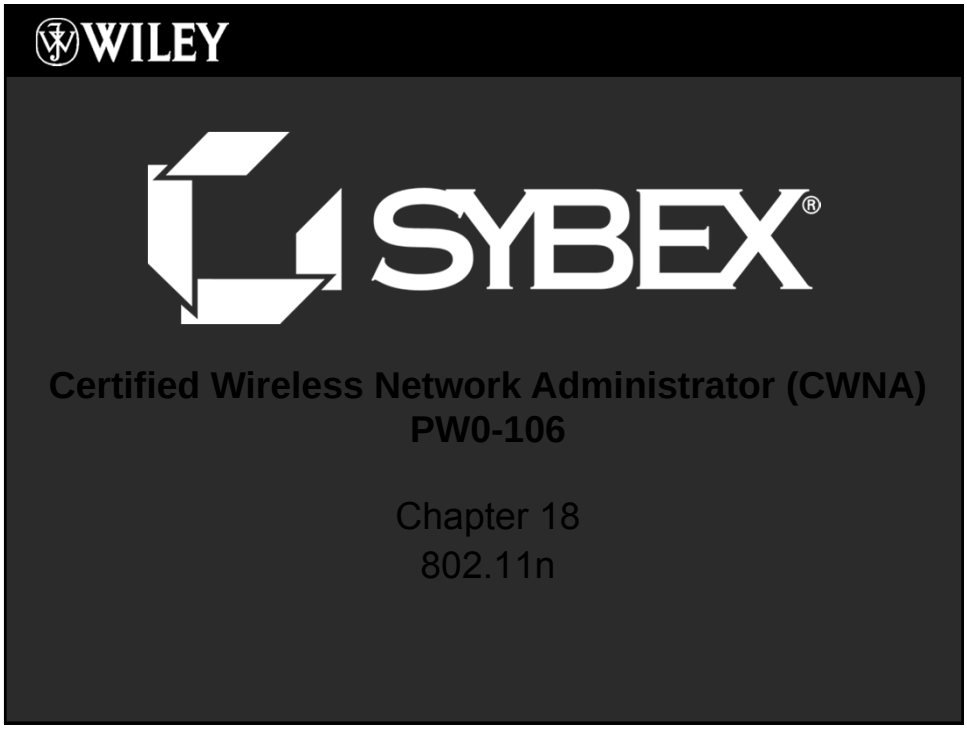
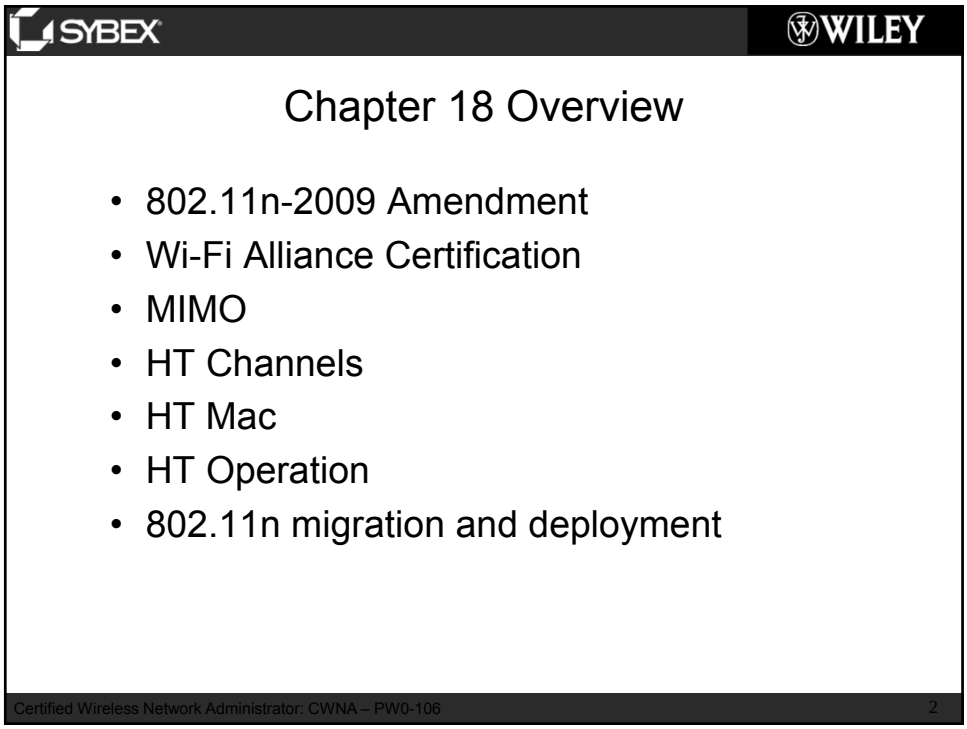

