802.11n

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Agenda

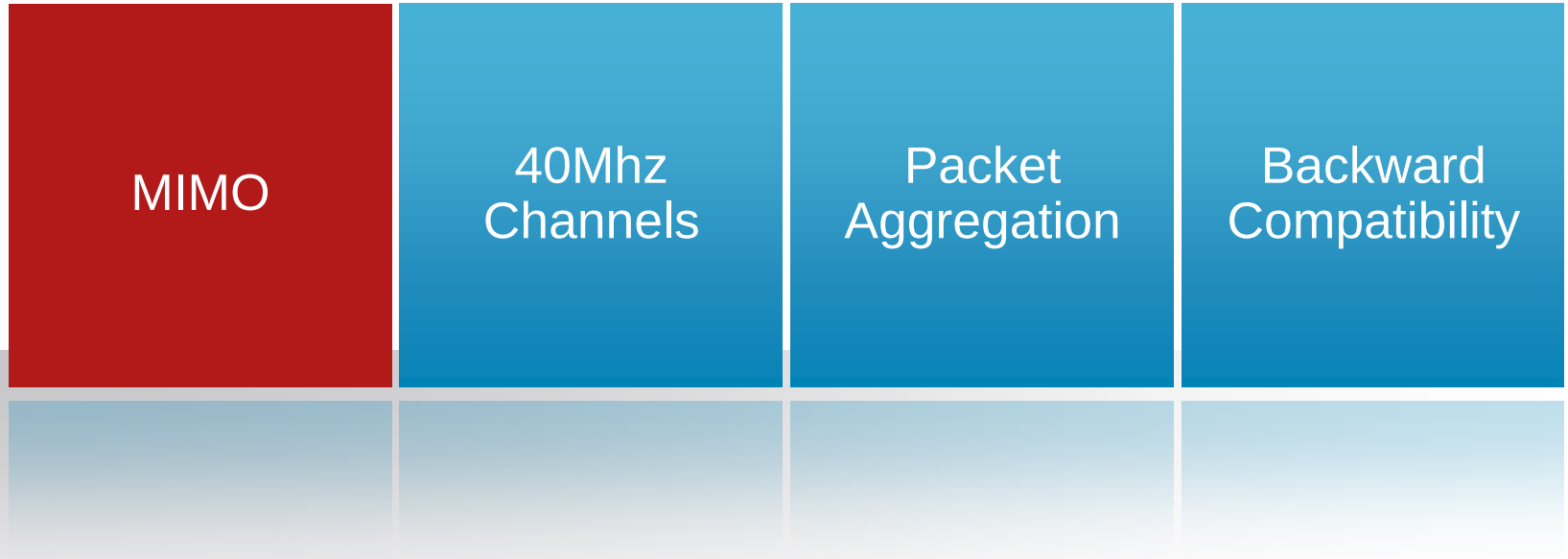
- 802.11n Technology Fundamentals
- 802.11n Access Points
- Design and Deployment
  - Planning and Design for 802.11n in Unified Environment
  - Key Steps for Configuration of 11n in a Unified Environment
  - 11n Client Adapters

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



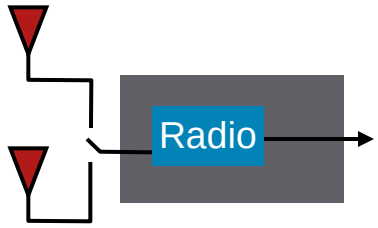
MIMO (Multiple Inputs Multiple Outputs)

- 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

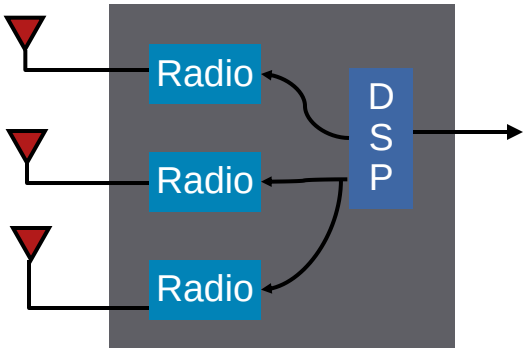
Note: MIMO provides improvements for non-n802.11 clients *

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

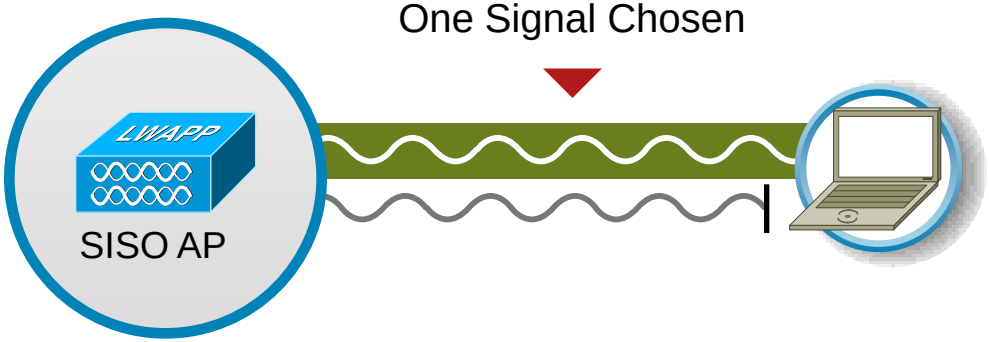
Maximum Ratio Combining

MIMO | 40Mhz Channels | Packet Aggregation | Backward Compatibility

MIMO (Multiple Input, Multiple Output)

