802.11n

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Agenda

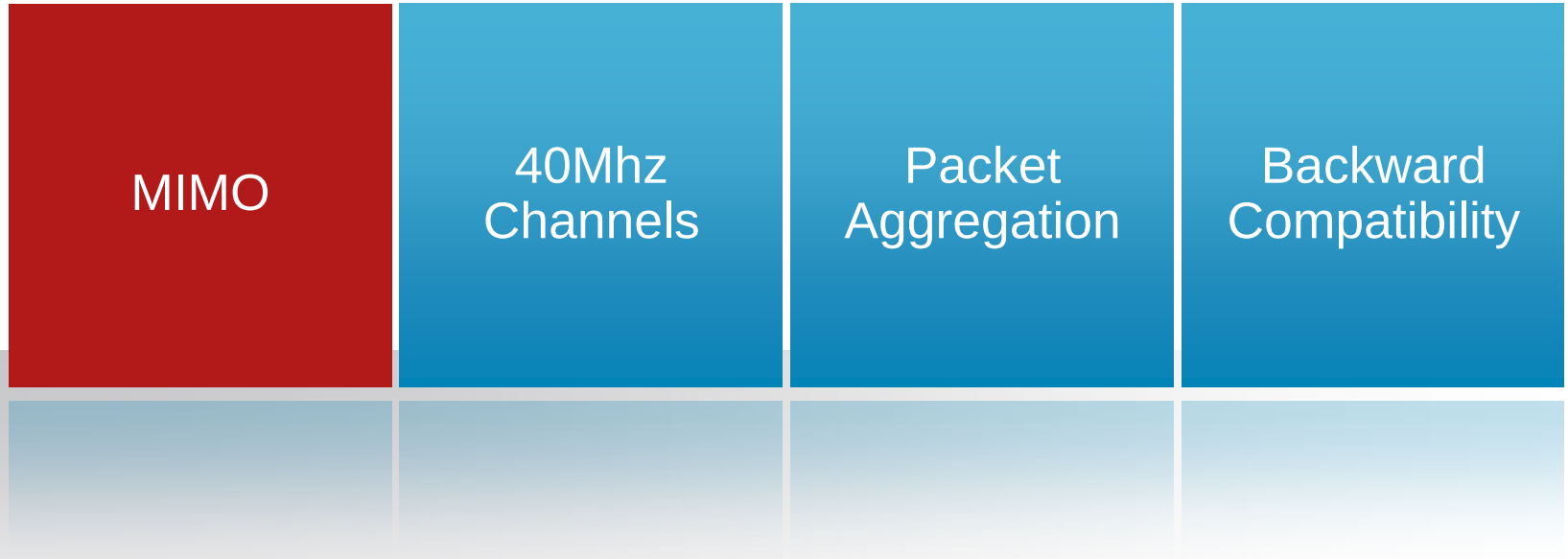
- 802.11n Technology Fundamentals
- 802.11n Access Points
- Design and Deployment
  - Planning and Design for 802.11n in Unified Environment
  - Key Steps for Configuration of 11n in a Unified Environment
  - 11n Client Adapters

802.11n Advantages

Throughput	Reliability	Predictability
Increased Bandwidth for emerging and existing applications	Reduced Retries permitting low latency and delay sensitive applications such as voice	Reduced dead spots permitting consistent connectivity for every application

Technical Elements of 802.11n

MIMO	40Mhz Channels	Packet Aggregation	Backward Compatibility



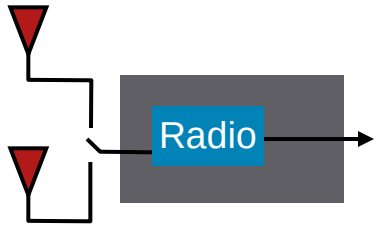
MIMO (Multiple Inputs Multiple Outputs)

- MIMO is pronounced mee-moh or my-moh
- 802.11n it is mandatory requirement to have at least two receivers and one transmit per band

  Optional to support up to four TXs and four RXs
- MRC—Maximum ratio combining
- SM—Spatial multiplexing

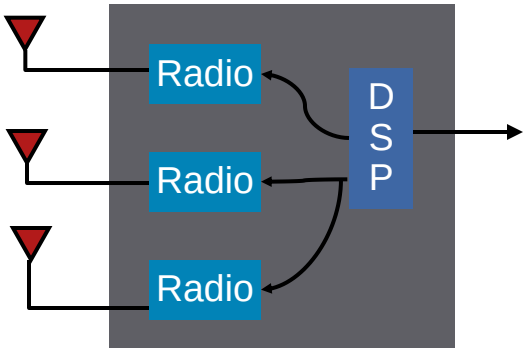
Note: MIMO provides improvements for non-n802.11 clients *

Comparing SISO and MIMO Signal Reception



- One radio chain
- Switches between antennas

  Either A or B
- Multipath degrades



- Three radio chains
- Aggregates all antennas

  A and B and C
- Multipath improves
- Better immunity to noise
- Better SNR than SISO

MIMO Radio Terminology

- TxR:S

  Transmit Antennas x Receive Antennas : Spatial Streams

- T – Transmit Antennas
- R – Receive Antennas
- S – Spatial Streams (1 = 150Mbps, 2 = 300Mbps)
- The 1250 and 1140 are 2x3:2

  Two Transmit, Three Receive, Two Spatial Streams

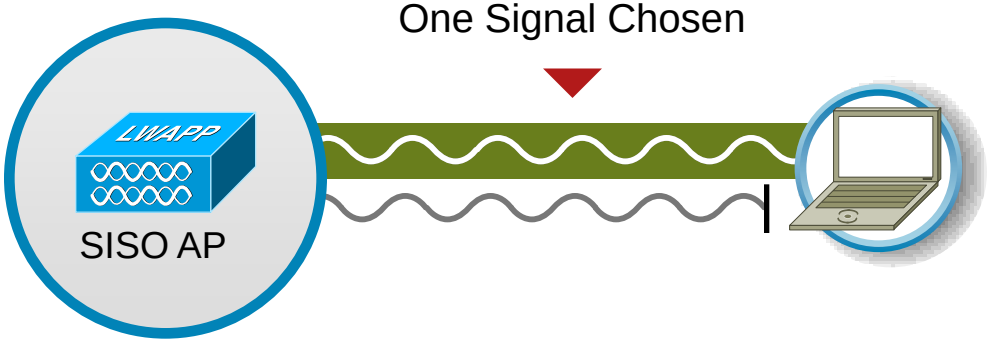
Maximum Ratio Combining

MIMO | 40Mhz Channels | Packet Aggregation | Backward Compatibility

MIMO (Multiple Input, Multiple Output)

Without MRC

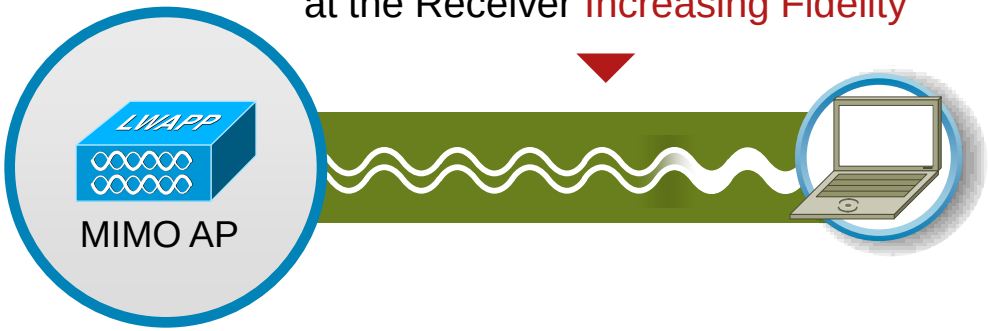
Multiple Signals Sent;
One Signal Chosen



Performance

With MRC

Multiple Signals Sent and Combined
at the Receiver Increasing Fidelity

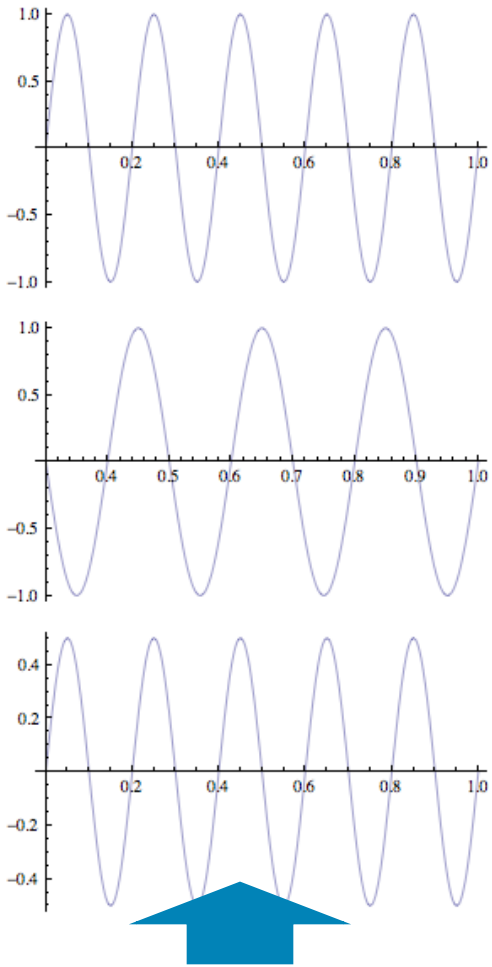


Performance

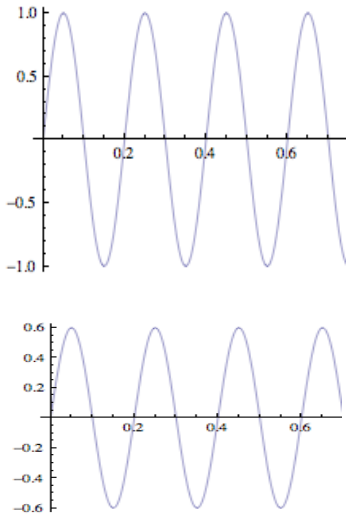
Maximum Ratio Combining

- Performed at receiver (either AP or client)
- Combines multiple received signals
- Increases receive sensitivity
- Works with both 11n and non-11n clients
- MRC is like having multiple ears to receive the signal

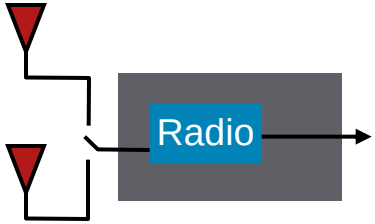
Illustration of Three Multipath Reflections to SISO AP

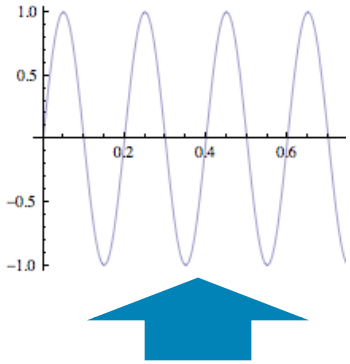


Multipath Reflections of Original Signal



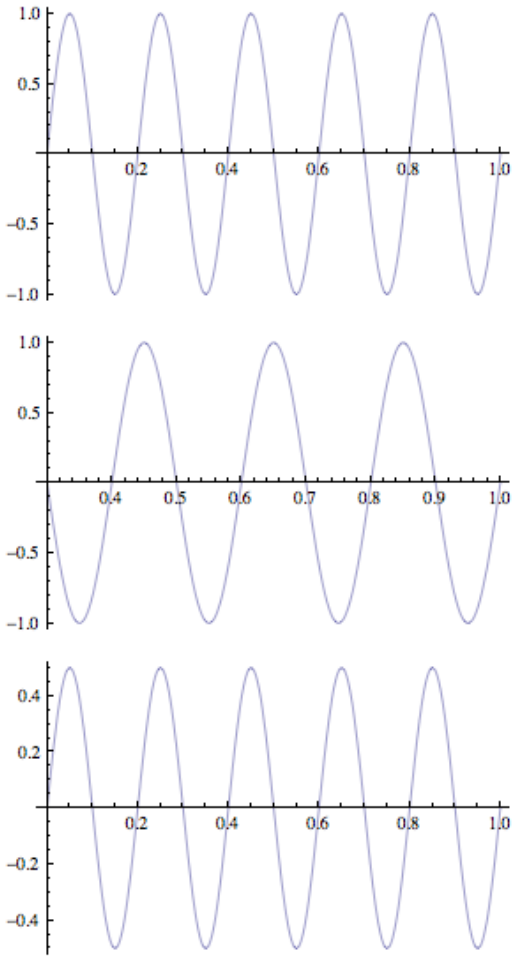
Signal Each Antenna Sees Due to Multipath Effect