WILEY
SYBEX®
Certified Wireless Network Administrator (CWNA)
PW0-106
Chapter 18
802.11n


SYBEX
WILEY
Chapter 18 Overview
• 802.11n-2009 Amendment
• Wi-Fi Alliance Certification
• MIMO
• HT Channels
• HT Mac
• HT Operation
• 802.11n migration and deployment
Certified Wireless Network Administrator: CWNA – PW0-106
2

SYBEX WILEY

## 802.11n-2009 Amendment

- Defines the High Throughput (HT) PHY
  - Sometimes called clause 20
  - Part of the 802.11-2012 rollup
- Supports both 2.4 GHz and 5 GHz operations
  - Dual-band APs or separate APs are required
- Recently ratified 802.11ac-2013 Very High Throughput (VHT) amendment builds upon 802.11n technology to achieve gigabit and higher data rates.



SYBEX WILEY

## Wi-Fi Alliance Certification

- Wi-Fi Alliance maintains an 802.11n certification
  - Wi-Fi CERTIFIED n
- Products are tested for two types of capabilities (Table 18.1)
  - Mandatory
  - Optional
- Support must also be provided for WMM and WPA/WPA2 Security

SYBEX WILEY

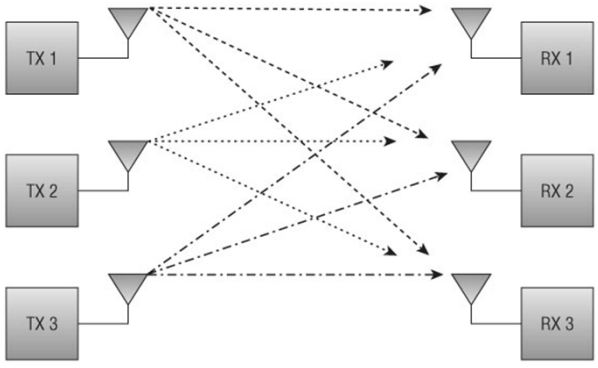
## MIMO

- Multiple-Input Multiple-Output (MIMO)
  - Uses multiple radios and antennas
    - Radio chains
- MIMO uses multipath to advantage
- Spatial multiplexing is used to improve throughput
- MIMO will also use diversity at the same time



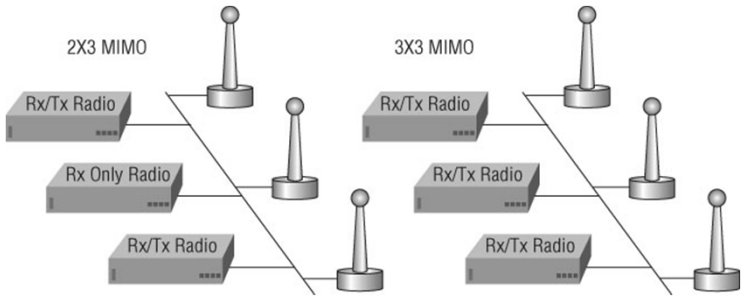
SYBEX WILEY

## MIMO operation and multipath



SYBEX WILEY

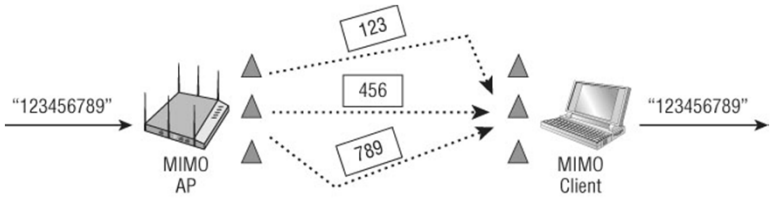
## MIMO (2x3 and 3x3)