Without MRC

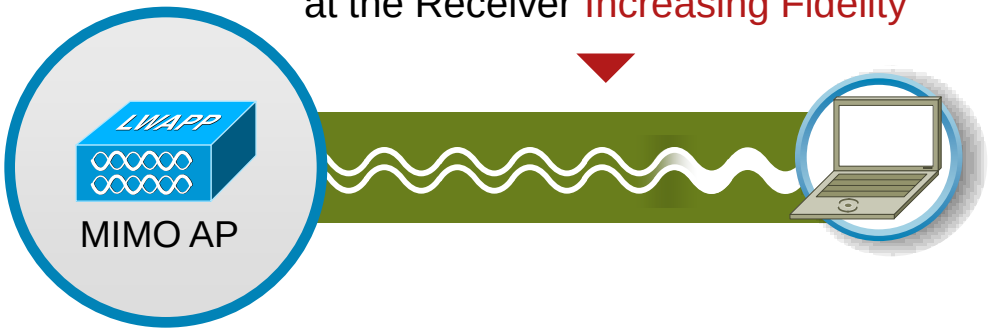
Multiple Signals Sent;
One Signal Chosen



Performance

With MRC

Multiple Signals Sent and Combined
at the Receiver Increasing Fidelity

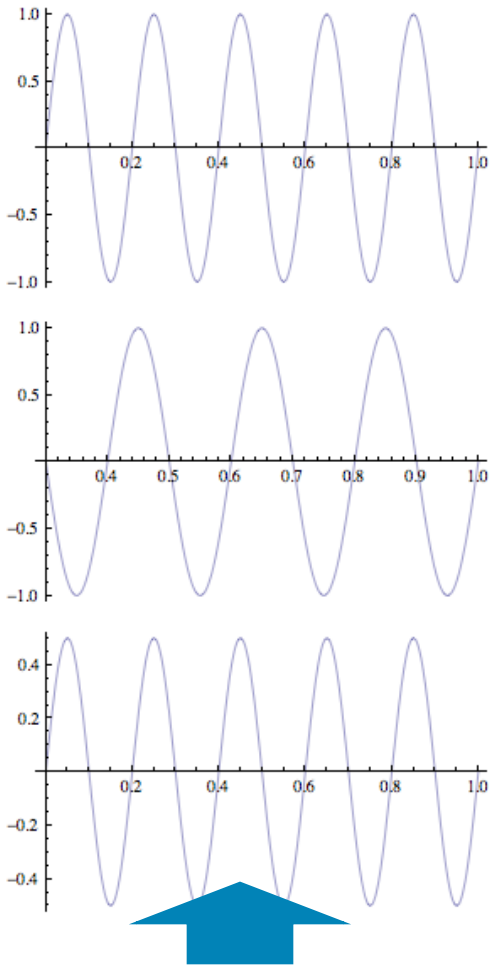


Performance

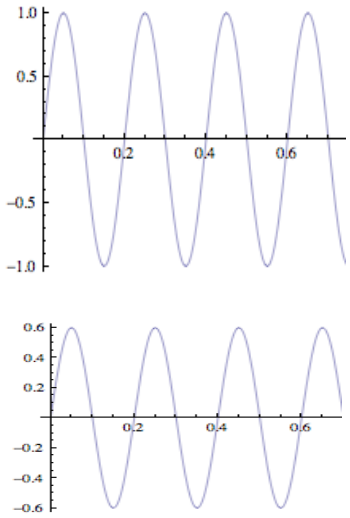
Maximum Ratio Combining

- 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

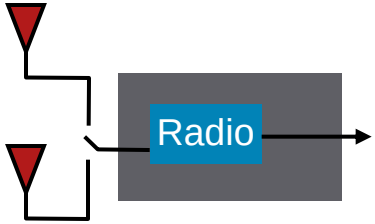
Illustration of Three Multipath Reflections to SISO AP

