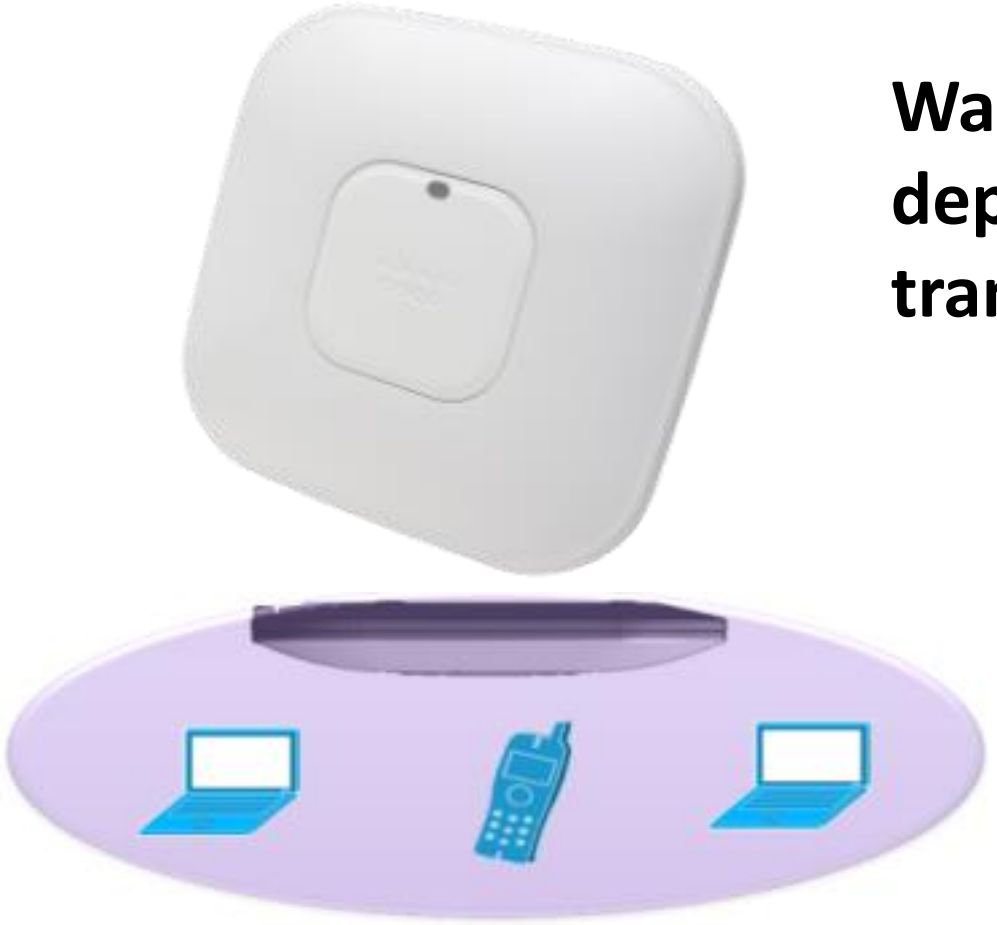
1572EAC

ANT2568 ANT2547

1552E ATEX

1552i (Integrated Ant)

Wall Mounting Access Point with Internal Antennas



Wall mounting is acceptable for small deployments such as hotspots, kiosks, transportation or small coverage areas.

Note: Wall mounting may create unwanted coverage areas on the floor above or below - This is not desirable for voice as it may cause excessive roams and is directional as metal is behind the antennas (backside).

Coverage is always more uniform when installed on the ceiling tile or grid area

Wall mounting AP-3500e, 2700e & 3700e

Orientation of the Dipoles if Wall Mounting

Note: The ceiling is usually higher and a better location for RF.

If using advanced features like location or voice try to locate the AP on the ceiling, or when mounting the AP on a wall orient the dipoles in this configuration.

Because dipoles on a wall can easily get orientated wrong as people touch and move them. Better still might be to use a Patch antenna or use the Oberon wall bracket. Be aware walls can add directional properties to the signal as they can have wiring, metal 2x4 construction and the wall attenuates the signal behind the AP limiting a nice 360 degree coverage.

