



**Certified Wireless Network Administrator (CWNA)  
PW0-106**



Chapter 18  
802.11n



### 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



## 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.

Certified Wireless Network Administrator: CWNA – PW0-106 3



## 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

Certified Wireless Network Administrator: CWNA – PW0-106 4

**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

Certified Wireless Network Administrator: CWNA – PW0-106 5

**SYBEX** **WILEY**

## MIMO operation and multipath

The diagram illustrates MIMO operation and multipath. It shows three transmitters (TX 1, TX 2, TX 3) on the left and three receivers (RX 1, RX 2, RX 3) on the right. Each transmitter is connected to its respective receiver by a solid line. Dashed arrows represent multiple paths between each transmitter and receiver, illustrating multipath propagation. For example, TX 1 has three dashed arrows pointing to RX 1, RX 2, and RX 3. Similarly, TX 2 and TX 3 have multiple dashed arrows pointing to each of the three receivers.

Certified Wireless Network Administrator: CWNA – PW0-106 6

**SYBEX** **WILEY**

### MIMO (2x3 and 3x3)

2X3 MIMO

3X3 MIMO

Rx/Tx Radio

Rx Only Radio

Rx/Tx Radio

Rx/Tx Radio

Rx/Tx Radio

Rx/Tx Radio

Certified Wireless Network Administrator: CWNA – PW0-106

7

**SYBEX** **WILEY**

### MIMO (Spatial Streams)

"123456789"

MIMO AP

123

456

789

MIMO Client

"123456789"

Certified Wireless Network Administrator: CWNA – PW0-106

8

SYBEX WILEY

## Maximal ratio combining (MRC)

The diagram shows a MIMO AP on the left with three antennas. Three dashed arrows, each labeled with the sequence "123456789", point from the AP's antennas towards a Non-MIMO Client on the right. The client has one antenna and a solid arrow labeled "123456789" points from it to the left, indicating the reconstructed signal.

Certified Wireless Network Administrator: CWNA – PW0-106 9

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

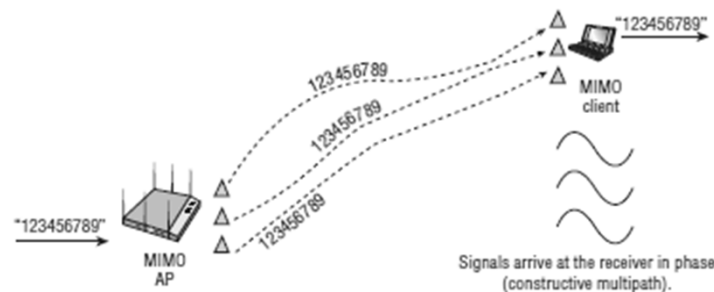
Certified Wireless Network Administrator: CWNA – PW0-106 10