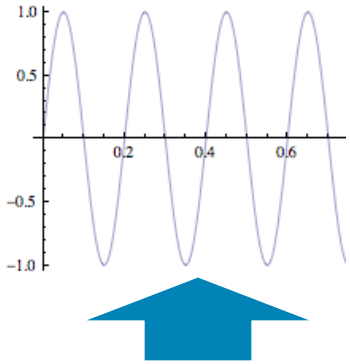


Multipath Reflections of Original Signal



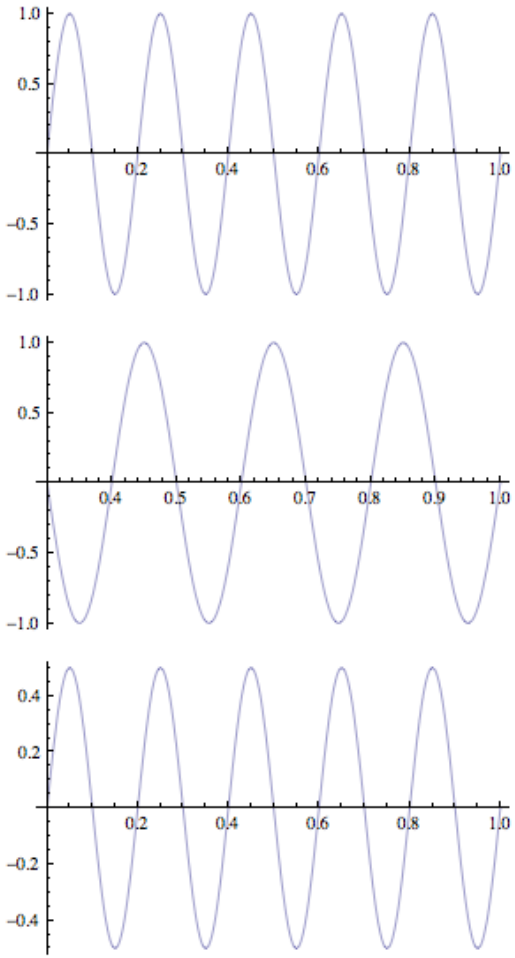
Signal Each Antenna Sees Due to Multipath Effect





Radio Switches to Best Signal with Least Multipath Effect

Illustration of Three Multipath Reflections to MIMO AP with MRC



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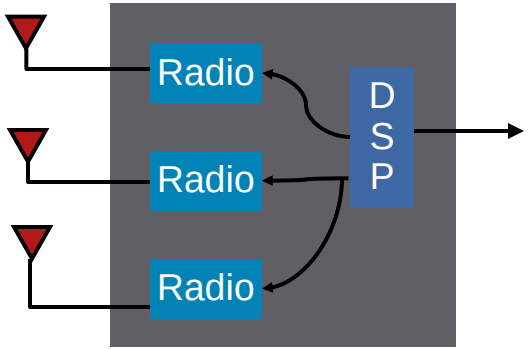
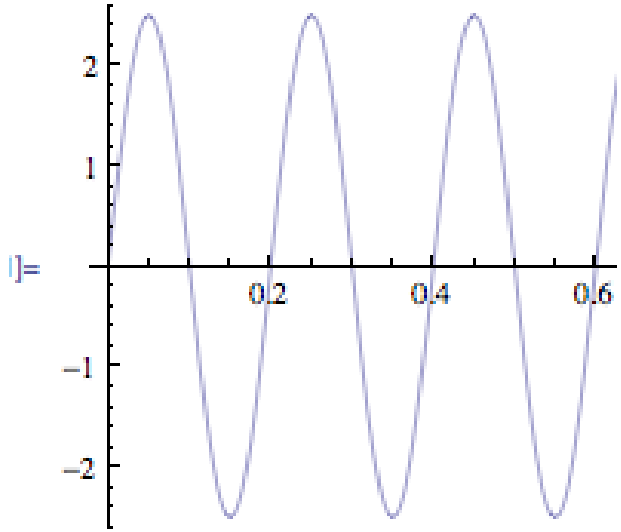


The DSP Adjusts the Received Signal Phase So They Can Be Added Together



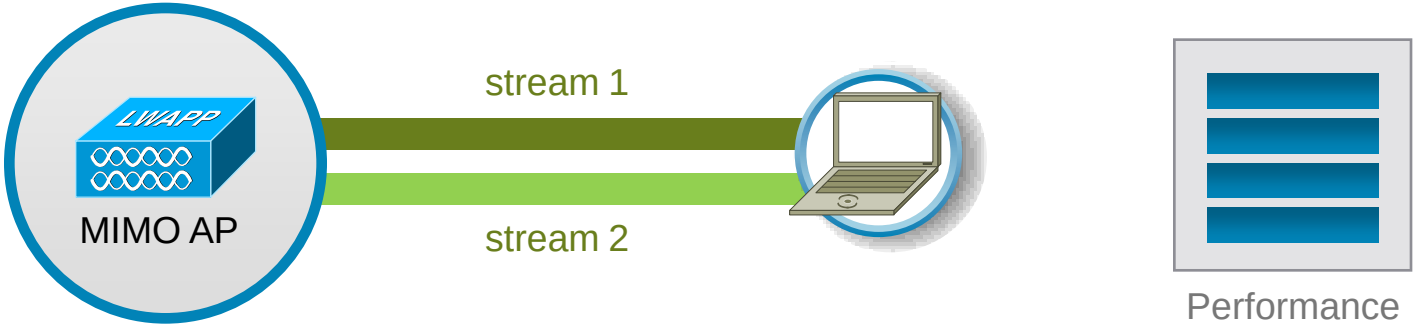
The Resulting Signal Is Addition of Adjusted Receive Signals