Aironet 802.11n/ac Wall Mount (Style Case)

Third Party Wall Mount Option is Available

This optional wall mount best positions the Access Point dipoles for optimum performance – Recommended for Voice applications I f you MUST mount the Access Point on a wall.

Ceiling is a better location as the AP will not be disturbed or consider using patch antennas on wall installations

Oberon model 1029-00 is a right angle mount works with "I" and "e" models

http://www.oberonwireless.com/WebDocs/Model1029-00_Spec_Sheet.pdf

Other Mounting Options?

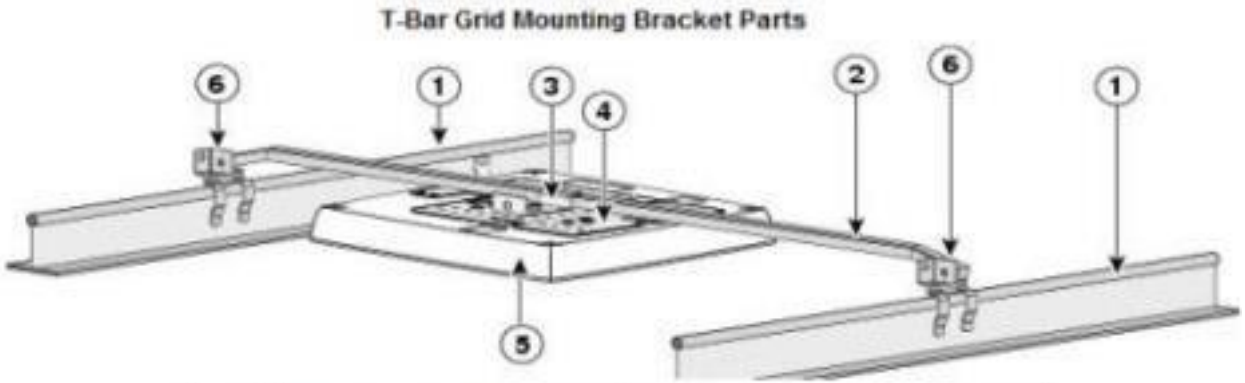
Different Mounting Options for Ceiling APs

Cisco has options to mount to most ceiling rails and directly into the tile for a more elegant look

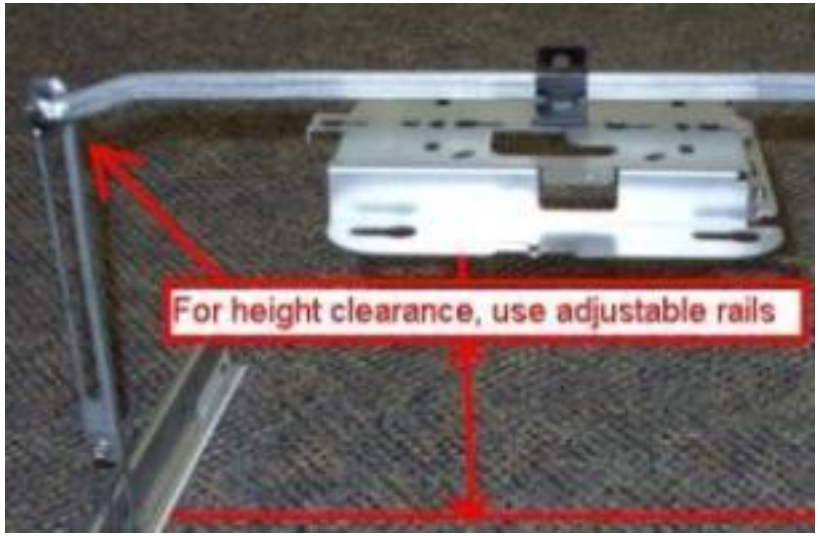
Locking enclosures and different color plastic "skins" available from third party sources such as
www.oberonwireless.com
www.terrawave.com