SYBEX WILEY

## MIMO (Spatial Streams)



SYBEX WILEY

## Maximal ratio combining (MRC)




SYBEX WILEY

## Space-Time Block Coding (STBC)

- Method where the same information is transmitted on two or more antennas.
- Can be used when the number of radio chains exceeds the number of spatial streams.
- Increases the receiver's ability to detect signals at a lower SNR than would be otherwise possible

SYBEX WILEY

## Cyclic Shift Diversity (CSD)

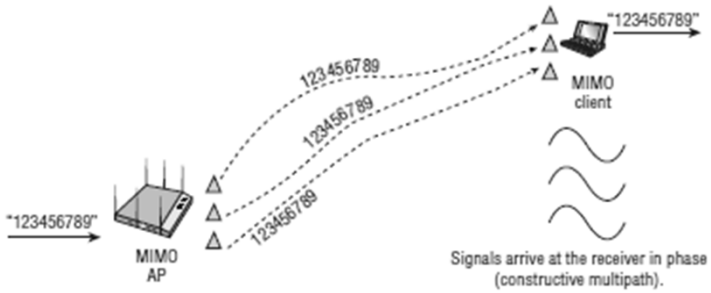
- A signal from a transmitter that uses CSD can be received by legacy 802.11g and 802.11a devices.
- A way of transmitting the symbols in the legacy OFDM preamble over multiple transmit antennas
- A cyclic delay is applied to each of the transmitted signals
- Delay is chosen to be within the limits of the guard interval (GI) so that it does not cause excessive intersymbol interference



SYBEX WILEY

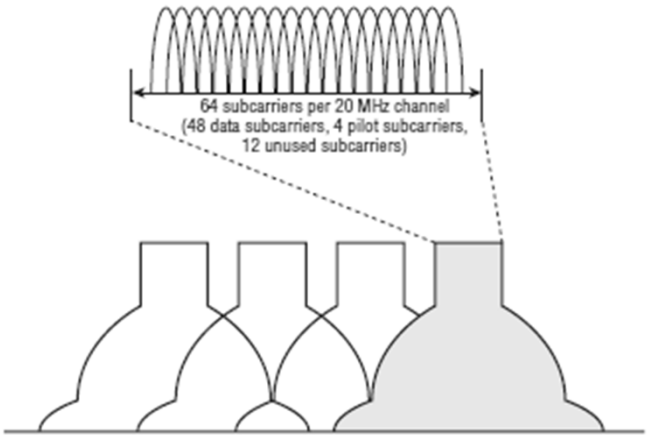
## Transmit Beamforming (TxBF)

- Can be used when there are more transmitting antennas than there are spatial data streams.



