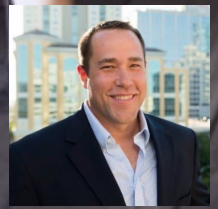
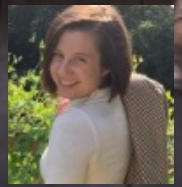
THE LEADER IN WIRELESS EXPERIENCE MONITORING

HOW CCA-SD WORKS IN SECONDARY CHANNELS



Don Cook
Chief Marketing Officer



Heather Dremel
Digital Marketing Manager
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Jim Vajda
CWNE #183
Chief Wireless Officer
7SIGNAL

On with the show…

ABOUT GJERMUND RAAEN

- Twitter: @gjermundraaen
- Blog: www.gjermundraaen.com

- CWNA/CWDP/CWAP/CWSP
- Cisco CCNP Enterprise (R&S) and Service Provider
- Ekahau Design
- Lorawan Fundamental
- JNCIA-Mist AI

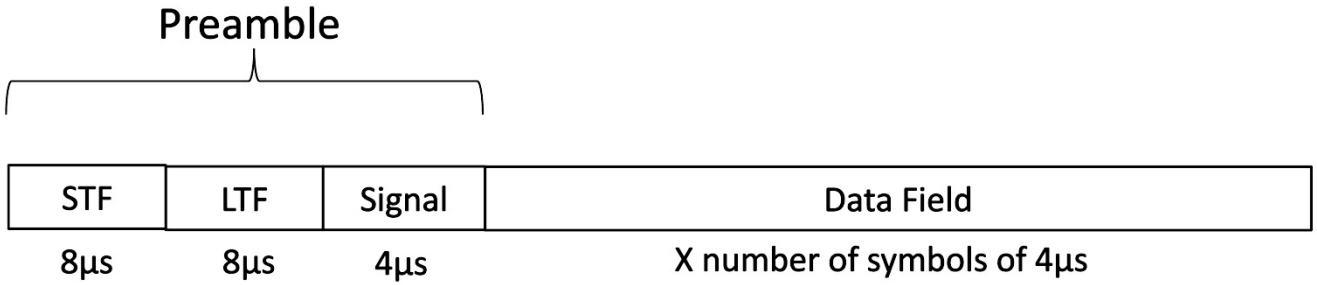
- The WiFi Awards Rookie of the Year 2021
- Finalist in the Cisco IT Blog Awards 2020 for Best Analysis
- Cisco Champion 2020 and 2021

HOW CCA WORKS ON SECONDARY CHANNELS

- How a receiving station synchronizes to a receiving frame
- What happens if the station don’t see the preamble
- How CCA works on secondary channels
- RTS/CTS with bandwidth signaling

I will mainly talk about 5 GHz, but some of it is also valid for OFDM-PHYs in 2,4GHz (g, n, ax).