Installation above the Ceiling Tiles

An Optional Rail Above the Tiles May Be Used



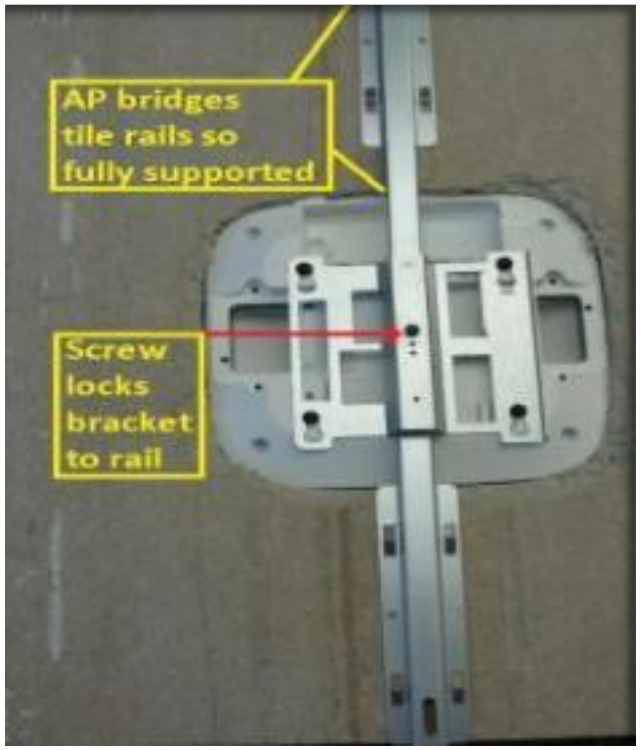
1	Suspended ceiling T-rail	4	Optional mounting bracket
2	T-bar box hanger	5	Access point
3	Bracket mounting clip	6	T-rail clip



Note: The AP should be as close to the tile as practical

AP bracket supports this optional T-bar box hanger item 2 (not supplied) Such as the Erico Caddy 512 or B-Line BA12

Integrated Ceiling Mount – Public Areas



Flush mount bracket part number is AIR-AP-BRACKET-3
This is a Cisco factory bracket that can be specified at time of order
Full strut on right provides support across two ceiling rails
Making it ideal for safety in (earthquake prone areas)

Antenna Placement Considerations

- AP antennas need placements that are away from reflective surfaces for best performance
- Avoid metal support beams, lighting and other obstructions.
- When possible or practical to do so, always mount the Access Point (or remote antennas) as close to the actual users as you reasonably can
- Avoid the temptation to hide the Access Point in crawl spaces or areas that compromise the ability to radiate well
- Think of the Access Point as you would a light or sound source, would you really put a light there or a speaker there?

Never mount antennas near metal objects as it causes increased multipath and directionality

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April 1-2, 2015

A look at some installations that went wrong

Installations that Went Wrong

NEVER EVER MIX ANTENNA TYPES

Antennas should always cover the same RF cell watch polarity

Installations that Went Wrong

Patch antenna shooting across a metal fence Multipath distortion causing severe retries

Mount the box horizontal and extend the antennas down and not right up against the metal enclosure

Above ceiling installs that went wrong

Yes it Happens and When it Does it is Expensive to Fix and No One is Happy

Dipole antennas up against a metal box and large metal pipes. This creates unwanted directionality and multipath distortion – This also creates nulls (dead areas) and creates packet retries

When a dipole is mounted against a metal object you lose all Omni-directional properties.