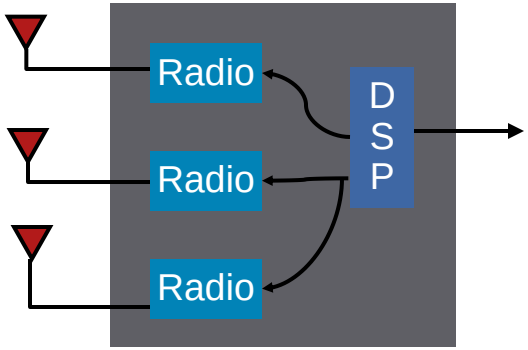


Radio Switches to Best Signal with Least Multipath Effect

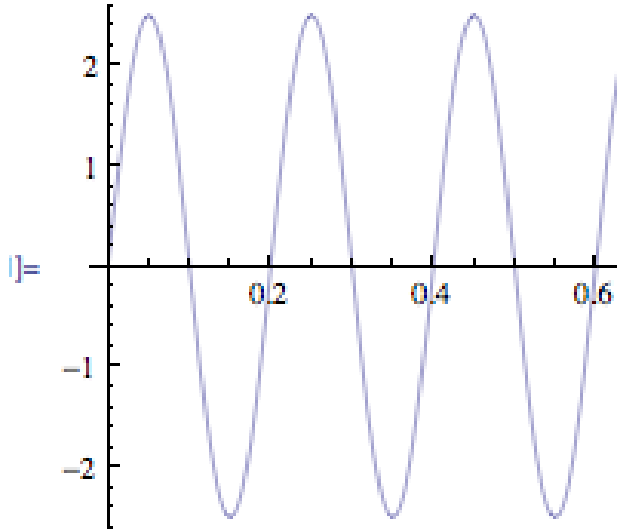
Illustration of Three Multipath Reflections to MIMO AP with MRC



Multipath Reflections of Original Signal



The DSP Adjusts the Received Signal Phase So They Can Be Added Together



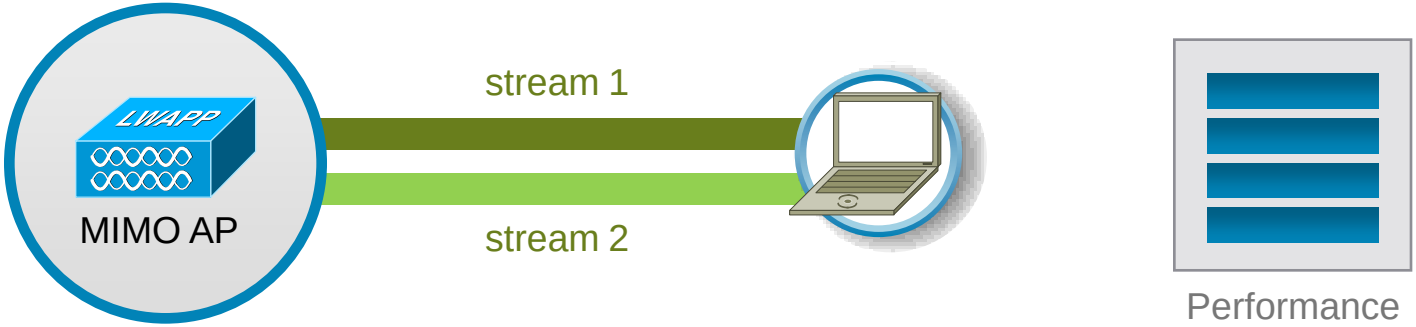
The Resulting Signal Is Addition of Adjusted Receive Signals

Spatial Multiplexing

	40Mhz Channels	Packet Aggregation	Backward Compatibility

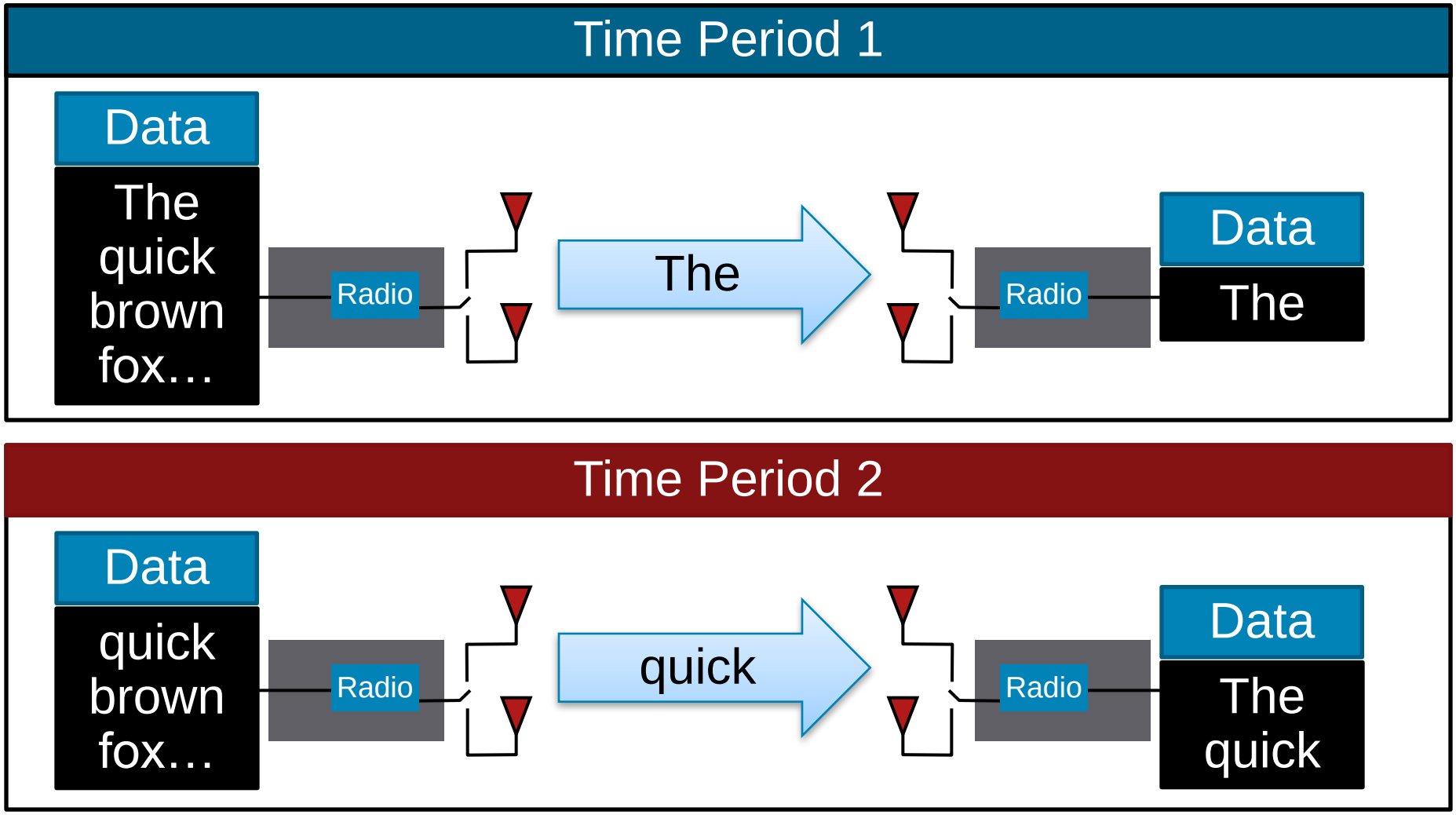
MIMO (Multiple Input, Multiple Output)

Information Is Split and Transmitted on Multiple Streams

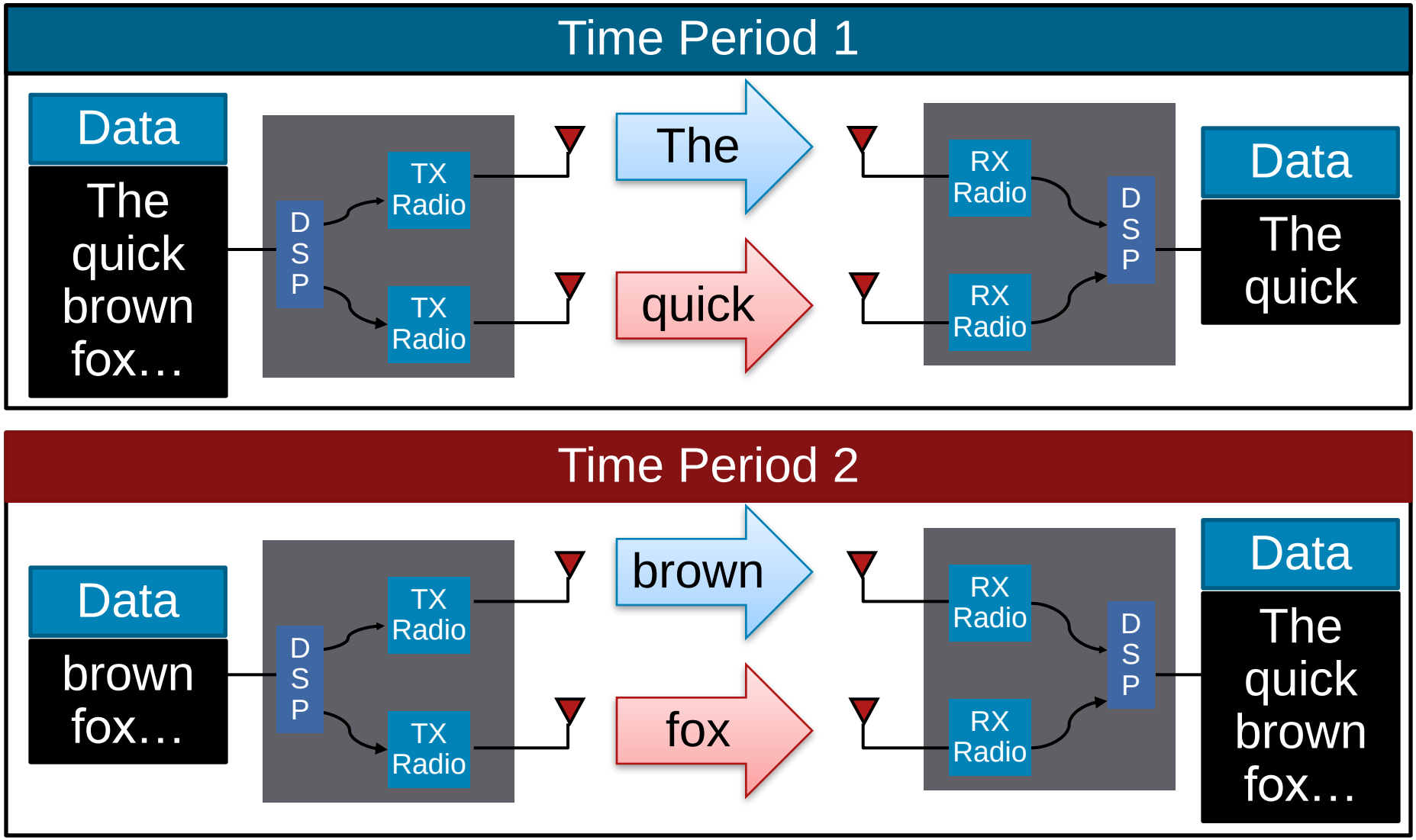


Transmitter and Receiver Participate	Concurrent Transmission on Same Channel	Increases Bandwidth	Requires 11n Client