Spatial Multiplexing

	40Mhz Channels	Packet Aggregation	Backward Compatibility

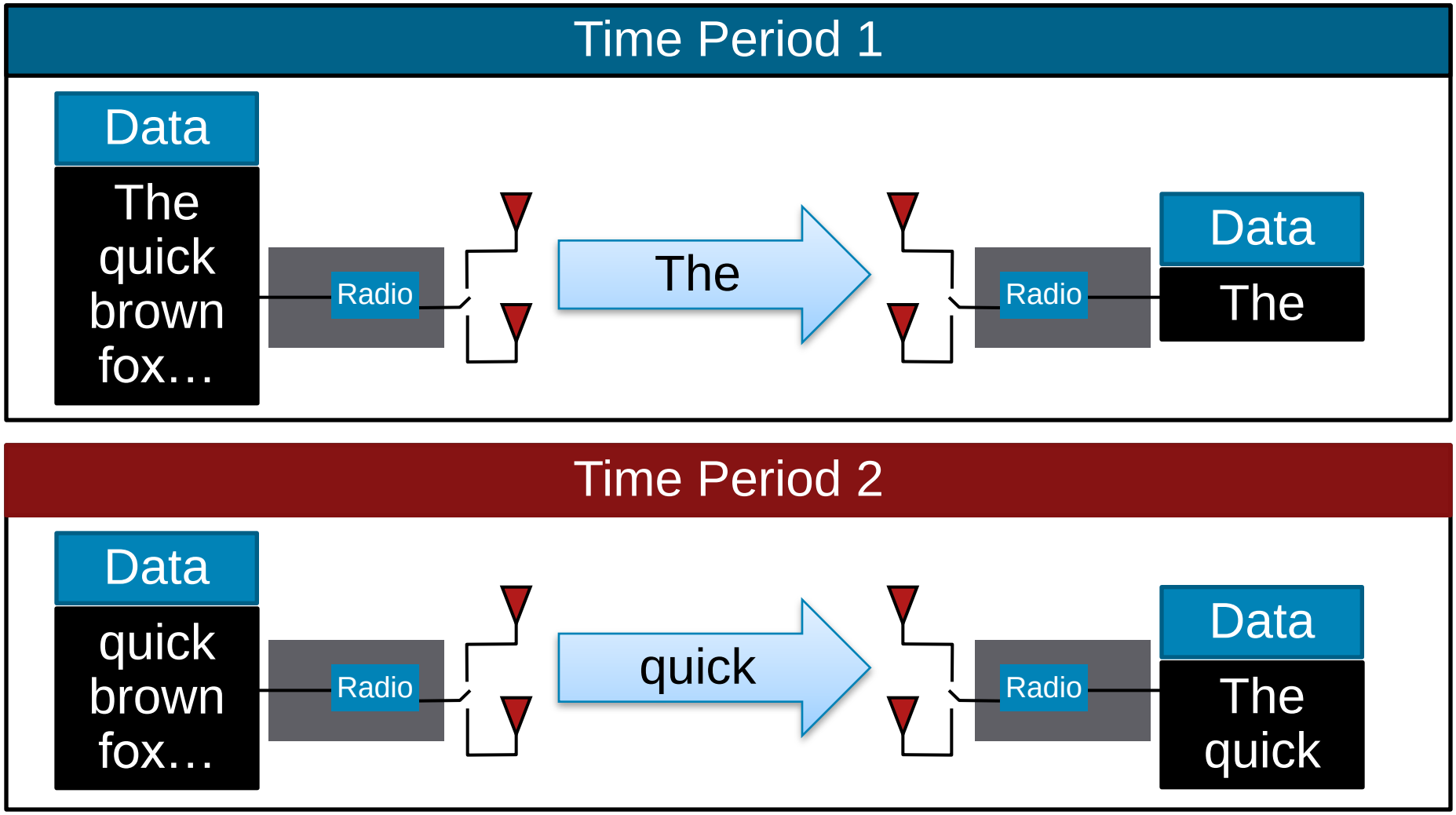
MIMO (Multiple Input, Multiple Output)