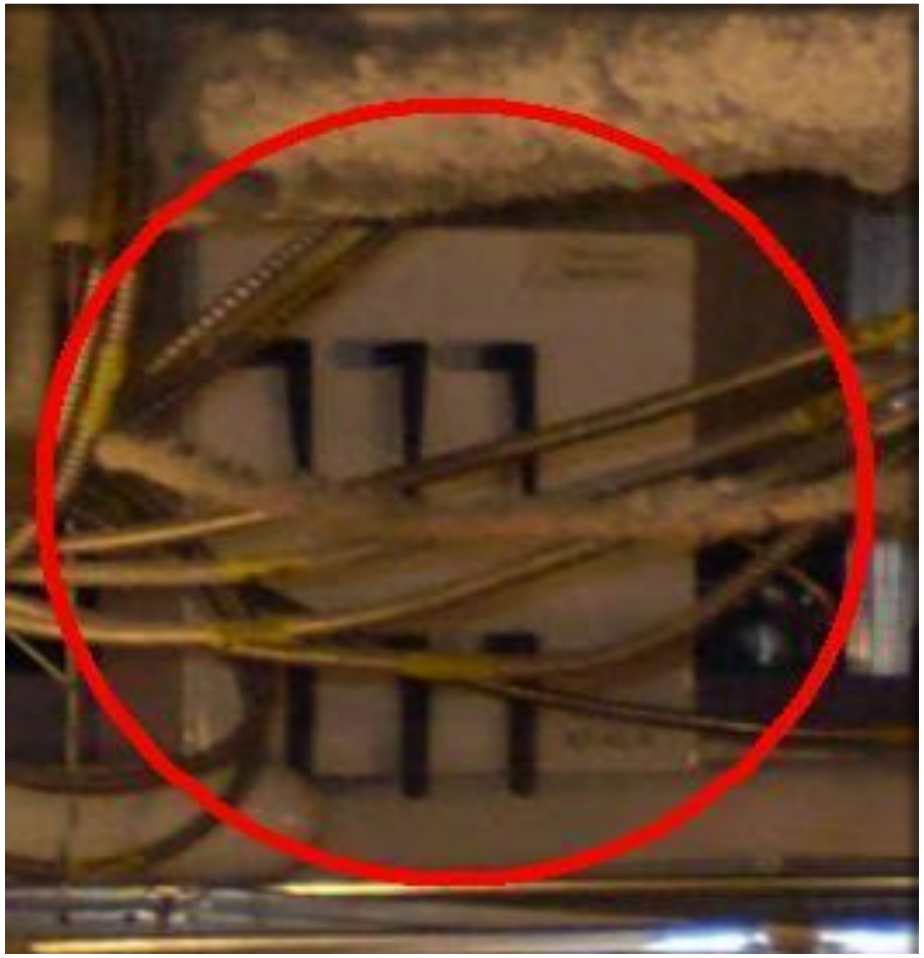
It is now essentially a directional patch suffering from acute multipath distortion problems.

Add to that the metal pipes and it is a wonder it works at all

Tip: Access Points like light sources should be in t he clear and near the users

Above Ceiling Installs that Went Wrong

You Mean it Gets Worse?