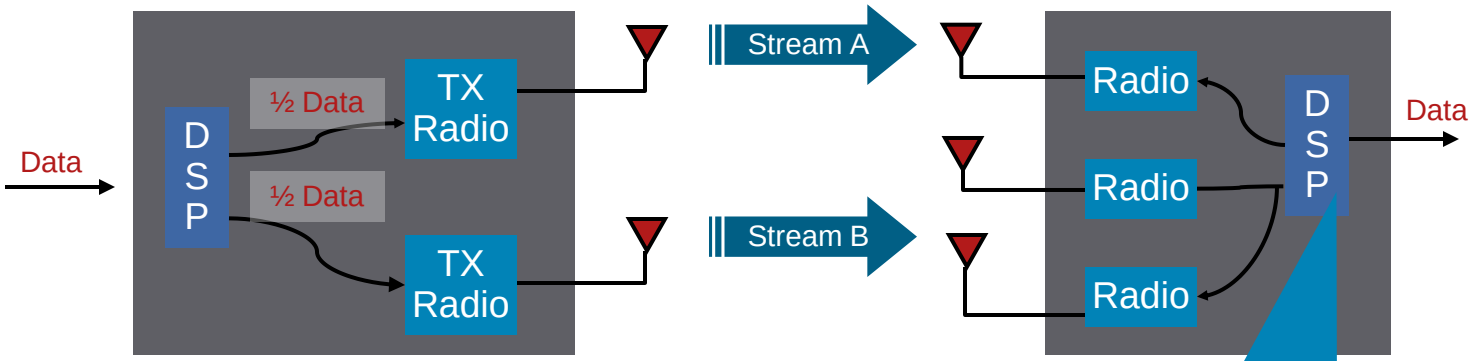
SISO Data Transmission



MIMO Spatial Multiplexing Data Transmission



More Efficient Spectrum Utilization with MIMO Spatial Multiplexing



- The data is broken into two streams transmitted by two transmitters at the same frequency

I Can Recognize the Two Streams Transmitted at the Same Frequency Since the Transmitters Have Spatial Separation Using My Three RX Antennas with My Multipath and Math Skills

Technical Elements of 802.11n

MIMO	40Mhz Channels	Packet Aggregation	Backward Compatibility

40-MHz Channels

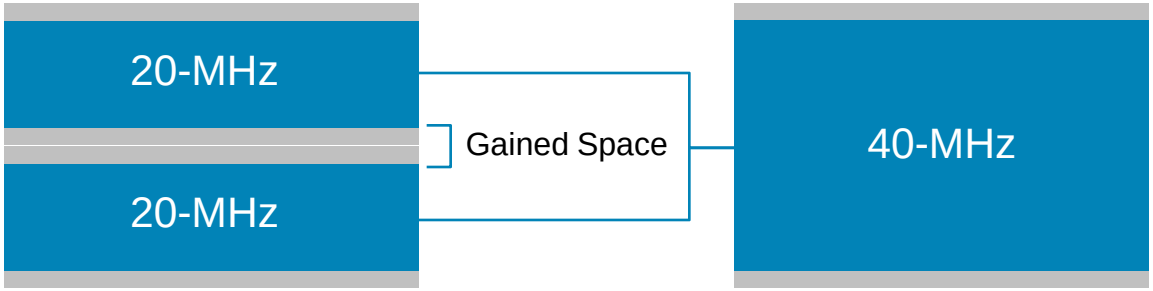
40Mhz Channels

Moving from 2 to 4 Lanes

- 40-MHz = 2 aggregated 20-MHz channels—takes advantage of the reserved channel space through bonding to gain more than double the data rate of 2 20-MHz channels

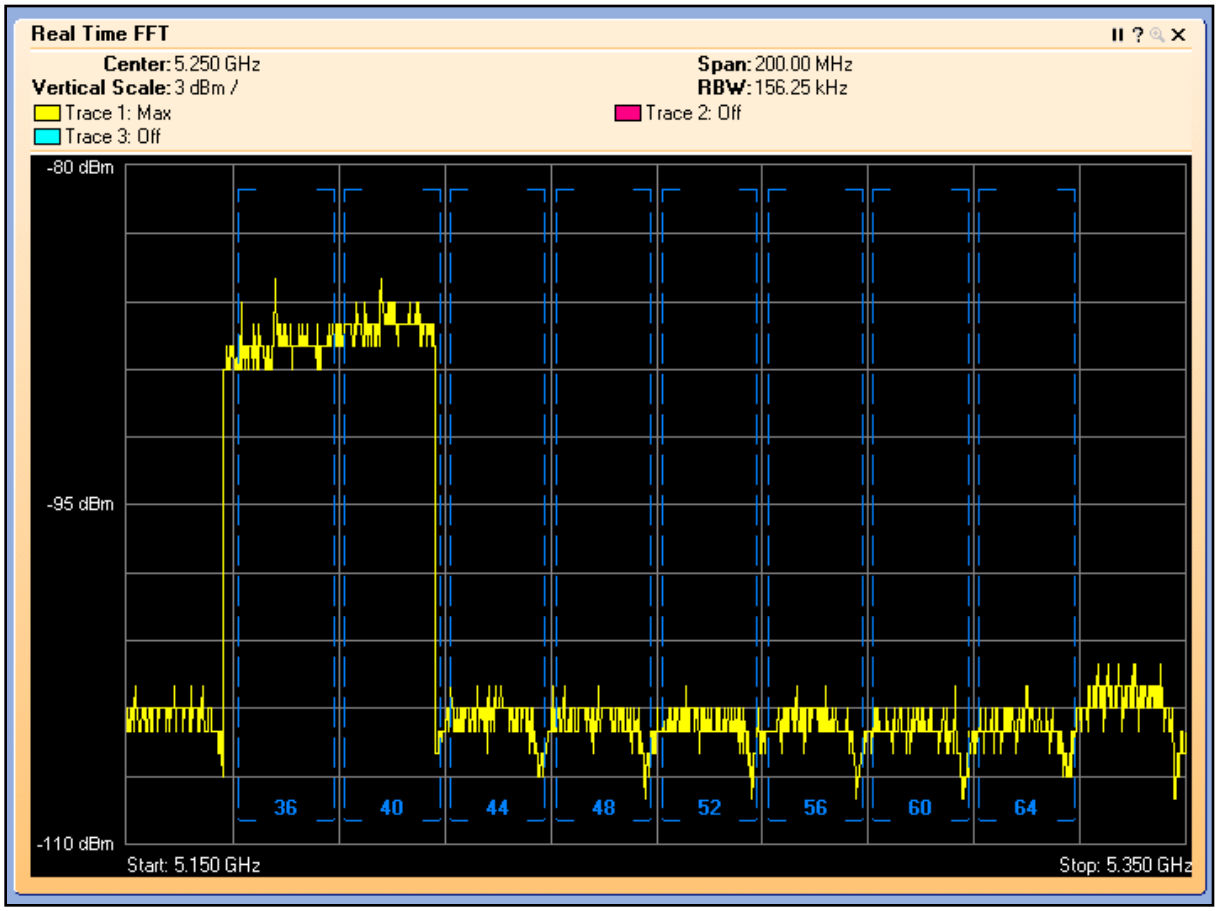
Double Wide Channel

40-MHz Wide Channel Support



- 802.11n supports 20 or 40 MHz wide channels
  - 40 MHz wide channels recommended only for 5 GHz
- Consists of a primary channel and a secondary channel also referred to as extension channel
  - Second channel must be adjacent
  - Can be above or below primary
  - Protection provided for 20 MHz wide client use

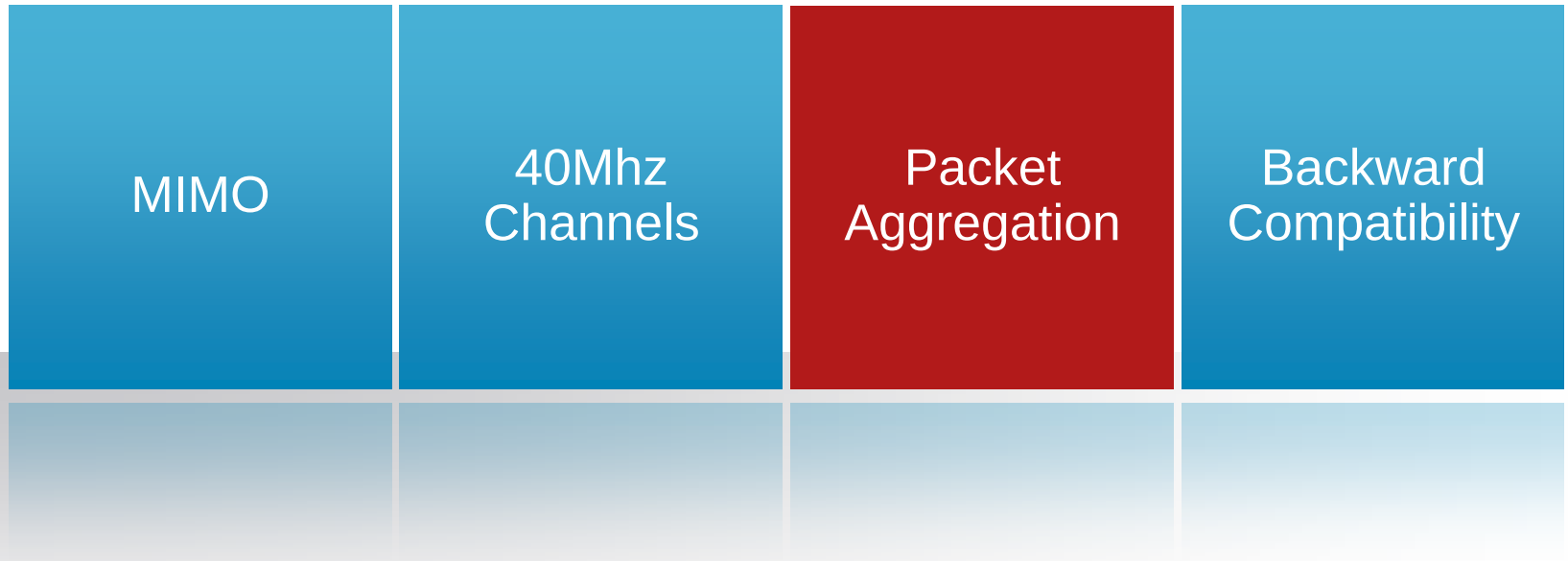
40 MHz-Wide Channel



- Spectrum Expert Trace for 40 MHz-wide channel channel 36 primary and channel 40 extension

Technical Elements of 802.11n

MIMO	40Mhz Channels	Packet Aggregation	Backward Compatibility

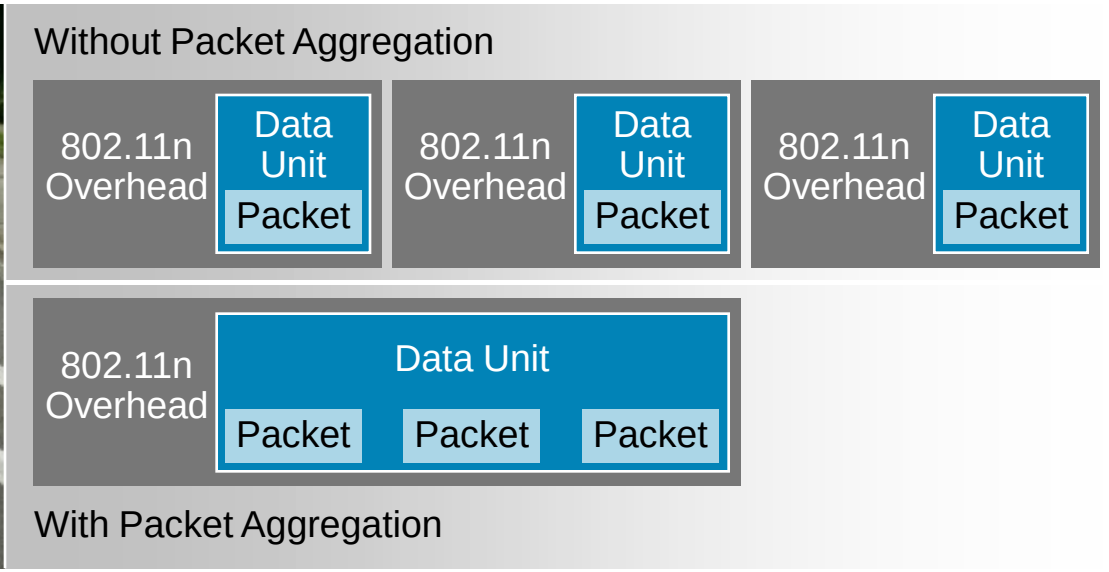


Aspects of 802.11n

MIMO | 40Mhz Channels | Packet Aggregation | Backward Compatibility

Packet Aggregation

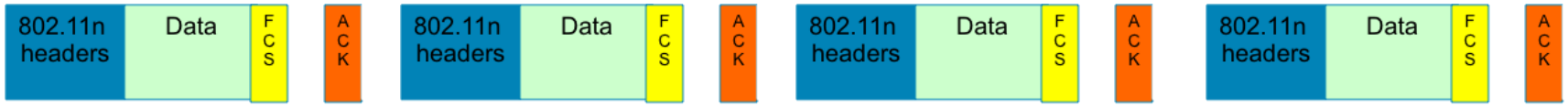
Carpooling Is More Efficient Than Driving Alone