Information Is Split and Transmitted on Multiple Streams

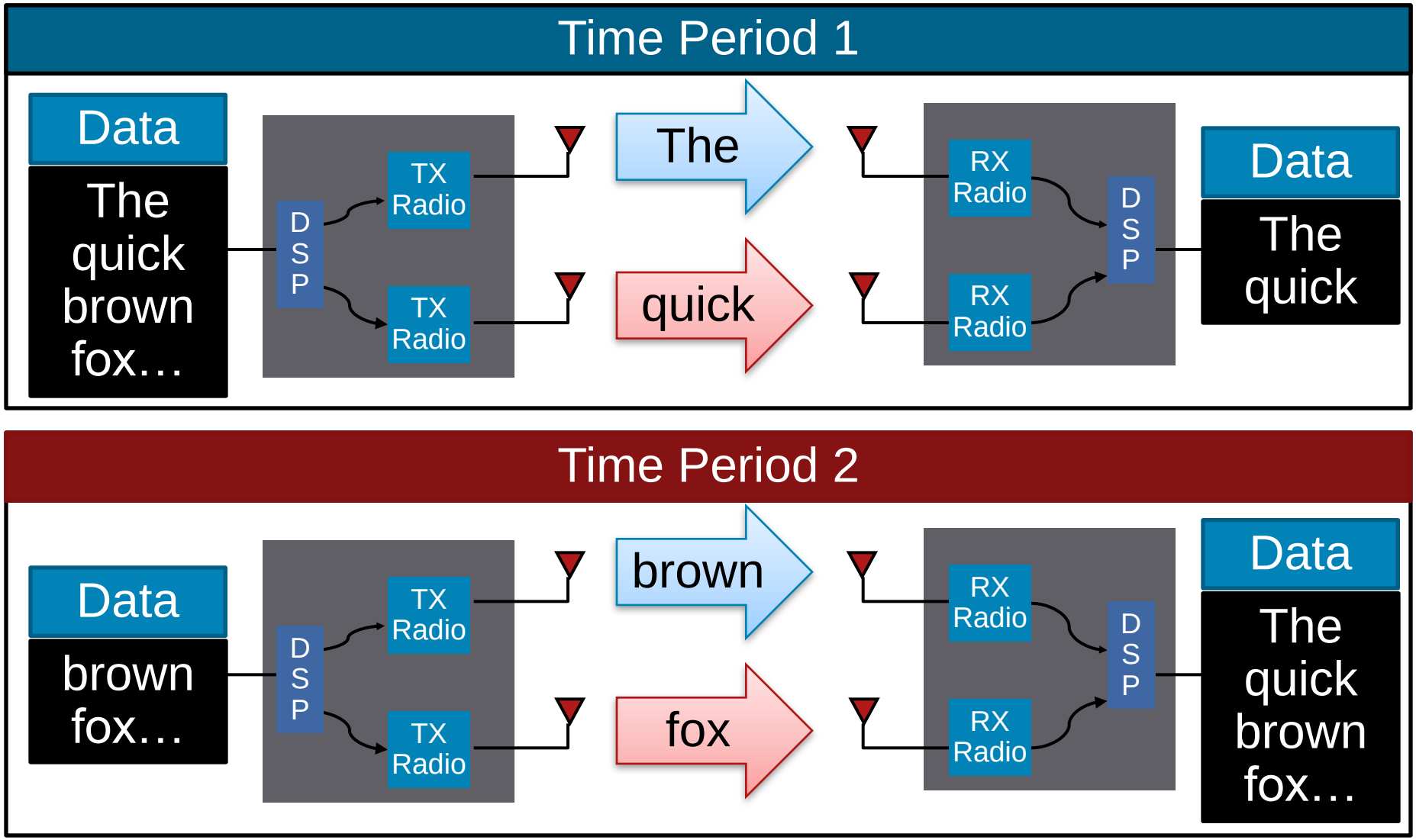


Transmitter and Receiver Participate	Concurrent Transmission on Same Channel	Increases Bandwidth	Requires 11n Client