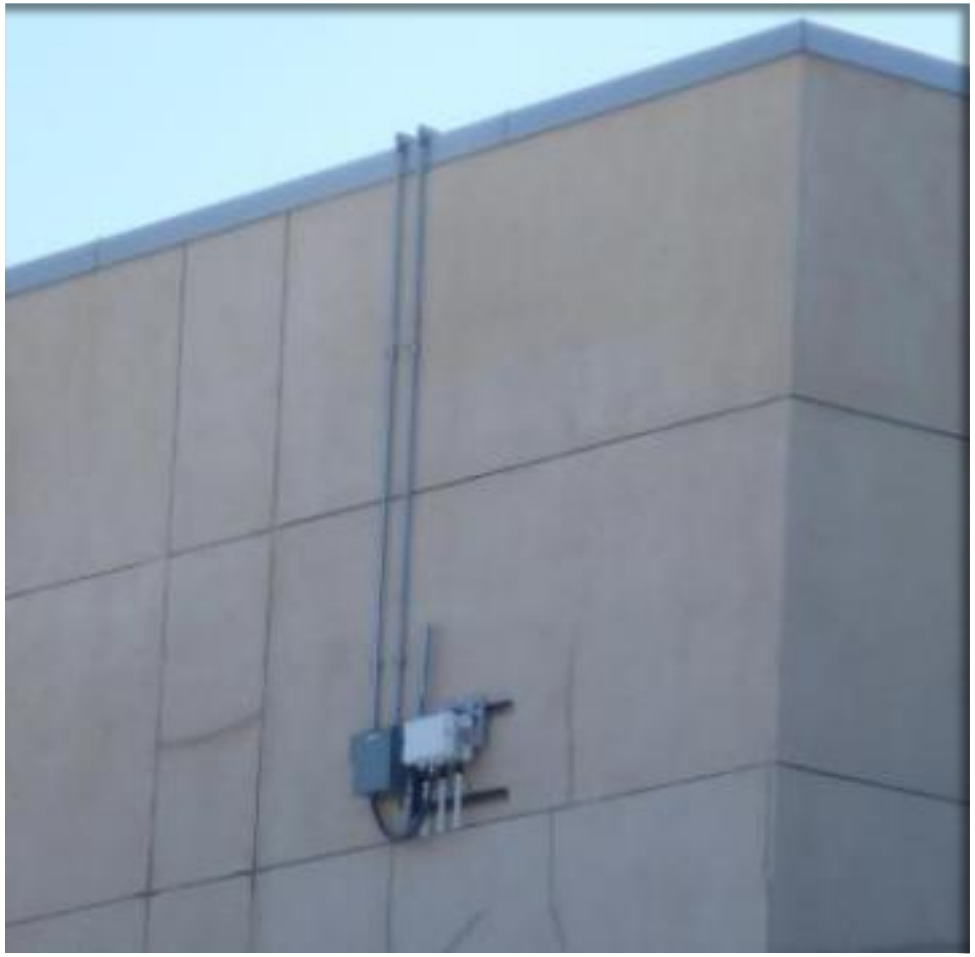


Installations that Went Wrong – Really???

RADIO WAVES DO NOT LIKE METAL CAGES

Installations that Went Wrong - Mesh

Installations that Went Wrong - Mesh



Building aesthetics matters – Antennas obstructed

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Cisco Cloud Based Predictive RF Planning Tool

Cisco Cloud Based Predictive RF Tool Features

Cisco Connect

- First Cloud based Wireless Tool
- Supports all Cisco Access points – Aironet, Meraki
- Supported on all Browsers
- Cisco Commerce Workspace Integration
- Google Earth Integration
- Simple drag & draw from RF legends provided
- Easy to switch between access points and applications
- Optimized for better access points coverage
- Easy RF proposal generation

FCS
March 2015

Cisco Cloud Based Predictive RF Tool Features (Cont.)

Cisco Connect

- Multi-floor planning
- Several coverage models (Data, Voice, Location)
- Flexible maps (ability to re-dimension, stretch, edit, copy/add/delete maps, floors, walls)
- Flexible coverage personalization (ability to change number of APs, change AP power, change target band of operation, change AP model)
- Flexible AP positioning (ability to move, add, remove APs)
- User-friendly display (sliding ruler to see the exact edge of a given coverage value, extensible and contextual menus to offer options without clogging screen)

Cisco Cloud Based Predictive RF Planning Tool – Benefits

Cisco Connect

- ✓First Cloud based Wireless Tool with 24x7 availability from anywhere
- ✓No Software to Install & No hardware dependency
- ✓Supports all Cisco Access points – Aironet, Meraki
- ✓Supported on all Browsers
- ✓Cisco Commerce Workspace Integration
- ✓Google Earth Integration
- ✓Simple and Intuitive for end user
- ✓Easy & Fast RF proposal generation within less than 15 minutes @ Customer site

NOT FOR RESALE

Cisco Connect
Seoul, Korea
April 1-2, 2015

Cisco Cloud Based Predictive RF Planning Tool – Demo

Summary

- ✓ Current Wireless Trends
  - ✓ Reasons for Customers to move to Newer Technology
  - ✓ Supremacy of Cisco 802.11ac technology
- ✓ RF Matters
- ✓ Examples of Good and Bad Installation
- ✓ Cisco Cloud Based Predictive RF Planning tool
  - ✓ Demo of the tool

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Thank You

Cisco Connect
Seoul, Korea
April 1-2, 2015

Reference slides

Cisco Connect
Seoul, Korea
April 1-2, 2015

1. 제목을 넣어주세요

2. 제목을 넣어 주세요

- 클라우드, 보안, 모빌리티 및 프로그래밍 가능한 네트워크에 대한 새로운 소비 모델의 등장과 함께 기술이 급격하게 변화하고 있습니다. 이러한 개념은 새로운 시장과 비즈니스 요구를 창출하며 커뮤니케이션과 정보 공유 방식을 바꾸고 IT의 역할을 크게 변화시키고 있습니다.

2. 제목을 넣어 주세요

- 클라우드, 보안, 모빌리티 및 프로그래밍 가능한 네트워크에 대한 새로운 소비 모델의 등장과 함께 기술이 급격하게 변화하고 있습니다. 이러한 개념은 새로운 시장과 비즈니스 요구를 창출하며 커뮤니케이션과 정보 공유 방식을 바꾸고 IT 의 역할을 크게 변화시키고 있습니다.

Summary

- 마지막 요약 페이지는 꼭 넣어주시기 바랍니다.
- 고객님들께서 이 세션에서 꼭 기억 하고 가셔야 하는 것을 정리해 주세요