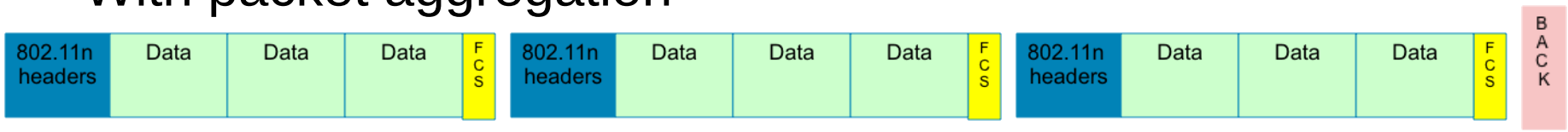
Packet Aggregation

- All 11n devices must support receiving of either packet aggregation method A-MPDU or A-MSDU
- A-MPDU packet aggregation is what 1250 and 1140 will use for packet aggregation with block acknowledge

Without packet aggregation



With packet aggregation



Technical Elements of 802.11n

MIMO	40Mhz Channels	Packet Aggregation	Backward Compatibility

Aspects of 802.11n

MIMO	40Mhz Channels	Packet Aggregation	Backward Compatibility

Backward Compatibility

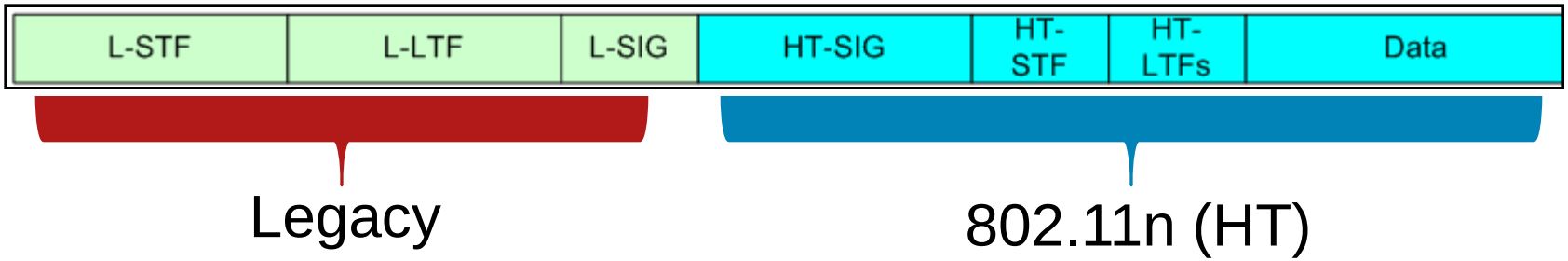
2.4GHz

5GHz

11n Operates in Both Frequencies

802.11ABG Clients Interoperate with 11n AND Experience Performance Improvements

802.11n HT PHY

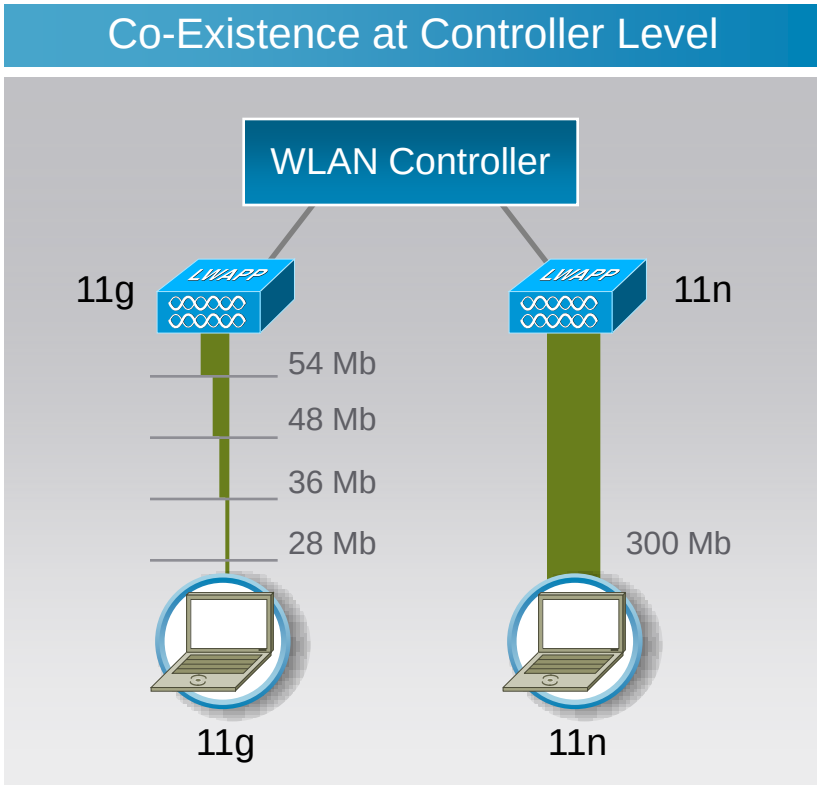


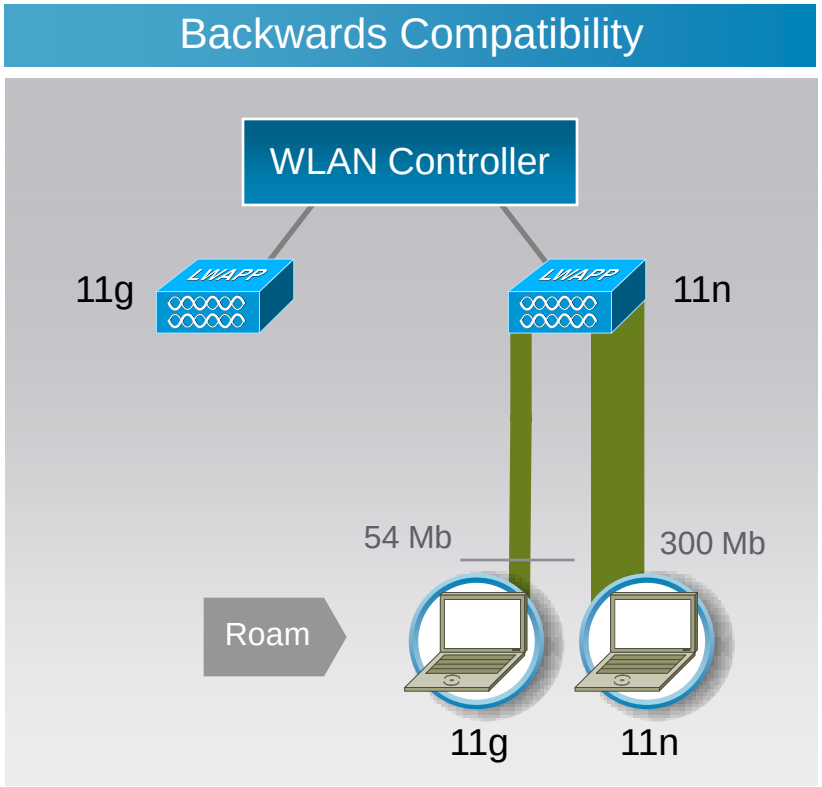
- To provide legacy co-existence all 11n transmissions today use a mixed mode PHY that encapsulates the HT PHY in the Legacy PHY when transmitting at HT rates
- Legacy devices degrade 11n device performance based on duty cycle they use in the spectrum

Backward Compatibility & Co-Existence

- Co-existence of ABG/N APs
- Benefits of 11n accrue to ABG clients

MIMO benefits ABG clients on the AP receive side from MRC





802.11n Data Rates

MCS—Modulation and Coding Scheme

- 802.11a/b/g used data rates
- 802.11n defines MCS rates
- 77 MCS rates are defined by standard
- 1140 and 1250 support 16 (MCS 0-15)

  Eight are mandatory
- Best MCS rate is chosen based on channel conditions
- MCS specifies variables such as

  Number of spatial stream, modulation, coding rate, number of forward error correction encoders, number data subcarriers and pilot carriers, number of code bits per symbol, guard interval

MCS Chart

MCS Index	Modul-ation	Spatial Streams	802.11n Data Rate			
			20 MHz		40 MHz	
			L-GI	S-GI	L-GI	S-GI
0	BPSK	1	6.5	7.2	13.5	15
1	QPSK	1	13	14.4	27	30
2	QPSK	1	19.5	21.7	40.5	45
3	16-QAM	1	26	28.9	54	60
4	16-QAM	1	39	43.3	81	90
5	64-QAM	1	52	57.8	108	120
6	64-QAM	1	58.5	65	122	135
7	64-QAM	1	**65**	**72.2**	**135**	**150**
8	BPSK	2	13	14.4	27	30
9	QPSK	2	26	28.9	54	60
10	QPSK	2	39	43.3	81	90
11	16-QAM	2	52	57.8	108	120
12	16-QAM	2	78	86.7	162	180
13	64-QAM	2	104	116	216	240
14	64-QAM	2	117	130	243	270
15	64-QAM	2	**130**	**144**	**270**	**300**

Maximum with 1 spatial stream

Maximum with 2 spatial streams

A Few More 802.11n Features Used to Increase Performance

- Beam forming
- Reduced inter-frame spacing
- Reduced guard interval

  From 800ns to 400ns between ‘symbols’

- QAM 64

Cisco Next-Generation Wireless Portfolio

- Cisco Aironet 1140 Series
  - Carpeted Indoor Environments
  - Easy to Deploy-Sleek design with integrated antennas
  - 802.11n performance with efficient 802.3af power
  - Blends seamlessly into the environment
- Cisco Aironet 1250 Series
  - Rugged Indoor Environments
  - Versatile RF coverage with external antennas
  - Flexible power options for optimal RF coverage

11a/g to 11n Access Point Migration

Indoor Environments

Integrated Antennas

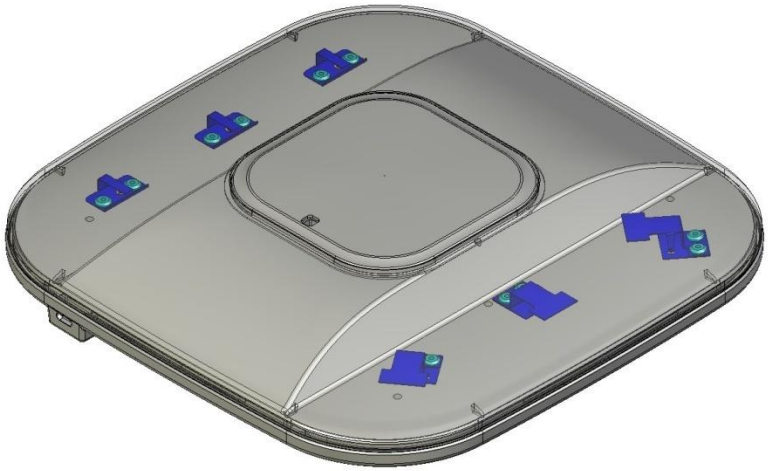
Rugged Environments

Antenna Versatility

Still Three Antennas per Band

1250

1140



2.4GHz – 4dBi

5GHz – 3dBi

Planning and Design for 802.11n

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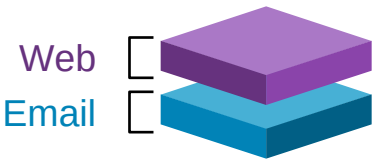
Phases of an 11n Deployment