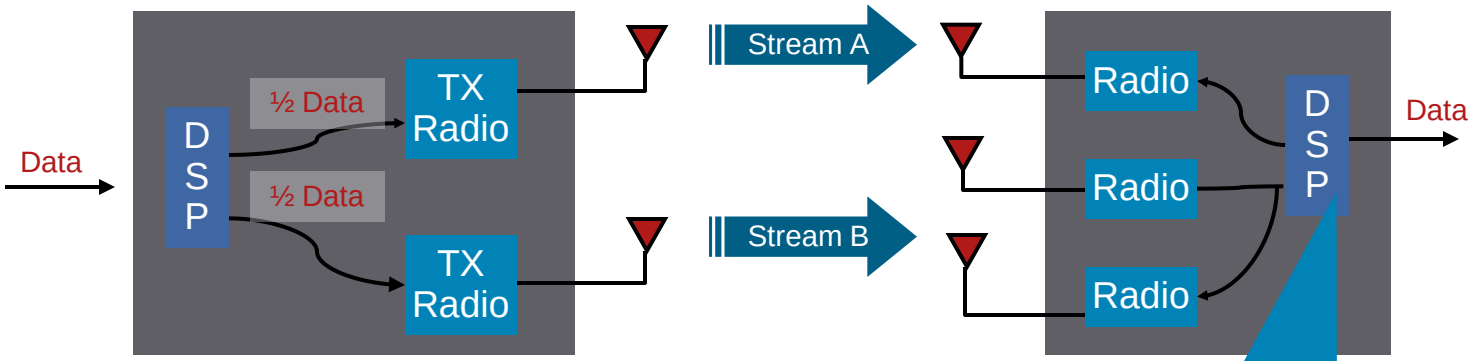
SISO Data Transmission



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

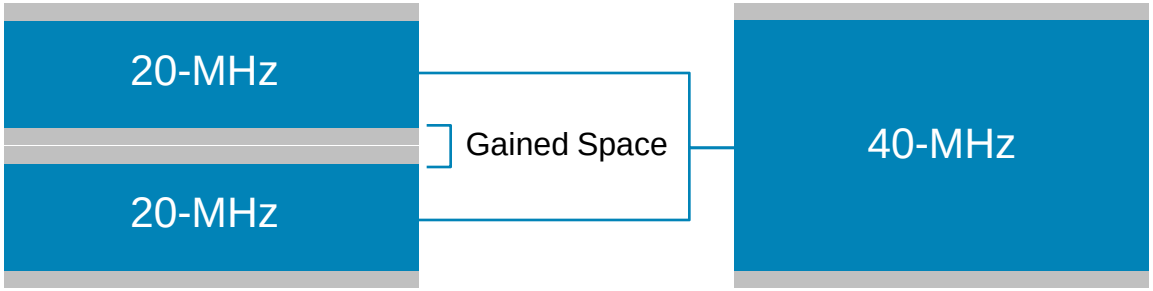
40Mhz Channels

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

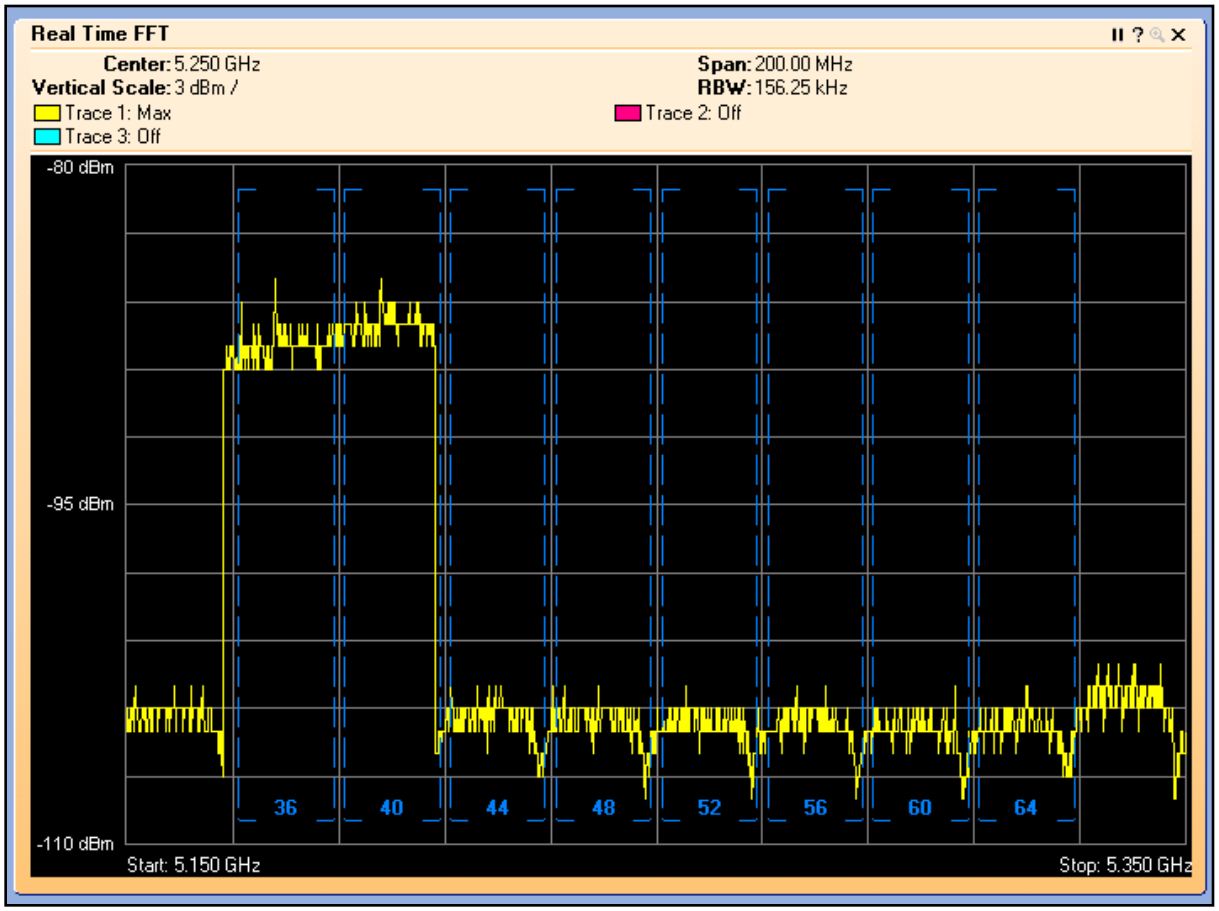
Double Wide Channel

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