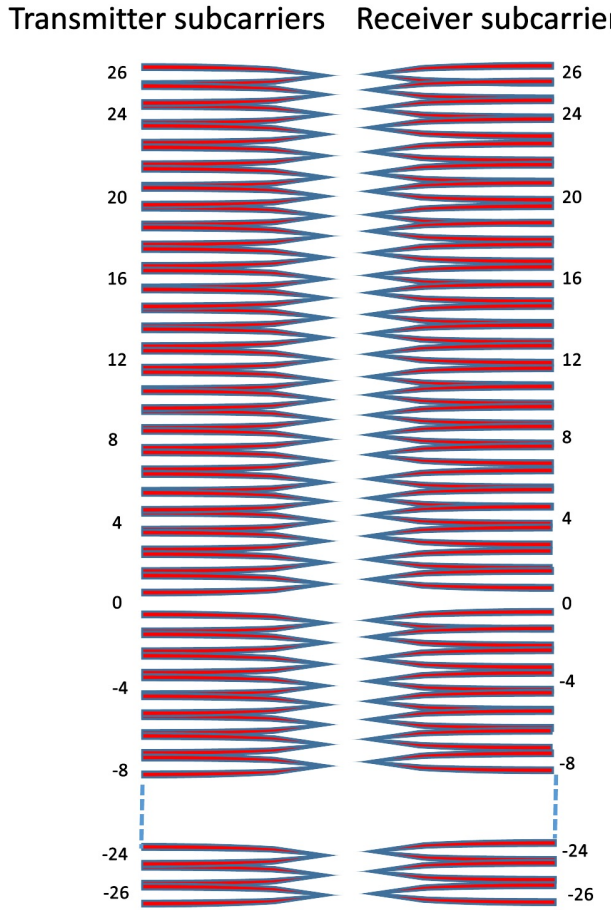
OFDM FRAME FORMAT, 802.11A



On 20 MHz channel

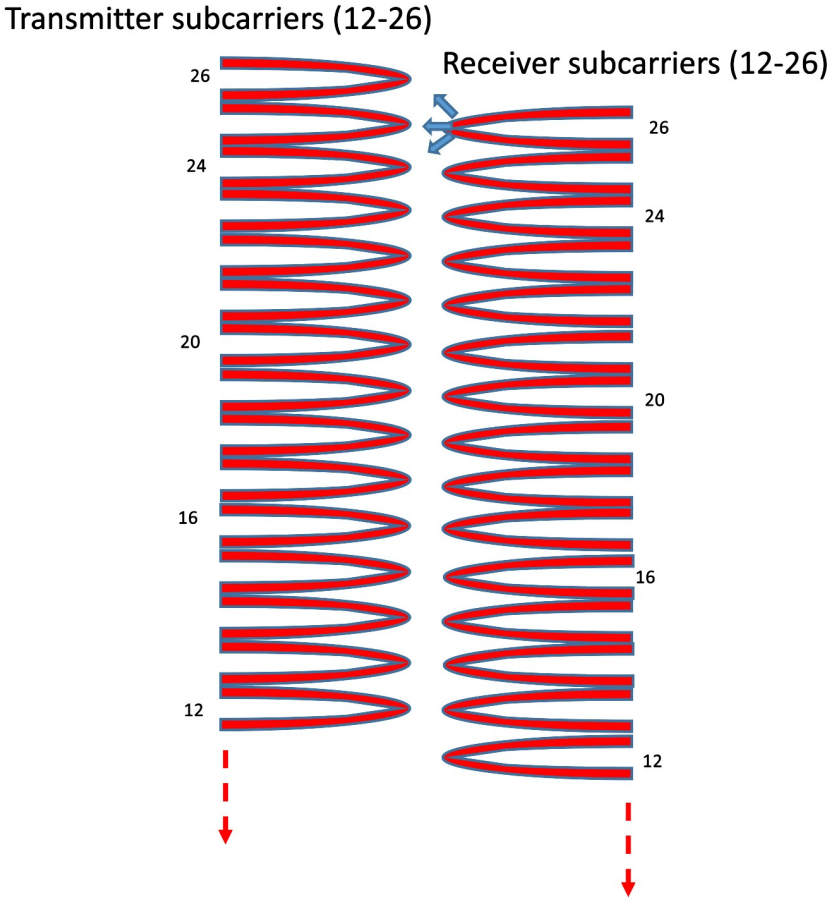
- 64 subcarriers in total
- 52 subcarriers in use, rest is guard band

Basic subcarrier setup
OFDM
Each subcarriers has a number
26-25-.....-1-0- (-1)-.....(-26)