SYBEX WILEY

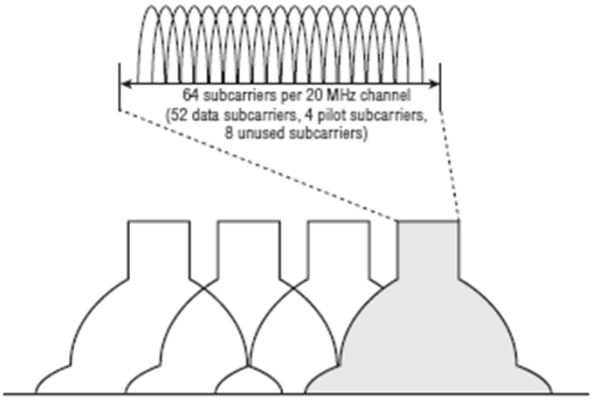
## 20 MHz non-HT channels





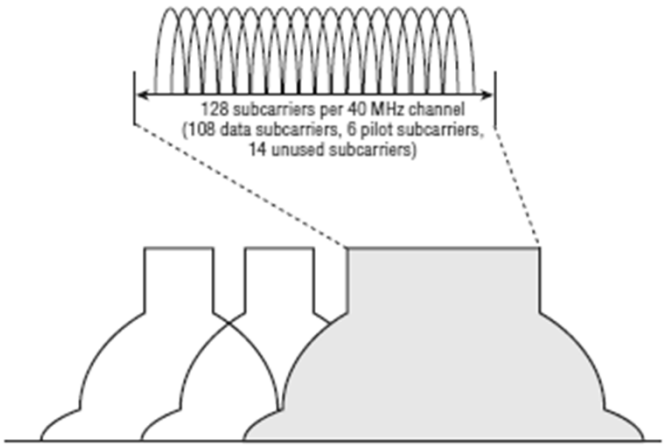

SYBEX WILEY

## 20 MHz HT channels



SYBEX WILEY

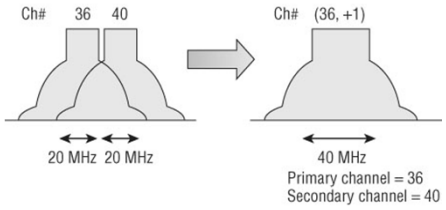
## 40 MHz HT Channels






SYBEX WILEY

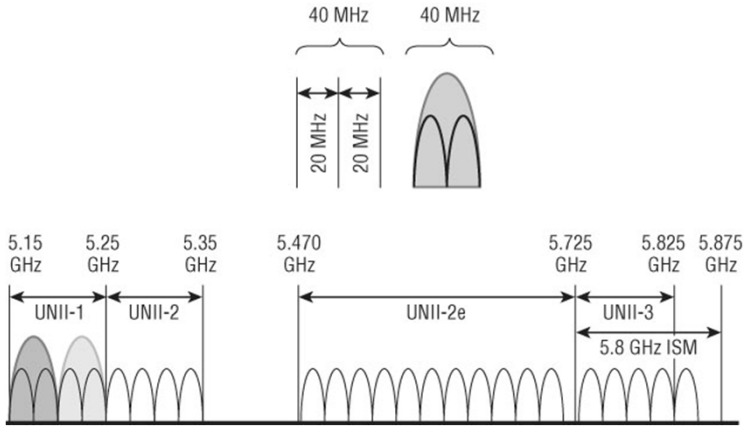
## HT Channels (Channel Bonding)




```
Additional HT Information
  Element ID:              61  Additional HT Information
  Length:                  22
  Primary Channel:         36
  Srvc Int Granularity:    %000  5ms
  PSMP STAs Only:          %0  Association Requests are Accepted Regardless of PSMP Capability
  RIFS Mode:               %0  Use of RIFS Prohibited
  STA Channel Width:       %1  Use Any Channel Width Enabled Under Supported Channel Width Set
  2nd Channel Offset:      %01  Above the Primary Channel
```

SYBEX WILEY

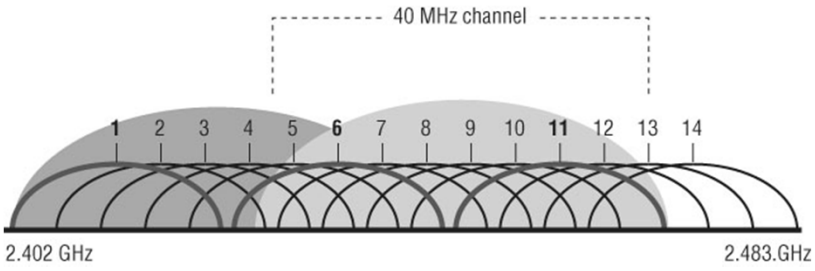
## HT Channels (Channel Bonding 5 GHz UNII)