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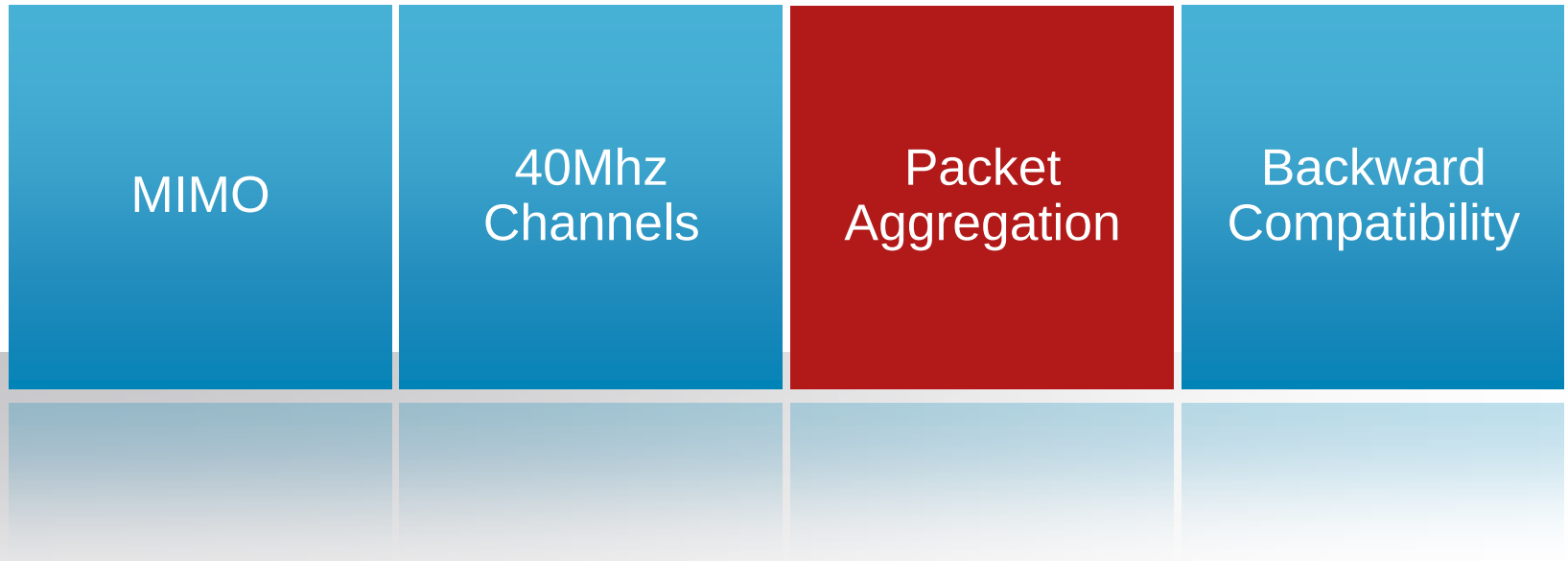
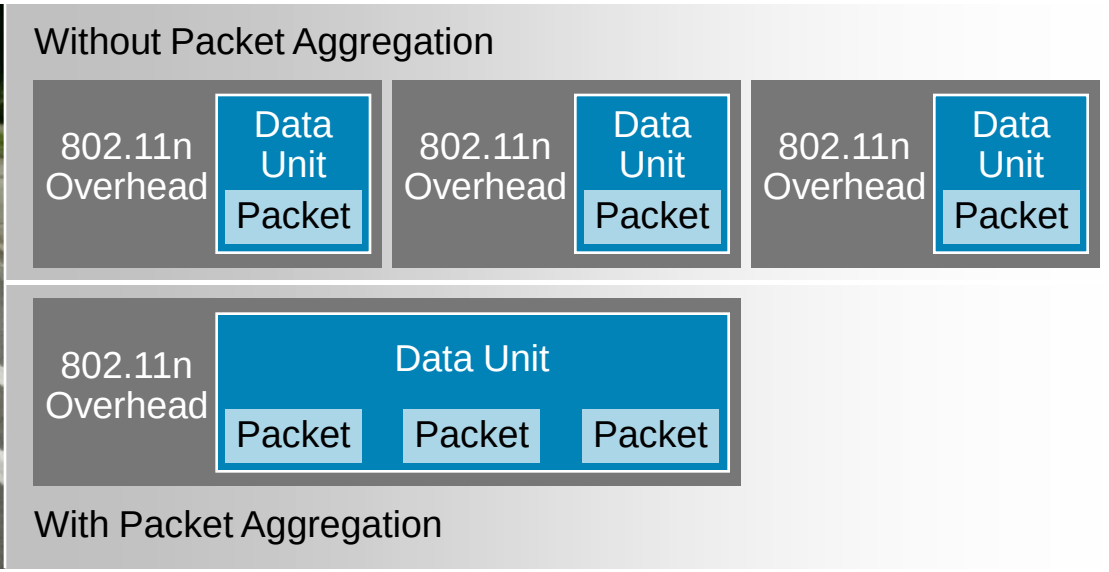


Aspects of 802.11n

MIMO | 40Mhz Channels | Packet Aggregation | Backward Compatibility

Packet Aggregation

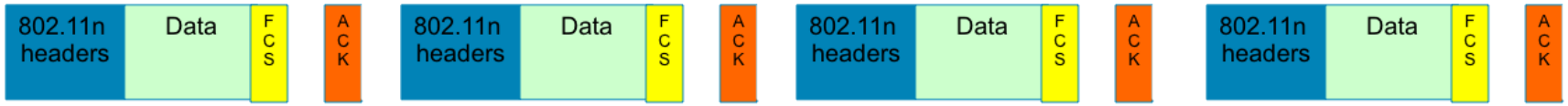
Carpooling Is More Efficient Than Driving Alone