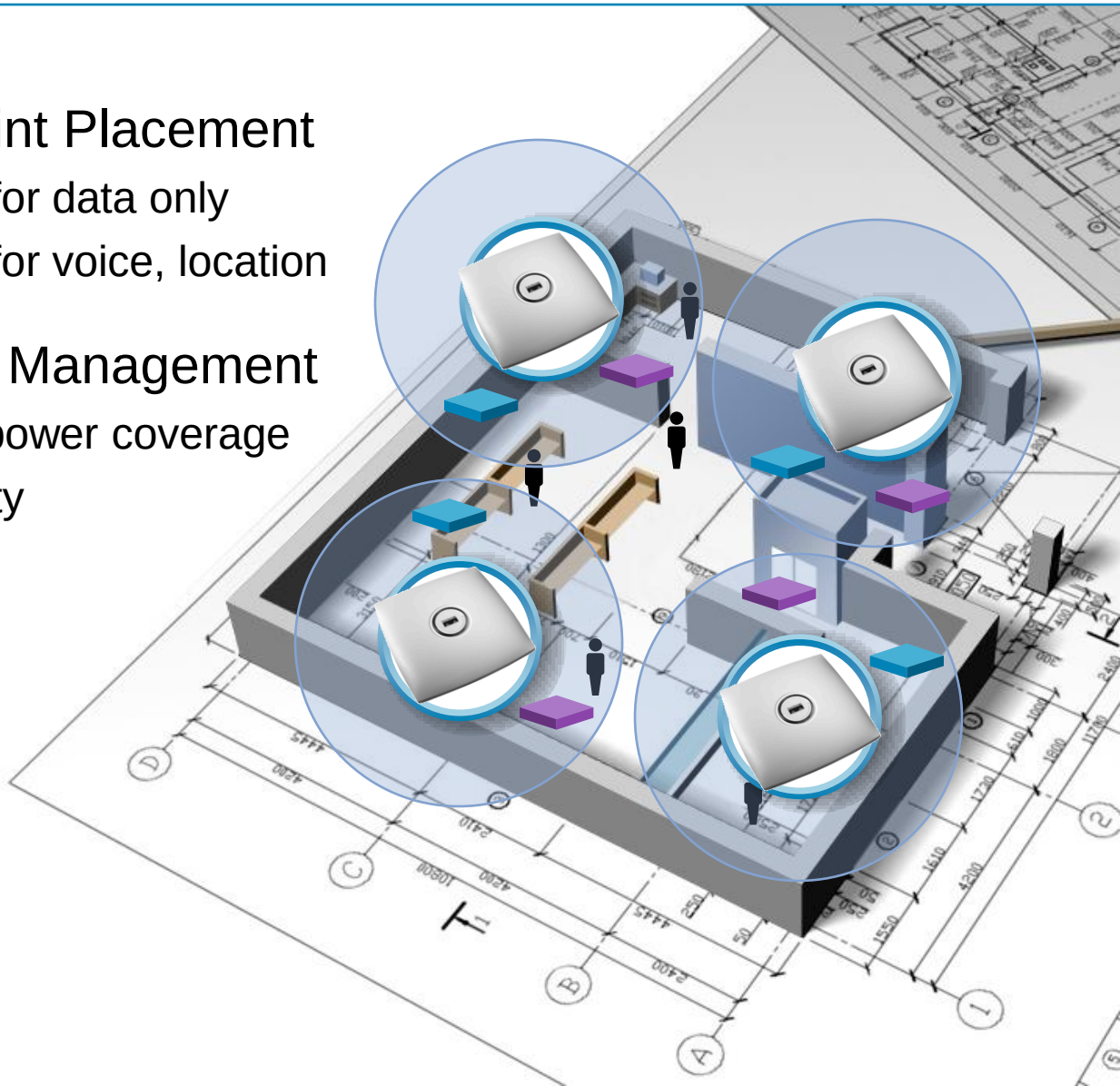
- Design Considerations
  - 1:1 Replacement Strategy for Capacity
  - 5GHz Strategy
- Planning
  - WCS Planning Tool
  - Infrastructure Considerations
- Deployment
  - Site Survey
- Operation
  - Configuration (40MHz RRM, Data Rates, Security, etc.)
  - Tracking and augmenting controller capacity

1130 Access Point Placement

- 1130 Access Point Placement
  - 1 per 5,000 sq feet for data only
  - 1 per 3,000 sq feet for voice, location
- Radio Resource Management
  - Adaptive channel / power coverage
  - Operational simplicity

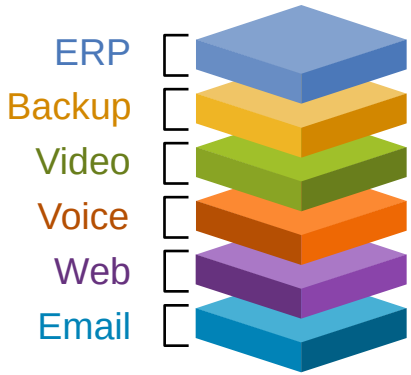


Several Supported Apps

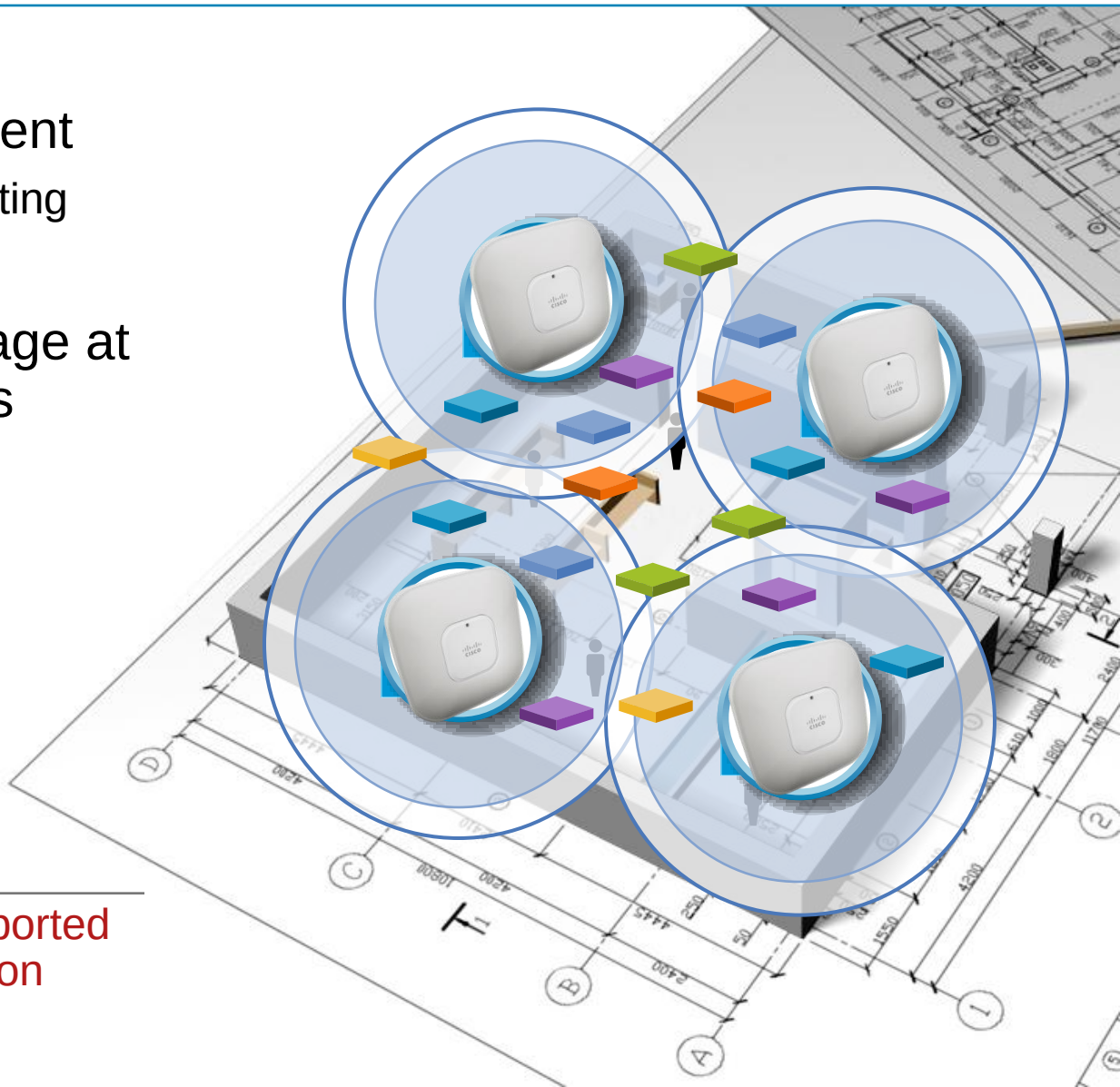


1140 Access Point Placement

- 1 for 1 replacement
  - AP1140 reuses existing AP1130 T-Rail Clip
- Improved coverage at higher data rates

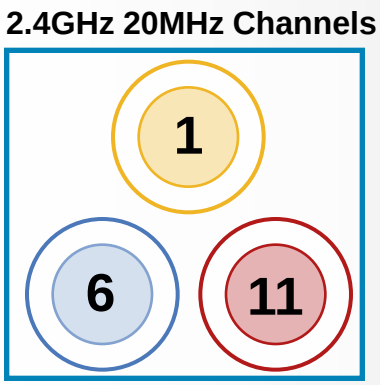


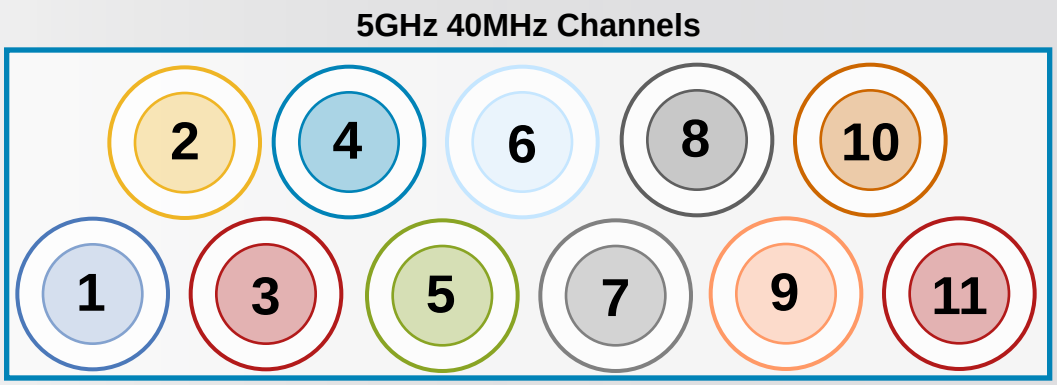
More Applications Supported at Any Given Location



Effective Frequency Use—5GHz and 2.4GHz
Create a 5GHz Strategy

- 5GHz Recommended for 802.11n
  - More available spectrum—greater number of channels
  - Reduced interference (no Bluetooth, Microwave Ovens, etc.)
  - Maximum throughput in a 40MHz channel
  - Many 11n devices only support 40MHz in 5GHz
- 2.4GHz still benefits from MIMO and packet aggregation





Capacity Principles

Channel Capacity: Use 5 GHz and 2.4 GHz

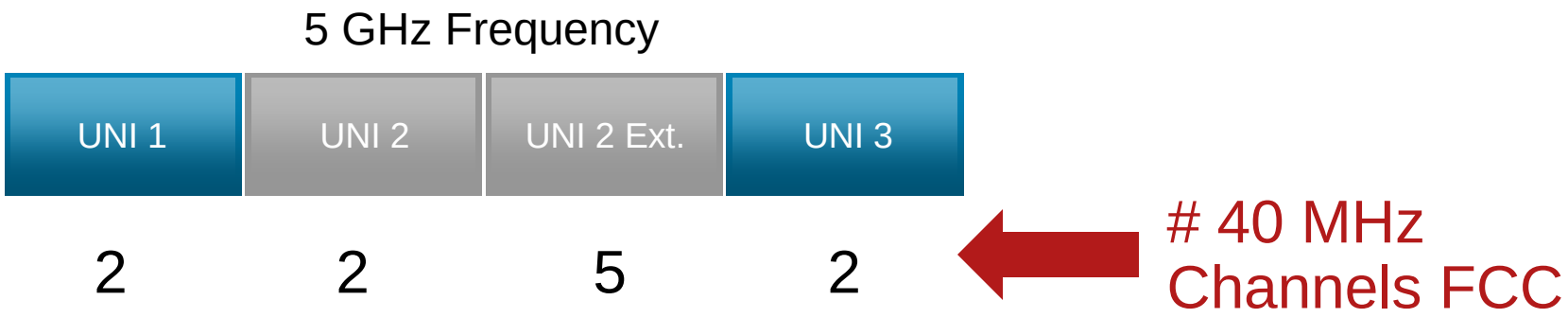
- 2.4 GHz clients using N will consume less spectrum
- 5 GHz will provide the most capacity for 802.11n clients

  More available spectrum—greater number of channels

  Greater speeds dues to 40 MHz channel the fact that many devices will only support 40 MHz channel in 5 GHz