SYBEX WILEY

## HT Channels (Channel Bonding 2.4 GHz ISM)



SYBEX WILEY

## Forty MHz Intolerant

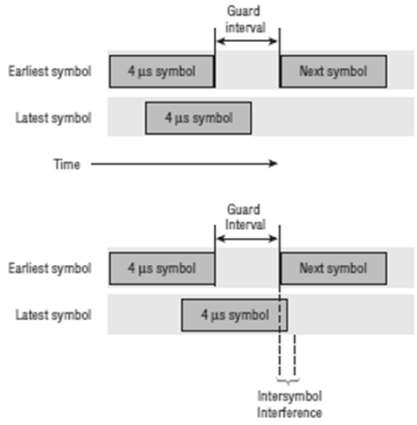
- Stations can advertise that they are Forty MHz Intolerant using various 802.11n management frames
- Any 802.11n AP using a 40 MHz channel will be forced to switch back to using only 20 MHz channels if they receive the frames from nearby 802.11n 2.4 GHz stations that are intolerant.



SYBEX WILEY

## HT PHY Guard Interval (GI)

- A period of time between symbols that accommodates the late arrival of symbols over long paths.




802.11a/g use an 800 ns GI

802.11n may use a 400 ns short GI

SYBEX WILEY

## HT PHY Modulation and Coding Scheme (MCS)

- The MCS is a matrix defining data rates
  - Based on channel width, modulation, spatial streams, and GI
- In addition to these factors, unequal modulation is supported
  - One stream uses 16-QAM and another uses QPSK for example



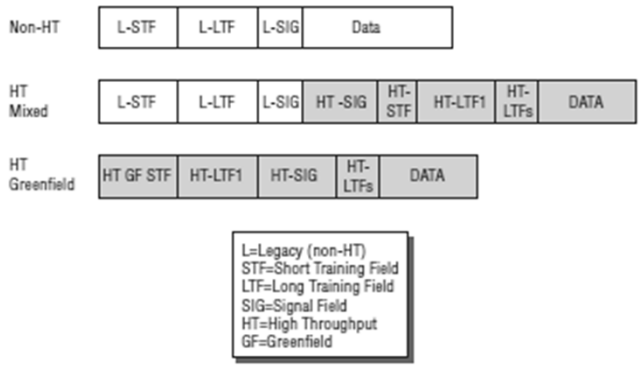
SYBEX WILEY

## HT PHY Operational Modes

- 802.11n amendment defines the use of three PPDU structures that use three different preambles.
  - Non-HT Legacy
  - HT Mixed
  - HT Greenfield

SYBEX WILEY

## HT PHY Operational Modes






SYBEX WILEY

## HT MAC sublayer

- Medium contention overhead is addressed by using two new methods of frame aggregation.
- New methods are also addressed using interframe spacing and block acknowledgments to limit the amount of fixed MAC overhead
- Two new methods of power management are defi ned for HT Clause 20 radios.

SYBEX WILEY

## Aggregate MAC Service Data Unit (A-MSDU).

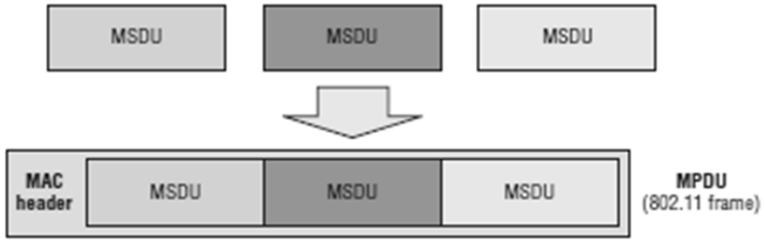
- Frame aggregation is a method of combining multiple frames into a single frame transmission
- Below is without frame aggregation




SYBEX WILEY

## Aggregate MAC Service Data Unit (A-MSDU).

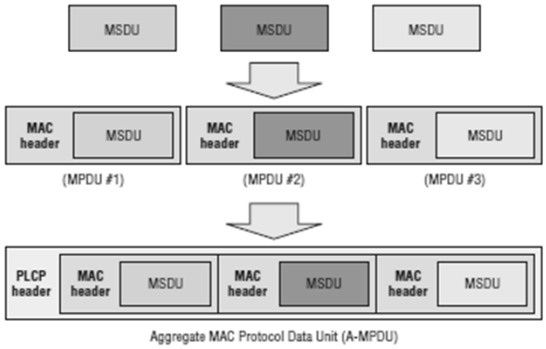
- Below is with frame aggregation



SYBEX WILEY

## Aggregate MAC Protocol Data Unit (A-MPDU)

- Second method of frame aggregation



Aggregate MAC Protocol Data Unit (A-MPDU)