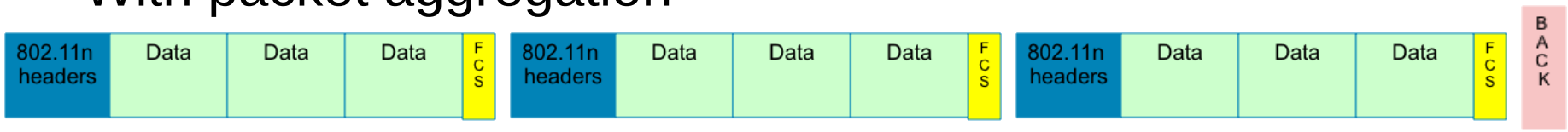
Packet Aggregation

- 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

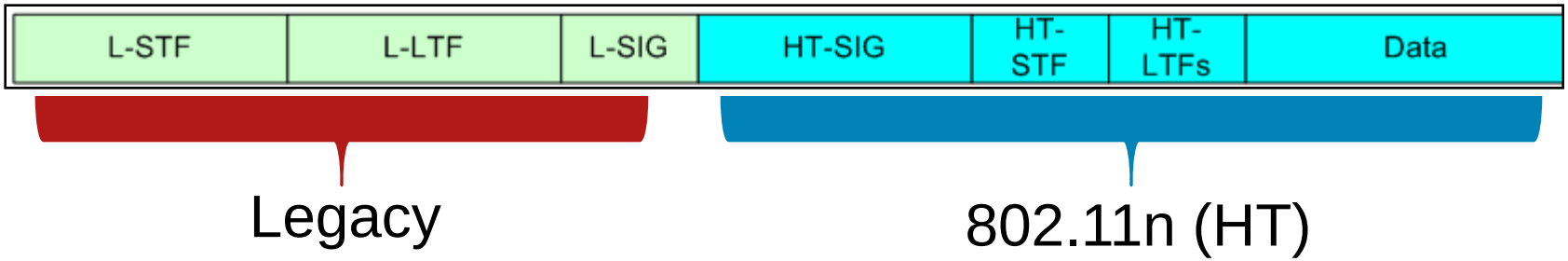
2.4GHz

5GHz

11n Operates in Both Frequencies

802.11ABG Clients Interoperate with 11n AND Experience Performance Improvements

802.11n HT PHY

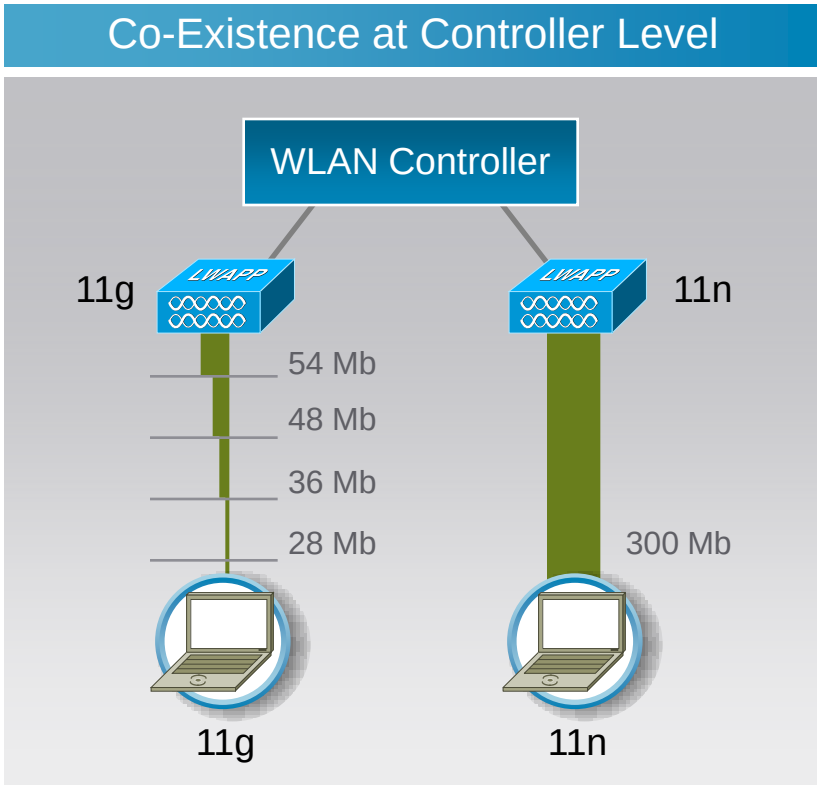


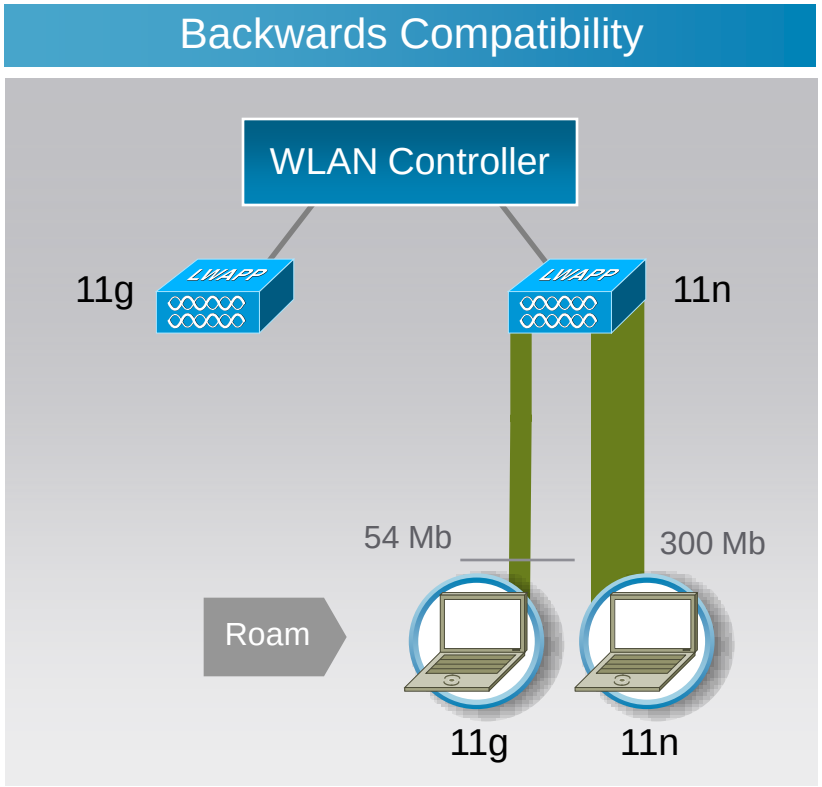
- To provide legacy co-existence all 11n transmissions today use a mixed mode PHY that encapsulates the HT PHY in the Legacy PHY when transmitting at HT rates
- Legacy devices degrade 11n device performance based on duty cycle they use in the spectrum

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