- DFS support allows up to 11–40 MHz wide channels to be used in 5 GHz band

  If radar is detect in the area some UNI2 and UNI2 channels may disabled



11n Deployment

Site Survey Recommendations

- Use “Active Survey” tools

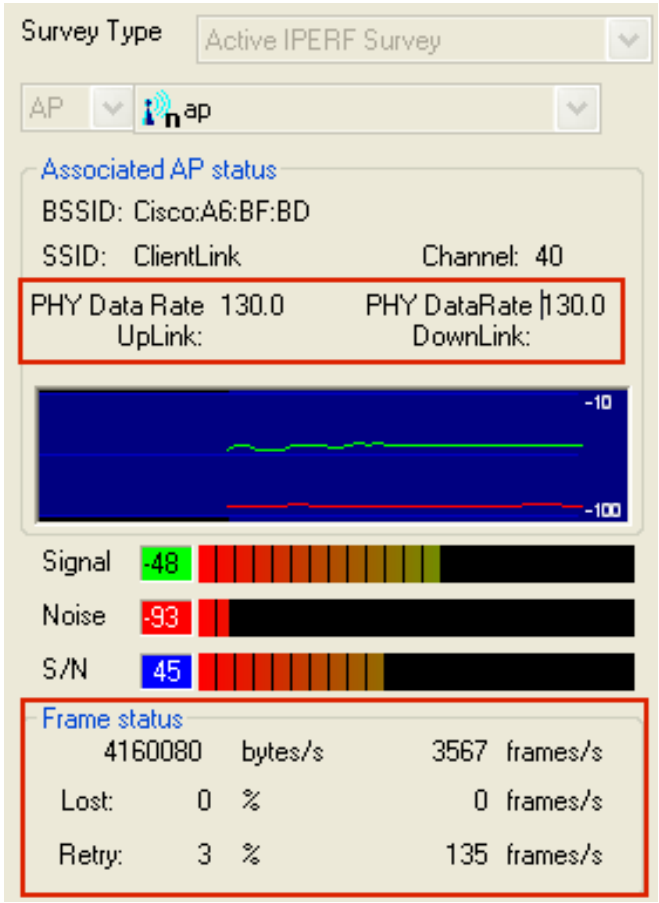
  AirMagnet 6.0 uses Iperf to send traffic when surveying to measure actual data link speeds

- Survey for lowest common client

  Once for 11a/g clients

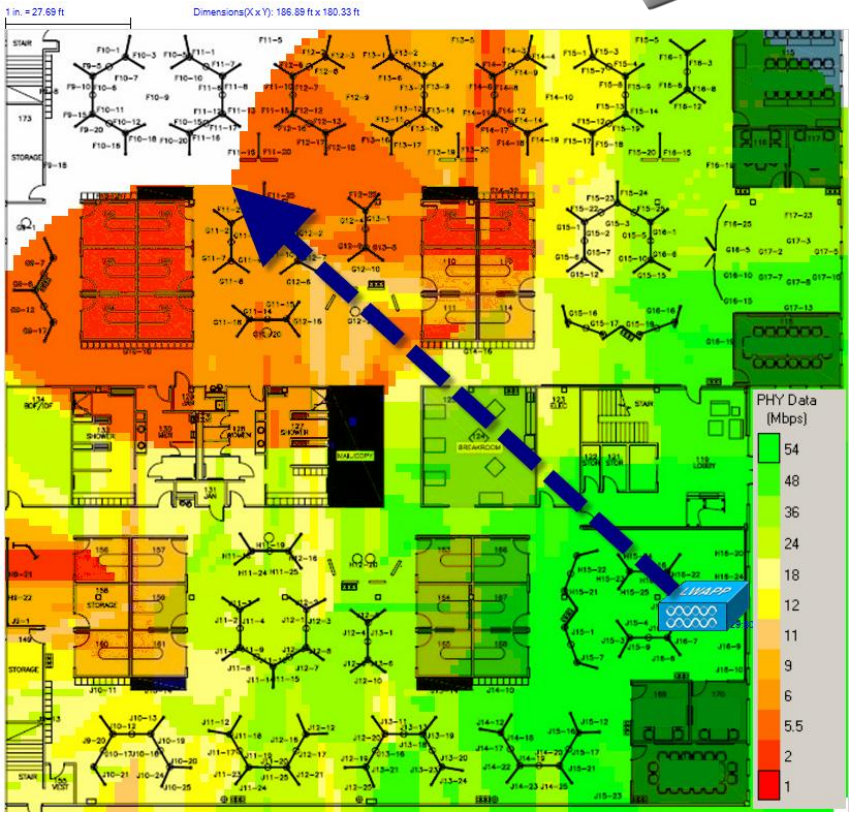
  Once for 11n clients (optional)