Basic subcarrier setup, 12-26 OFDM

Need for synchronization



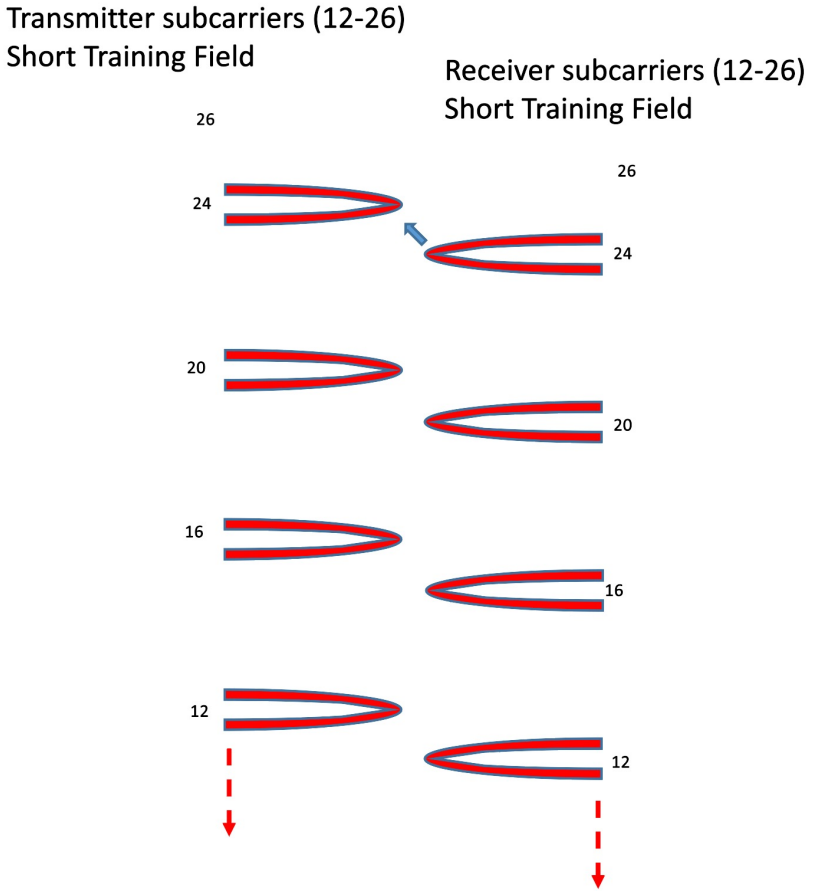
Short Training Field

8µs
10 reps of 0,8µs symbol
12 of 52 subcarriers

- Start-of-packet detection
- AGC
- Initial Frequency offset estimation
- Initial time synchronization

The receiver recognize this pattern and adjust its subcarriers

The receiver can be +/- 625MHz out of sync during STF

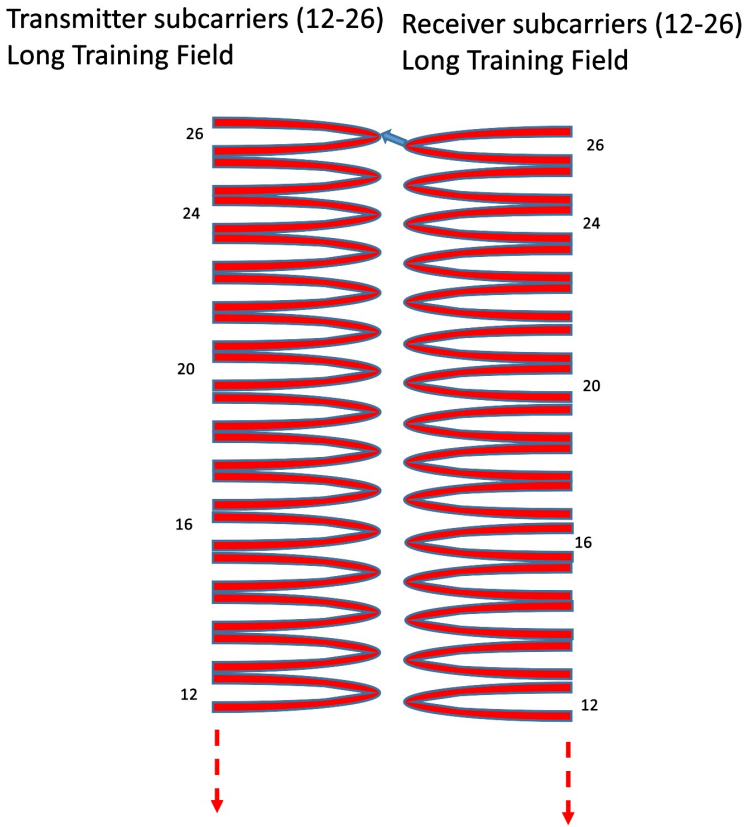


Long Training Field

8µs
Two 3,2µs symbols prepended by a 1,6µs cyclic prefix
52 subcarriers

- Channel estimation
- More accurate frequency offset estimation and time synchronization