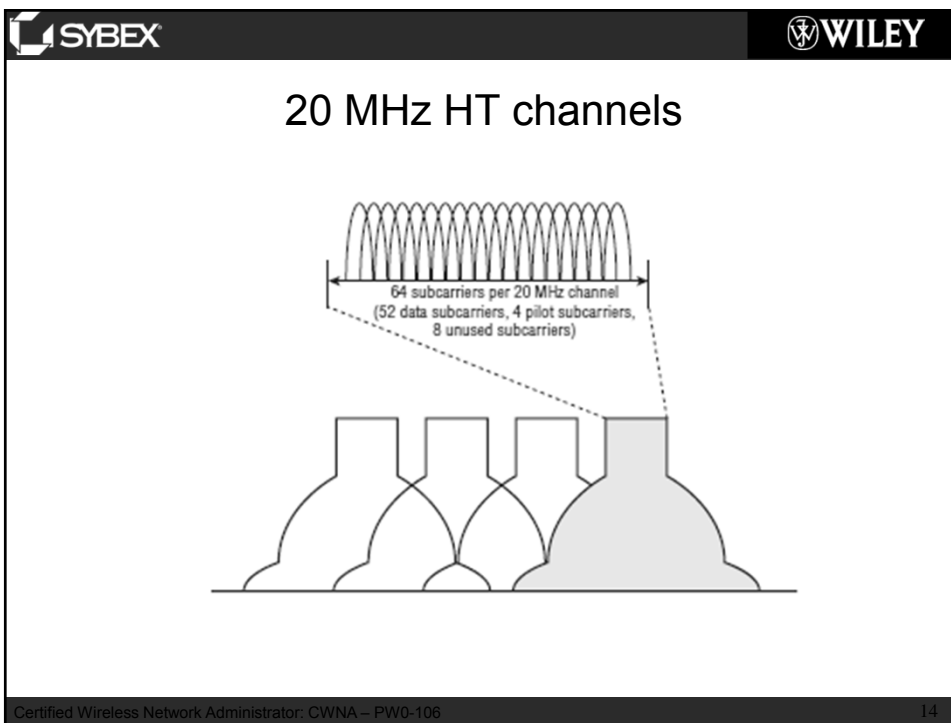
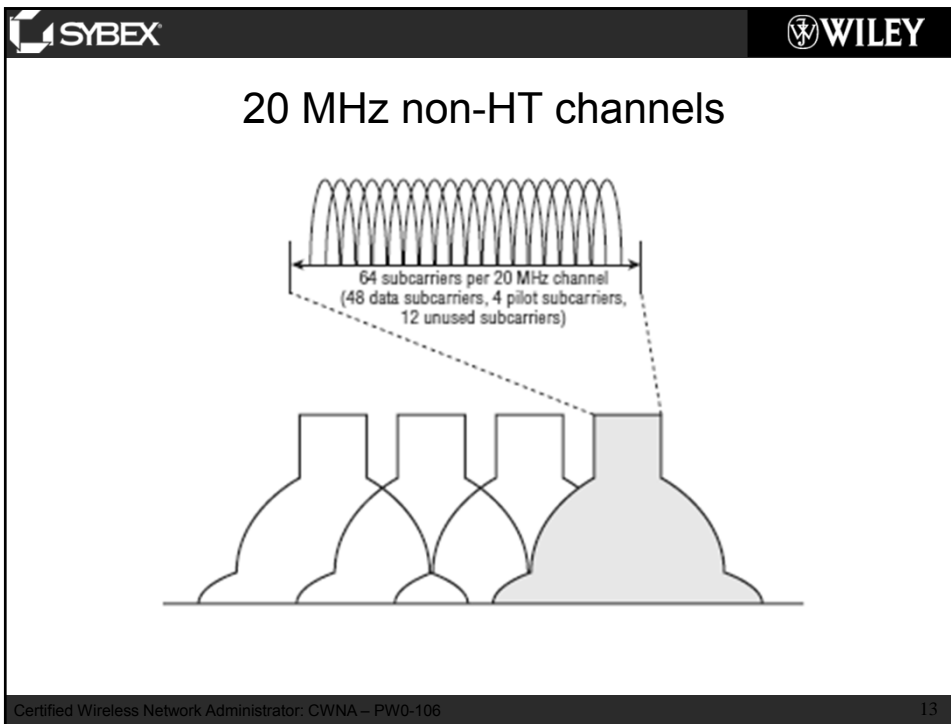
## Cyclic Shift Diversity (CSD)

- 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

## Transmit Beamforming (TxBF)

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





**SYBEX** **WILEY**

### 40 MHz HT Channels

128 subcarriers per 40 MHz channel  
(108 data subcarriers, 6 pilot subcarriers,  
14 unused subcarriers)

Certified Wireless Network Administrator: CWNA – PW0-106 15

**SYBEX** **WILEY**

### HT Channels (Channel Bonding)

Ch# 36 40 → Ch# (36, +1)