- Survey at intended AP power levels

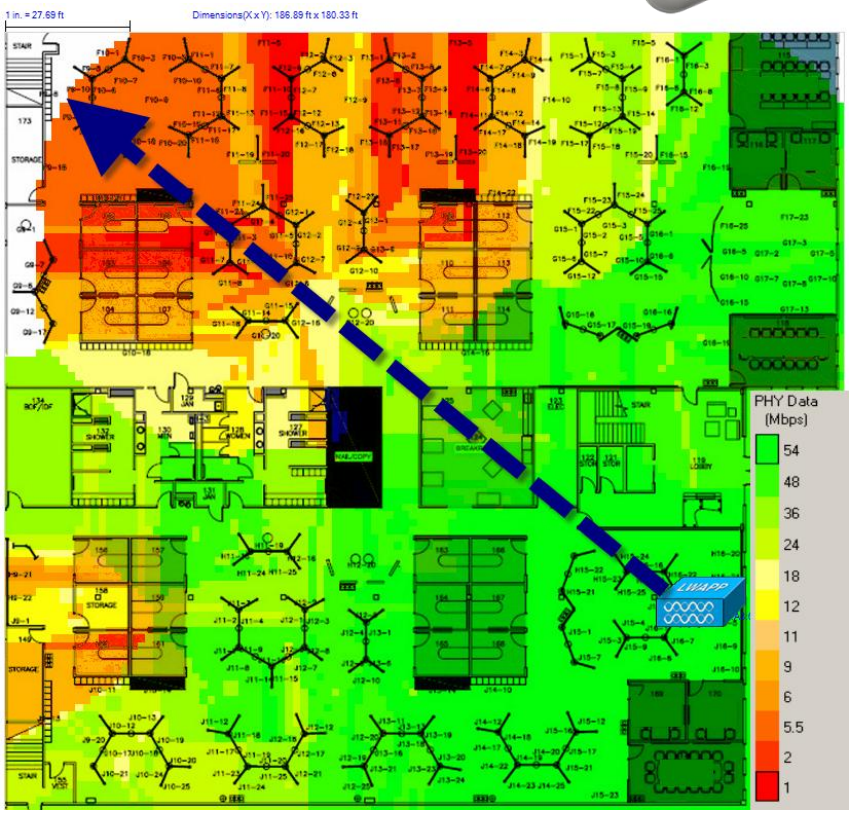


2.4GHz - Maximum Range

AP1130 – 2.4GHz



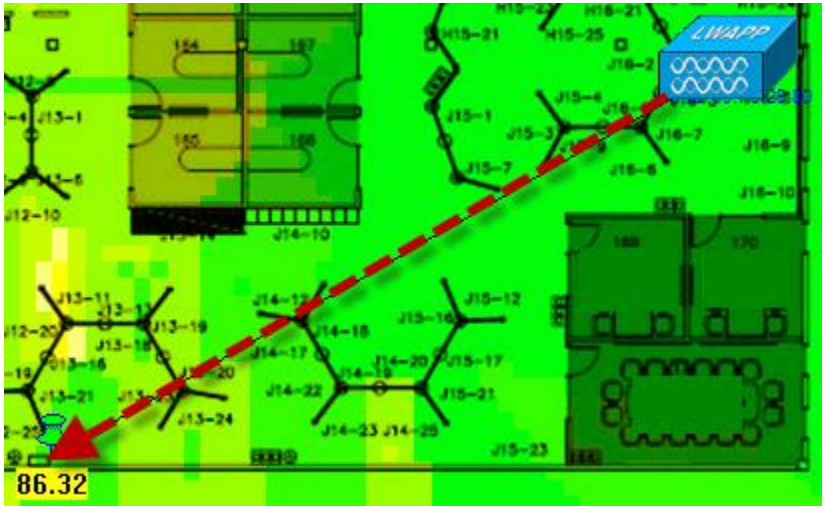
AP1140 – 2.4GHz

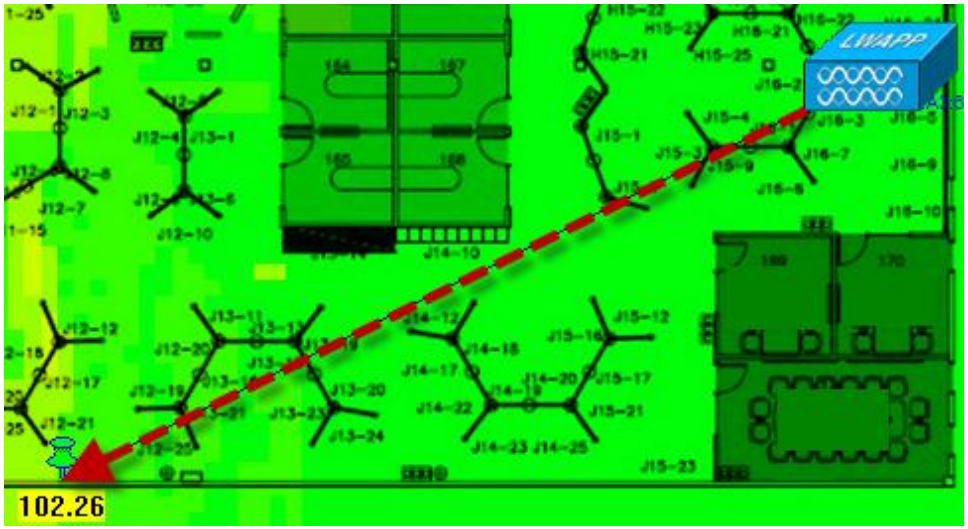


10% Increase in 802.11g Range

Improved 802.11g Coverage

1130 vs. 1140—11G Active Survey





1130 11G Survey

48 Mbps Coverage

86 Feet

1140 11G Survey

48 Mbps Coverage

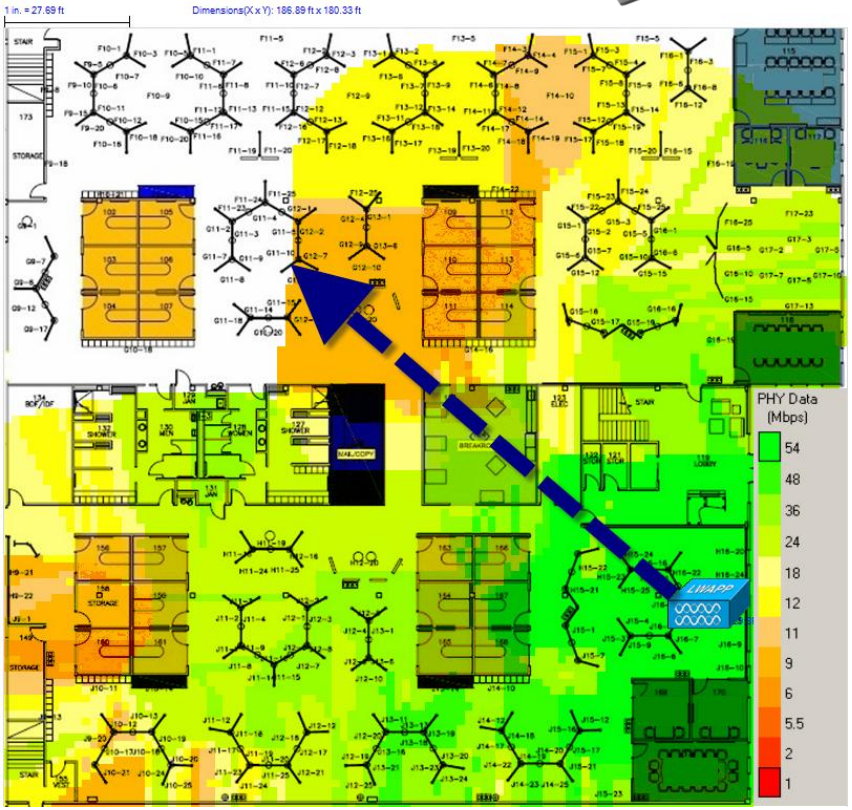
102 Feet

- Note the more uniform coverage of high (green) data rates

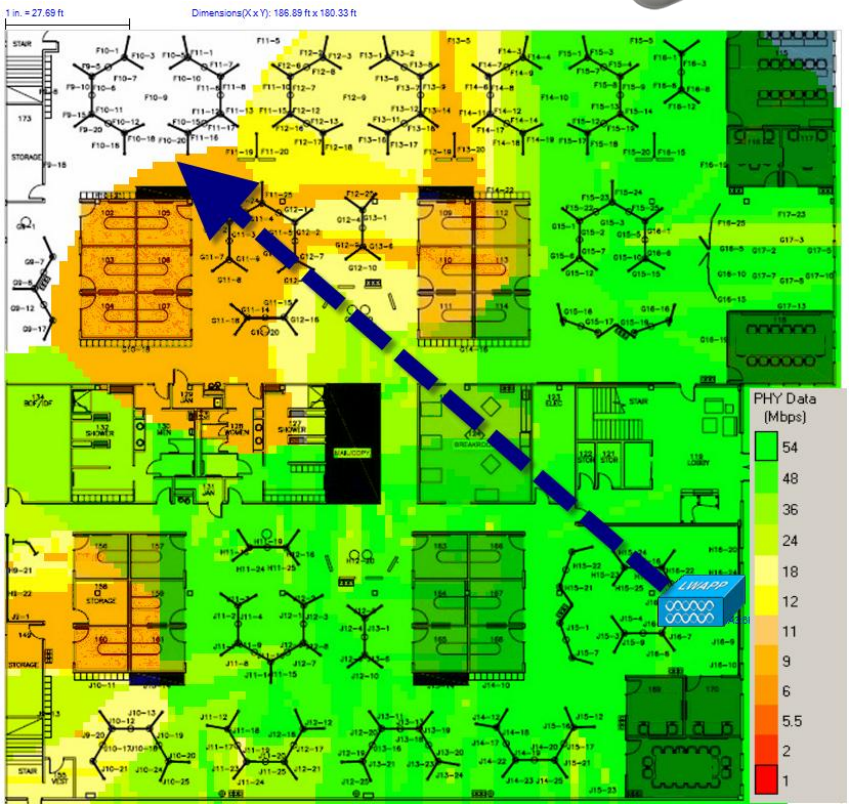
18% Increase in 802.11g Coverage

5GHz - Maximum Range

AP1130 – 5GHz



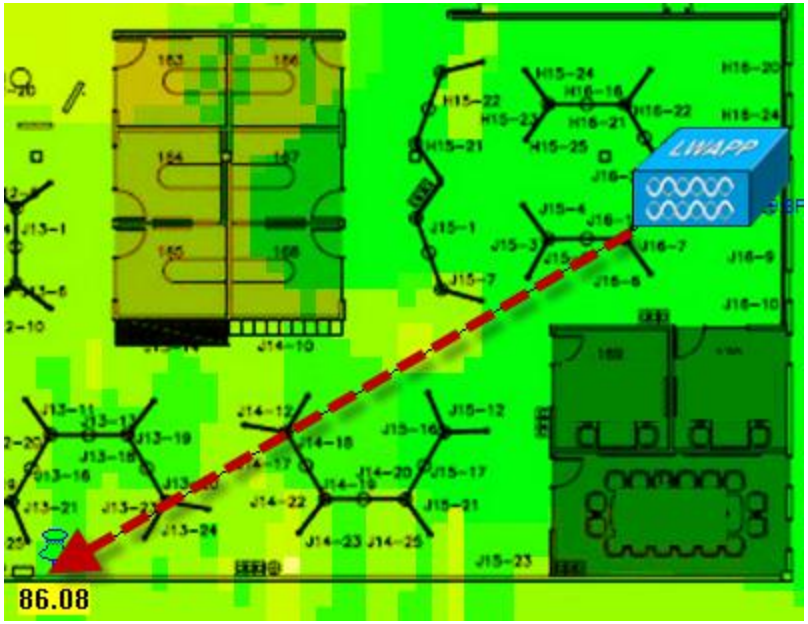
AP1140 – 5GHz

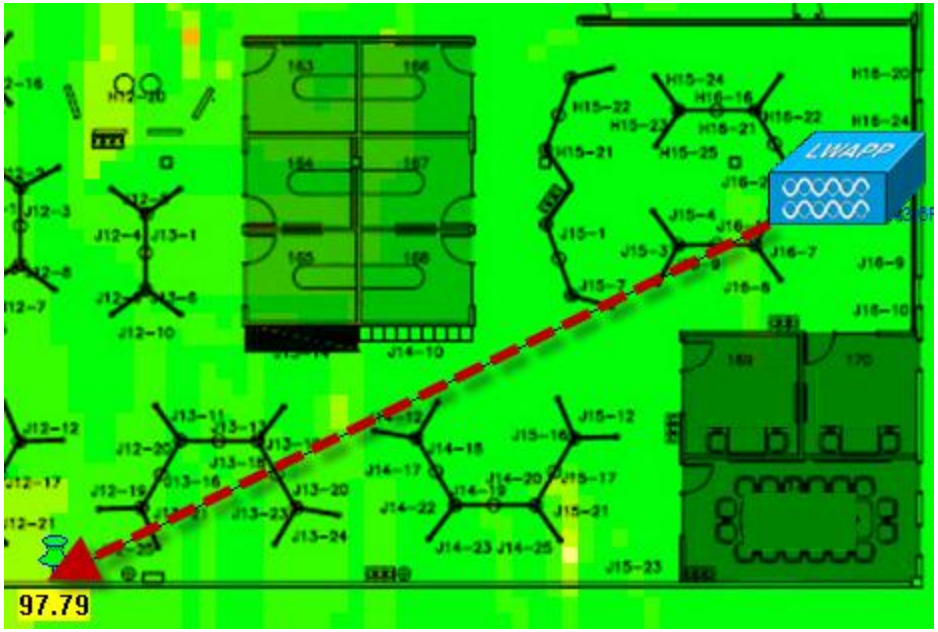


10-15% Increase in 802.11a Range

Improved 802.11a Coverage

1130 vs. 1140—11A Active Survey





1130 11A Survey

48 Mbps Coverage

86 Feet

1140 11A Survey

48 Mbps Coverage

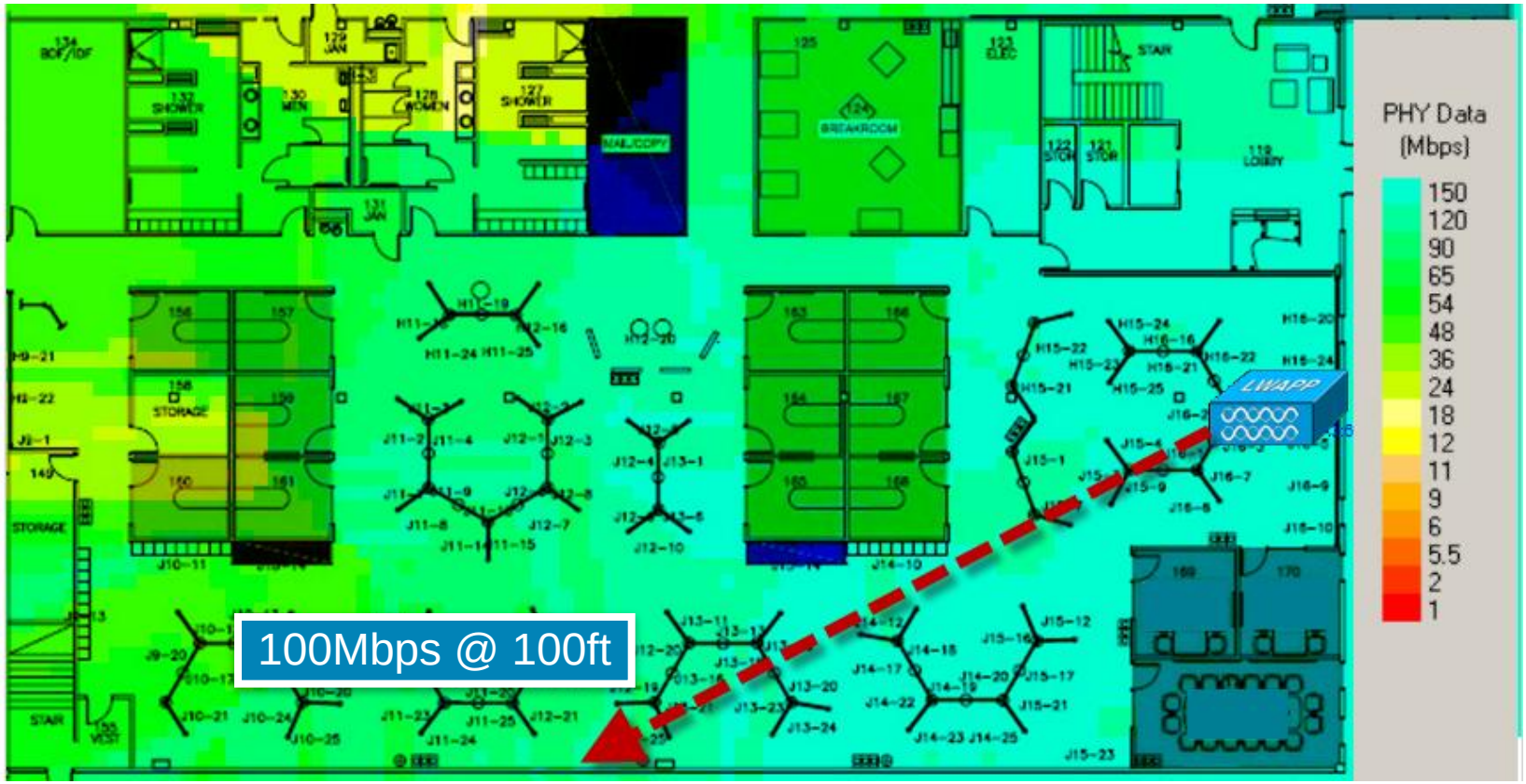
97 Feet

- Note the more uniform coverage of high (green) data rates

12% Increase in 802.11a Coverage

802.11n Coverage

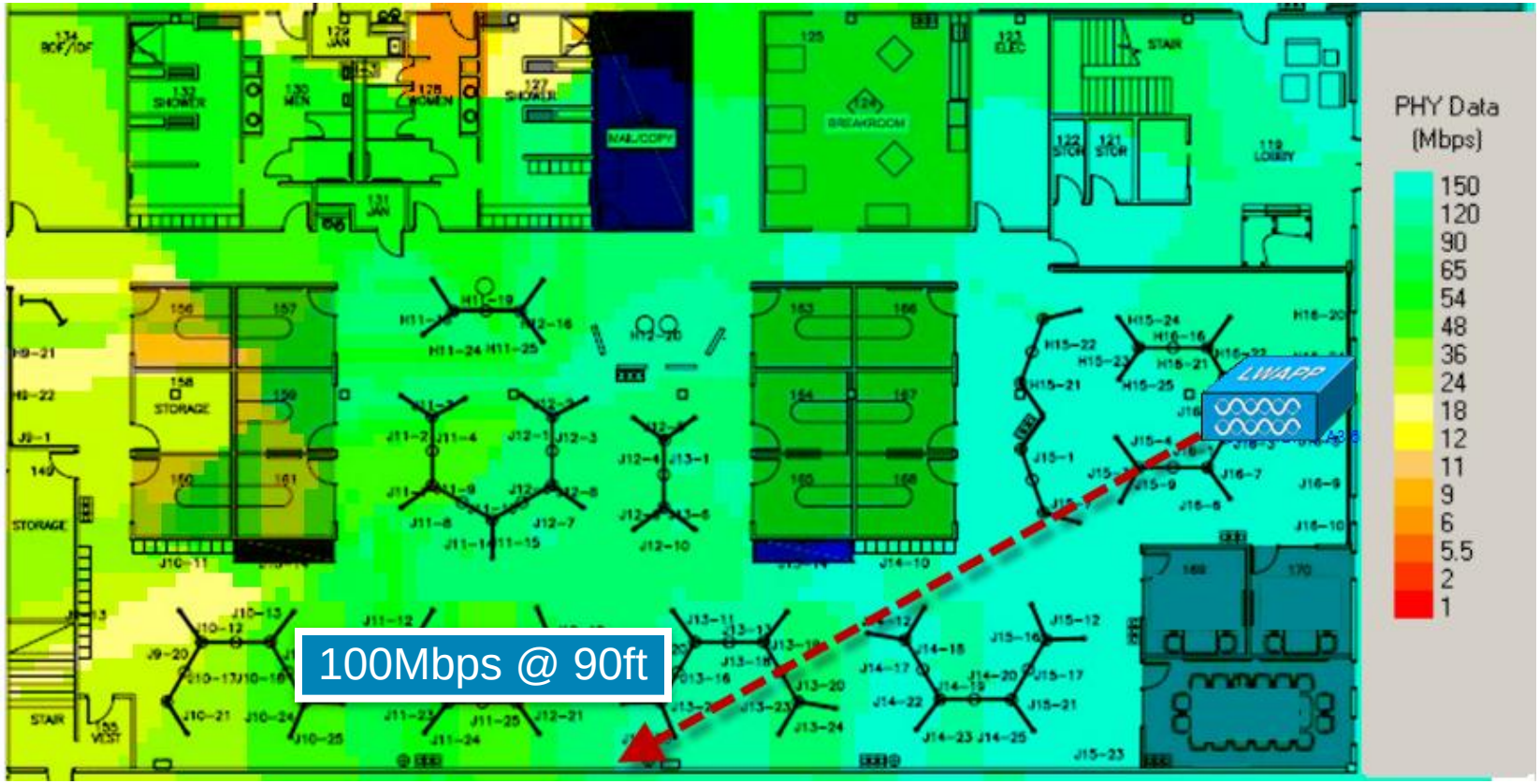
2.4GHz – 20MHz Channel Size



- Maximum of 144Mbps in a 2.4GHz 20MHz channel
- At 100ft average data rate is 100Mbps