All subcarriers in use
The receiver can adjust +/- 125MHz



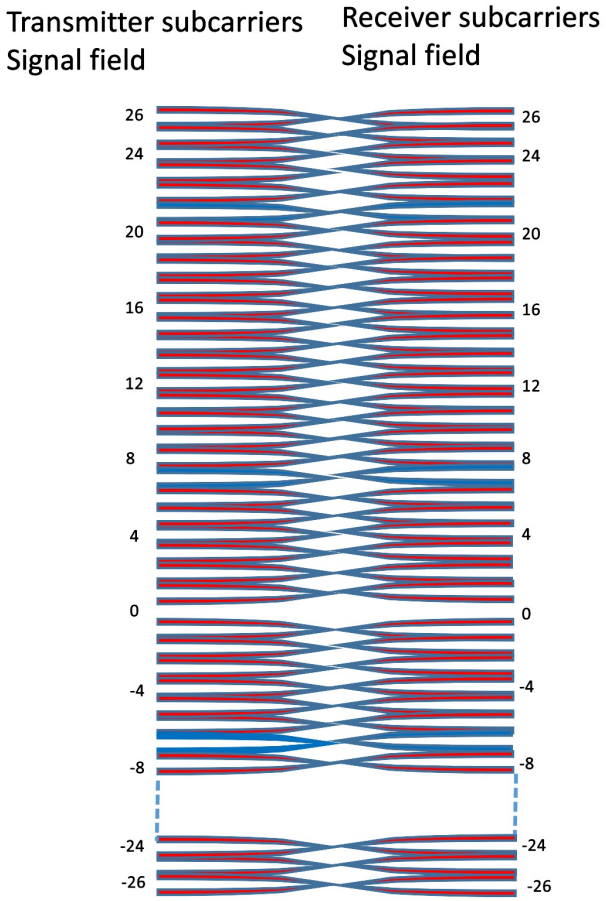
Signal field

4µs

52 subcarriers, 48 for data and 4 pilots

BPSK ½ -> 6 Mb/s

24 databit

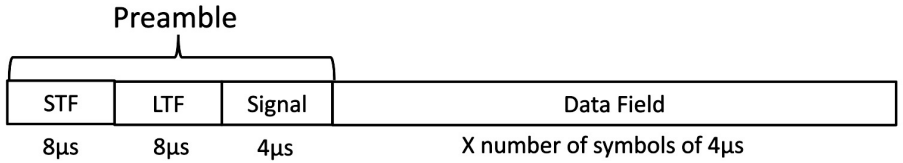


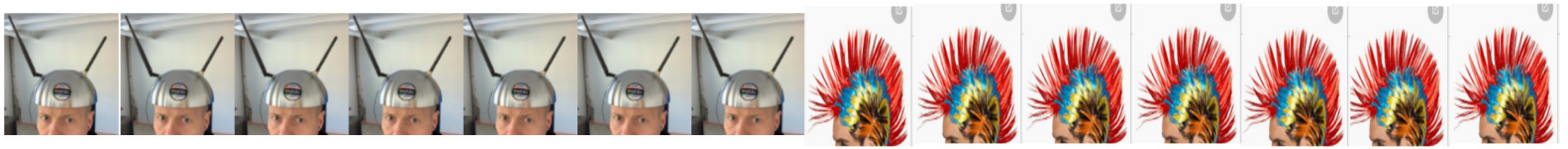
CCA (CLEAR CHANNEL ASSESSMENT) IN 802.11A

CCA-PD (CS/SD)	able to detect the start of a frame according to the standard at -82dBm more common to say 4 dB SNR
CCA-ED	any signal or energy on the channel according to standard, 20 dB over CCA-PD, -62dBm
Virtual carrier, NAV	network allocation vector