20 MHz 20 MHz → 40 MHz

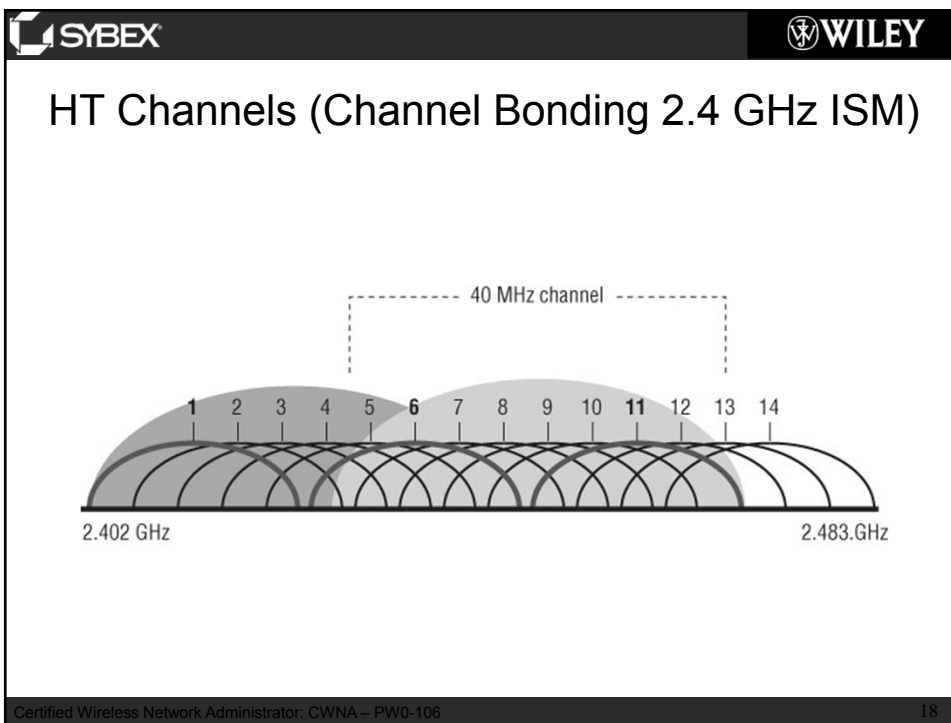
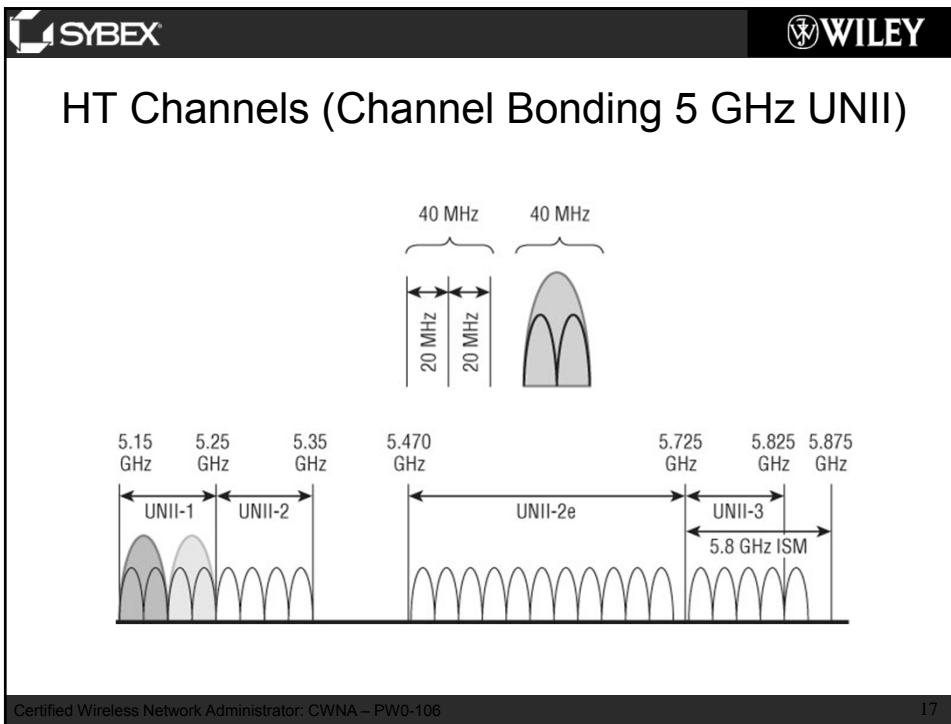
Primary channel = 36  
Secondary channel = 40

```

Additional HT Information
- Element ID: 61 Additional HT Information
- Length: 22
- Primary Channel: 36
- Srv Granularity: 4000 Sns
- PSMP STA Only: 40 Association Requests are Accepted Regardless of PSMP Capability
- RIFS Mode: 40 Use of RIFS Prohibited
- STA Channel Width: 41 Use Any Channel Width Enabled Under Supported Channel Width Sec
- 2nd Channel Offset: 401 Above the Primary Channel
    
```

Certified Wireless Network Administrator: CWNA – PW0-106 16





**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.

Certified Wireless Network Administrator: CWNA – PW0-106 19

**SYBEX** **WILEY**

## HT PHY Guard Interval (GI)



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

The diagram illustrates the HT PHY Guard Interval (GI) in two scenarios. In the top scenario, a 400 ns short GI is used, resulting in intersymbol interference between the '4 μs symbol' and the 'Next symbol'. In the bottom scenario, an 800 ns GI is used, which accommodates the late arrival of symbols over long paths, preventing intersymbol interference. A text box on the right states: '802.11a/g use an 800 ns GI' and '802.11n may use a 400 ns short GI'.