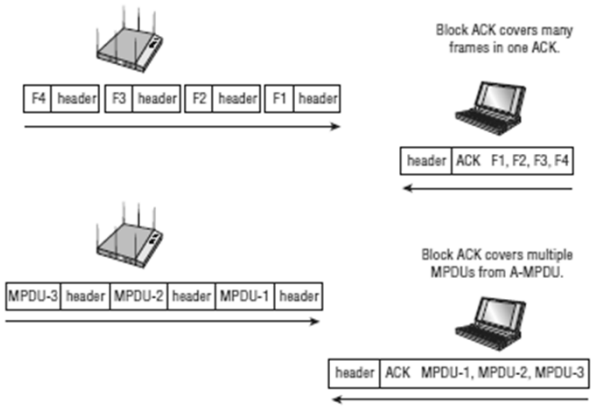
SYBEX WILEY

## Block Acknowledgment

- An A-MPDU contains multiple MPDUs, each with its own unique MAC header
- Each of the individual MPDUs must be acknowledged
- Accomplished by using a multiple traffic ID block acknowledgment (MTBA) frame

SYBEX WILEY

## Block Acknowledgment






SYBEX WILEY

## Reduced Interframe Space

- The 802.11e QoS amendment introduced the capability for a transmitting radio to send a burst of frames during a transmit opportunity (TXOP)
- 802.11n amendment defines a new interframe space that is even shorter in time than SIF, called a reduced interframe space (RIFS)
- 802.11a/n SIFS interval is 16 µs and an 802.11b/g/n SIFS is 10 µs.
- RIFS interval is only 2 µs.

SYBEX WILEY

## HT Power Management

- 802.11n amendment introduces two new power-management mechanisms
  - Spatial multiplexing power save (SM power save)
  - Power Save Multi Poll (PSMP)



SYBEX WILEY

## HT 20/40 Channel Operation

- The 802.11n access point must declare 20-only or 20/40 support in the beacon management frame.
- 802.11n client stations must declare 20-only or 20/40 in the association or reassociation frames.
- Client stations must reassociate when switching between 20-only and 20/40 modes.
- If 20/40-capable stations transmit by using a single 20 MHz channel, they must transmit on the primary channel and not the secondary channel.

SYBEX WILEY

## HT Protection Modes (0–3)

- Mode 0—Greenfield (No Protection) Mode
- Mode 1—HT Nonmember Protection Mode
- Mode 2—HT 20 MHz Protection Mode
- Mode 3—Non-HT Mixed Mode



SYBEX WILEY

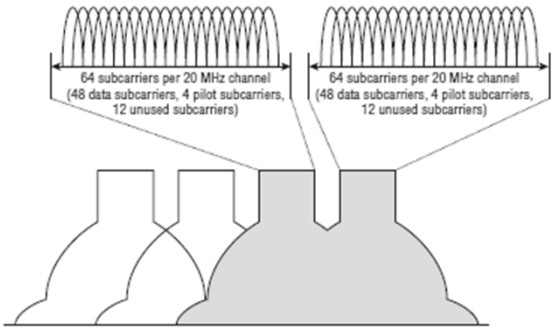
## RTS/CTS and CTS-to-Self

- When HT protection is enabled within an HT BSS, an HT STA will precede HT transmissions with either an RTS/CTS control frame exchange or a CTS-to-Self control frame using modulation and coding understandable to the STAs that are being protected
- Protection mechanism control frames can be sent over the 40 MHz channel using non-HT duplicate transmissions

SYBEX WILEY

## HT Operation (Non-HT Duplicate Format)

- Allows two identical 20 MHz non-HT control frames to be transferred simultaneously on both the primary and secondary channels






SYBEX WILEY

## Chapter 18 Summary

- 802.11n-2009 Amendment
- Wi-Fi Alliance Certification
- MIMO
- HT Channels
- HT MAC
- HT Operation