802.11n Coverage

5GHz – 20MHz Channel Size

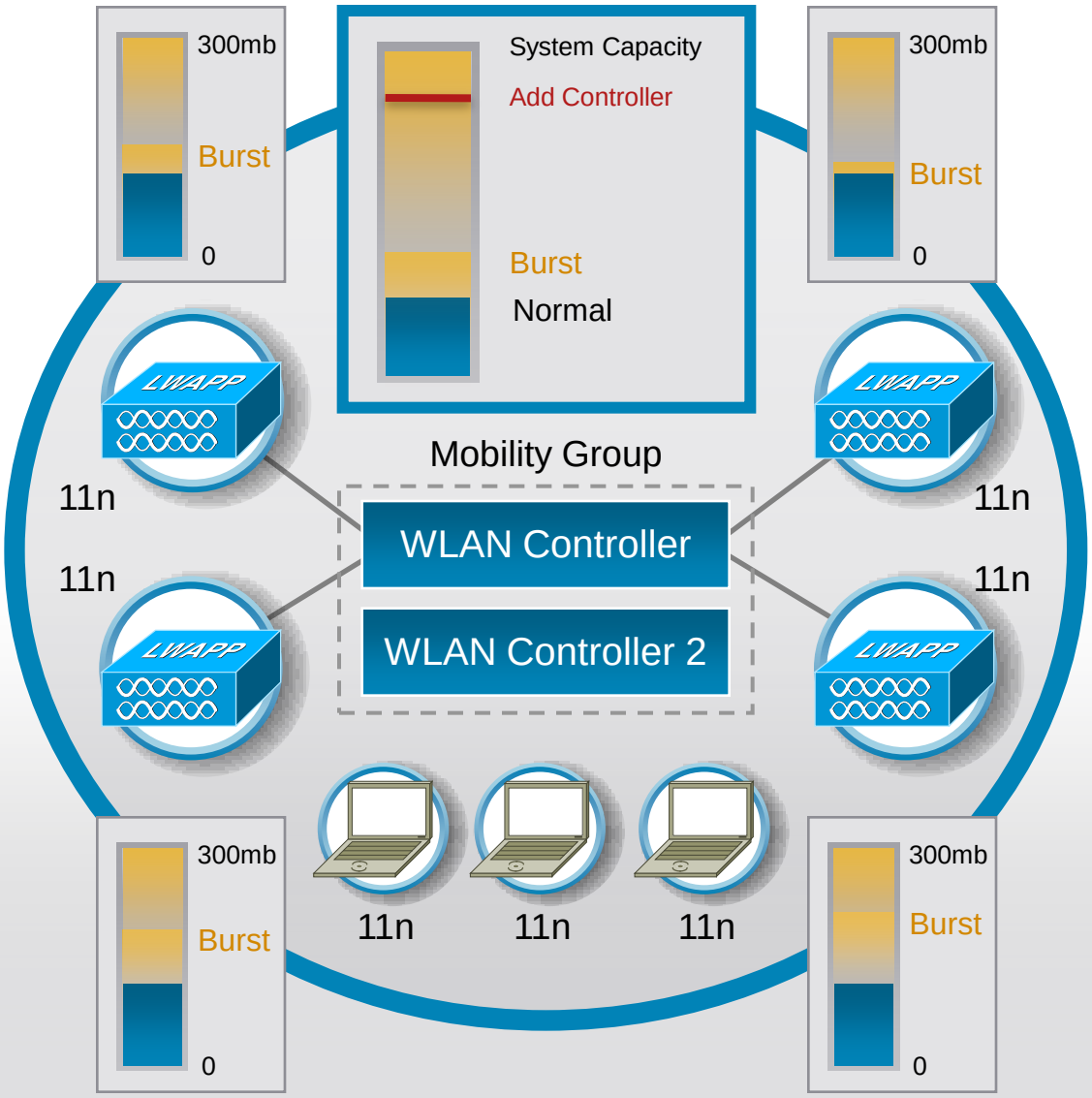


- Maximum of 144Mbps in a 5GHz 20MHz channel
- At 90ft average data rate is 100Mbps

Five Principles for Maximizing Capacity with 802.11n

1. Design for 5 GHz 40 MHz wide channels and increased cell density
2. Design for lowest common denominator legacy clients
   - Plan to migrate client devices to 11n
   - Disable lower legacy rates
3. Minimize noise and interference effects
   - Use RRM for interference avoidance
   - Use Spectrum Expert to find interference source
4. Design for GigE to APs
5. Specify a good 802.11n client adapter

Network Capacity and Scalability



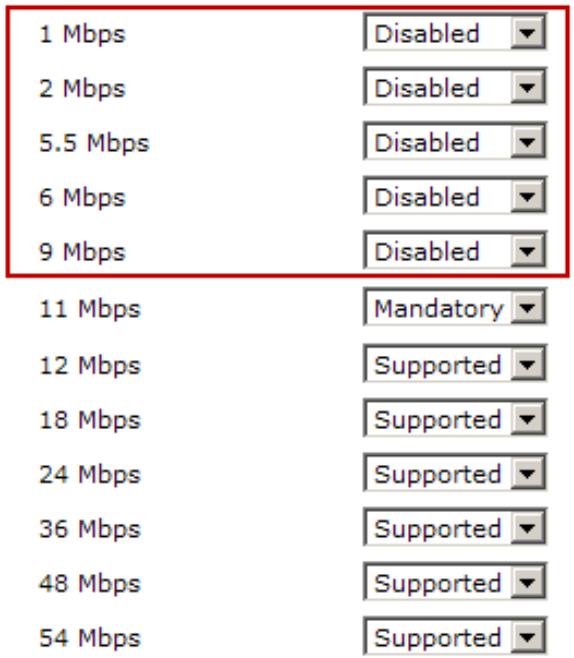
- Plan for system level capacity, not per AP capacity
- Plan for throughput (60% of data rate)
- Additional controller increases capacity and improves availability
- Typical Ethernet network oversubscription is 20:1

Improving Mixed Mode Performance

Disabling Unnecessary Data Rates

- Benefit: Beacons and Broadcast traffic utilize less “airtime”
- For 802.11b/g deployments
  Disable: 1, 2, 5.5, 6 and 9Mbps
- For 802.11g-only deployments
  Disable: 1, 2, 5.5, 6, 9 and 11Mbps
- For 802.11a deployments
  Disable: 6 and 9 Mbps
- Higher rates can also be disabled (ex. 12, 18Mbps) – dependant on deployment

Tuned 802.11b/g Data Rates:



802.11n Client Adapters

11n Client Adapters

- Make sure adapter is 11n Draft 2.0 certified by WiFi Alliance - http://www.wi-fi.org

- 802.11n adapters have a major influence on performance levels that can be achieved
- Built-in 11n adapters out perform add-on

  USB and PCMCIA 11n adapters have less than optimal antenna placement

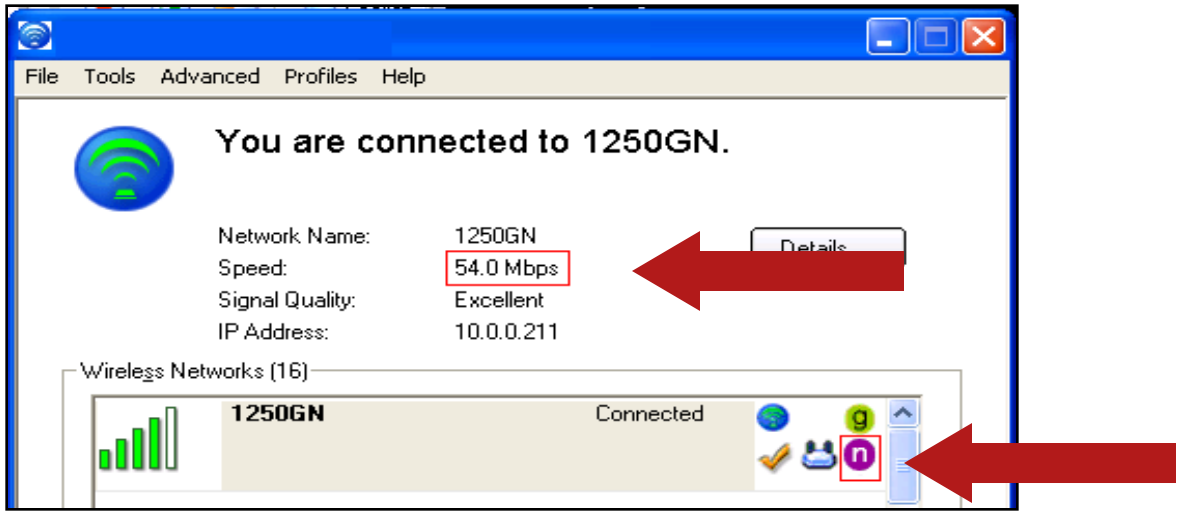
- Not realistic to upgrade most older laptops with internal 11n adapters

  Need three antennas connectors

11n Client Adapter Recommendations

- Update 802.11n client drivers to the latest revision
- Cisco-Intel relationship means that the Intel 11n adapter with Cisco's APs have had the most test time

Client Shows 11n SSID But Does Not Connect at 11n Data Rates

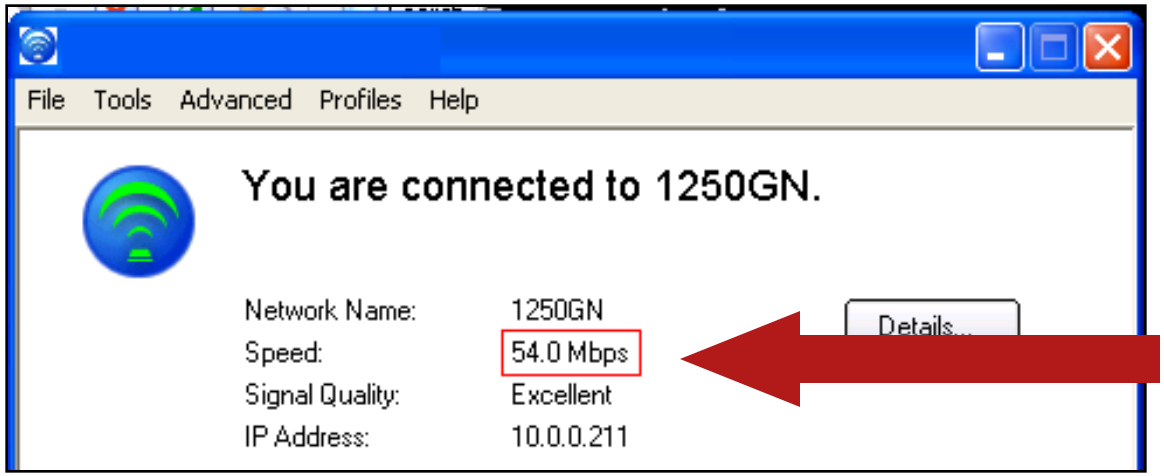


- Does the client have a 11n adapter?

  Some legacy clients will show that the AP support 11n even though the that client does not support 11n

- Is 11n support enabled in adapter driver?

Have 11n Adapter and Still Connecting at A or G Rates



- What type of encryption is allowed for WLAN?

  Must be AES or None

  If WEP or TKIP will not support 11n HT rates

- Is WMM allowed?

  WMM must be Enable or Require

  If WMM disabled will not support 11n HT rates