802.11a/g use an 800 ns GI

802.11n may use a 400 ns short GI



Certified Wireless Network Administrator: CWNA – PW0-106 20



## 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

Certified Wireless Network Administrator: CWNA – PW0-106 21



## 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

Certified Wireless Network Administrator: CWNA – PW0-106 22

**SYBEX** **WILEY**

## HT PHY Operational Modes

Non-HT	L-STF	L-LTF	L-SIG	Data				
HT Mixed	L-STF	L-LTF	L-SIG	HT-SIG	HT-STF	HT-LTF1	HT-LTFs	DATA
HT Greenfield	HT GF STF	HT-LTF1	HT-SIG	HT-LTFs	DATA			

L=Legacy (non-HT)  
 STF=Short Training Field  
 LTF=Long Training Field  
 SIG=Signal Field  
 HT=High Throughput  
 GF=Greenfield

Certified Wireless Network Administrator: CWNA – PW0-106 23

**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 defined for HT Clause 20 radios.

Certified Wireless Network Administrator: CWNA – PW0-106 24

**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

The diagram illustrates two separate frame transmissions. The first frame is composed of a PHY preamble, a PHY header, a MAC header, Data, and a Trailer. The second frame is composed of a PHY preamble, a PHY header, and an ACK. Below each frame, a double-headed arrow labeled 'Overhead' spans the width of the PHY preamble and header sections, indicating the overhead for each individual frame.

Certified Wireless Network Administrator: CWNA – PW0-106 25

**SYBEX** **WILEY**

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

- Below is with frame aggregation

The diagram illustrates frame aggregation. At the top, three separate MSDU (MAC Service Data Unit) blocks are shown. A large downward-pointing arrow indicates the aggregation process. Below the arrow, a single larger block represents the aggregated frame. This block starts with a MAC header, followed by the three MSDU blocks concatenated together. This entire structure is labeled as an MPDU (802.11 frame).

Certified Wireless Network Administrator: CWNA – PW0-106 26

**SYBEX** **WILEY**

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

- Second method of frame aggregation

The diagram illustrates the process of frame aggregation. At the top, three individual MSDU (Medium Service Data Unit) boxes are shown. An arrow points down to three MPDU (MAC Protocol Data Unit) boxes, labeled (MPDU #1), (MPDU #2), and (MPDU #3). Each MPDU box contains a 'MAC header' and an 'MSDU'. A second arrow points down to a single large box representing the 'Aggregate MAC Protocol Data Unit (A-MPDU)'. This A-MPDU box contains a 'PLCP header' followed by the three MPDU boxes, each with its own 'MAC header' and 'MSDU'.

Certified Wireless Network Administrator: CWNA – PW0-106 27

**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

Certified Wireless Network Administrator: CWNA – PW0-106 28

**SYBEX** **WILEY**

## Block Acknowledgment

Block ACK covers many frames in one ACK.

Block ACK covers multiple MPDUs from A-MPDU.



Certified Wireless Network Administrator: CWNA – PW0-106 29

**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 SIFS, called a reduced interframe space (RIFS)
- 802.11a/n SIFS interval is 16  $\mu$ s and an 802.11b/g/n SIFS is 10  $\mu$ s.
- RIFS interval is only 2  $\mu$ s.



Certified Wireless Network Administrator: CWNA – PW0-106 30



## HT Power Management

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

Certified Wireless Network Administrator: CWNA – PW0-106 31





## 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.

Certified Wireless Network Administrator: CWNA – PW0-106 32







## 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

Certified Wireless Network Administrator: CWNA – PW0-106 33



## 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

Certified Wireless Network Administrator: CWNA – PW0-106 34

**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

64 subcarriers per 20 MHz channel  
(48 data subcarriers, 4 pilot subcarriers, 12 unused subcarriers)

64 subcarriers per 20 MHz channel  
(48 data subcarriers, 4 pilot subcarriers, 12 unused subcarriers)

Certified Wireless Network Administrator: CWNA – PW0-106 35

**SYBEX** **WILEY**

## Chapter 18 Summary

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

Certified Wireless Network Administrator: CWNA – PW0-106 36