802.11A STATIONS NOT TRANSMITTING (IDLE) IS LISTENING

A 802.11 frame on the channel



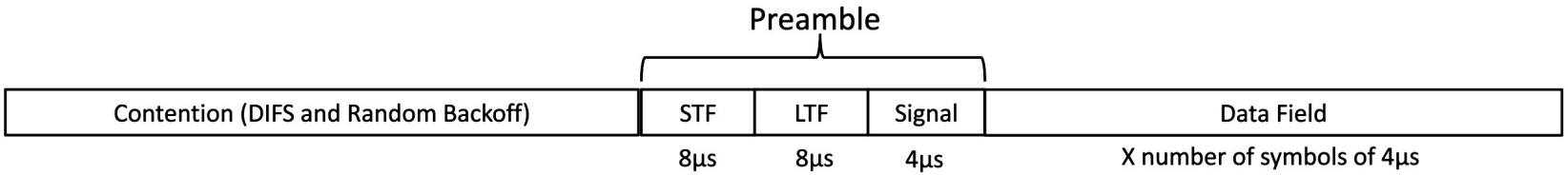


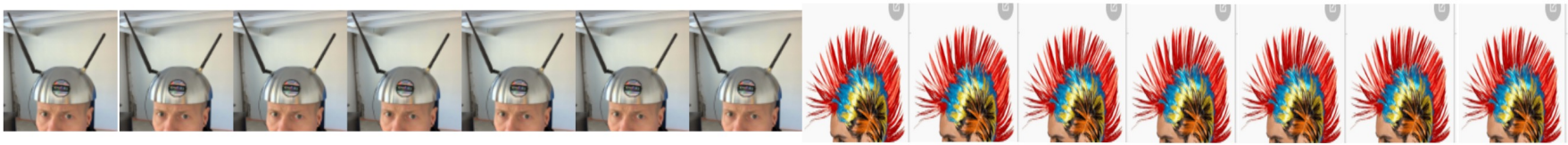
Receiving stations (Idle)
- Do I see the STF above CCA-PD?

Receiving stations
- Synchronization and reception

A STATION SENDING A 802.11A FRAME

Data to send

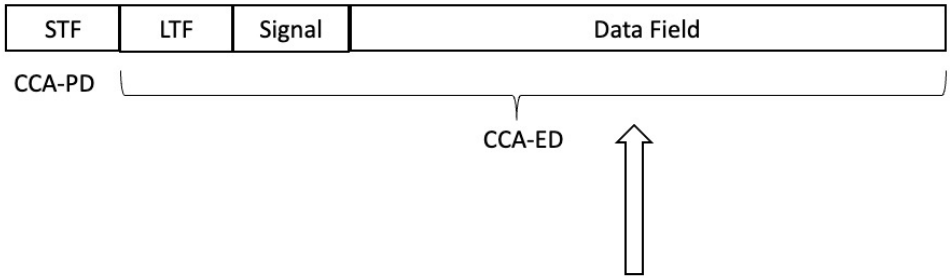




Transmitting station
- Do I see any STF above CCA-PD?
- Is there energy above CCA-ED?

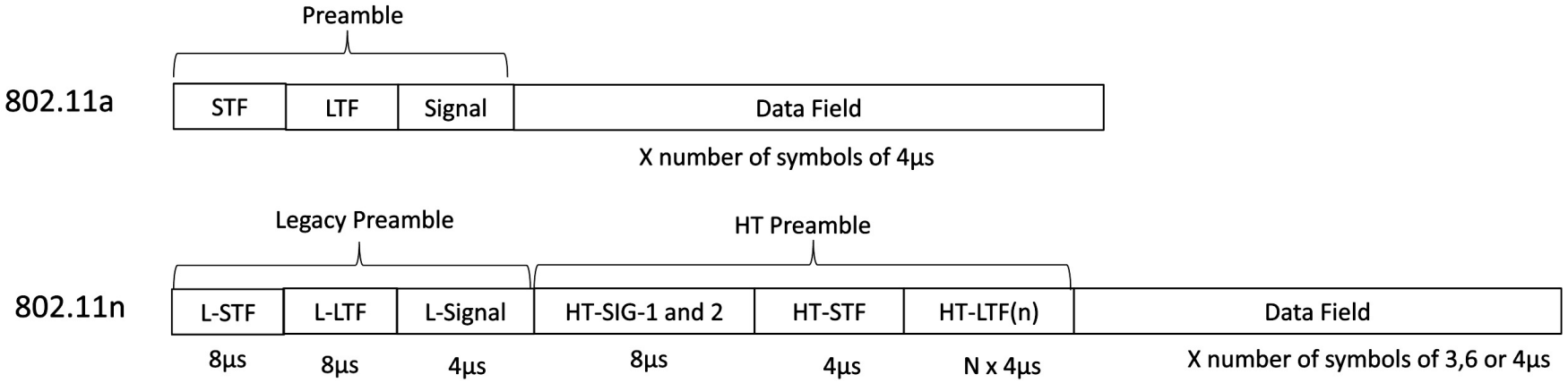
WHAT IF A STATION DON'T SEE THE STF (PREAMBLE)?

- A station wakes up after a sleep
- A station visiting the channel during channel scanning



If another station monitors the channel during a ongoing transmission and the overall energy level is below CCA-ED, it assumes the channel is idle and will starts it own contention process and start transmitting --> **collision**

OFDM FRAME FORMAT, 802.11A AND 802.11N



CCA (CLEAR CHANNEL ASSESSMENT) IN 802.11N

ON PRIMARY CHANNEL

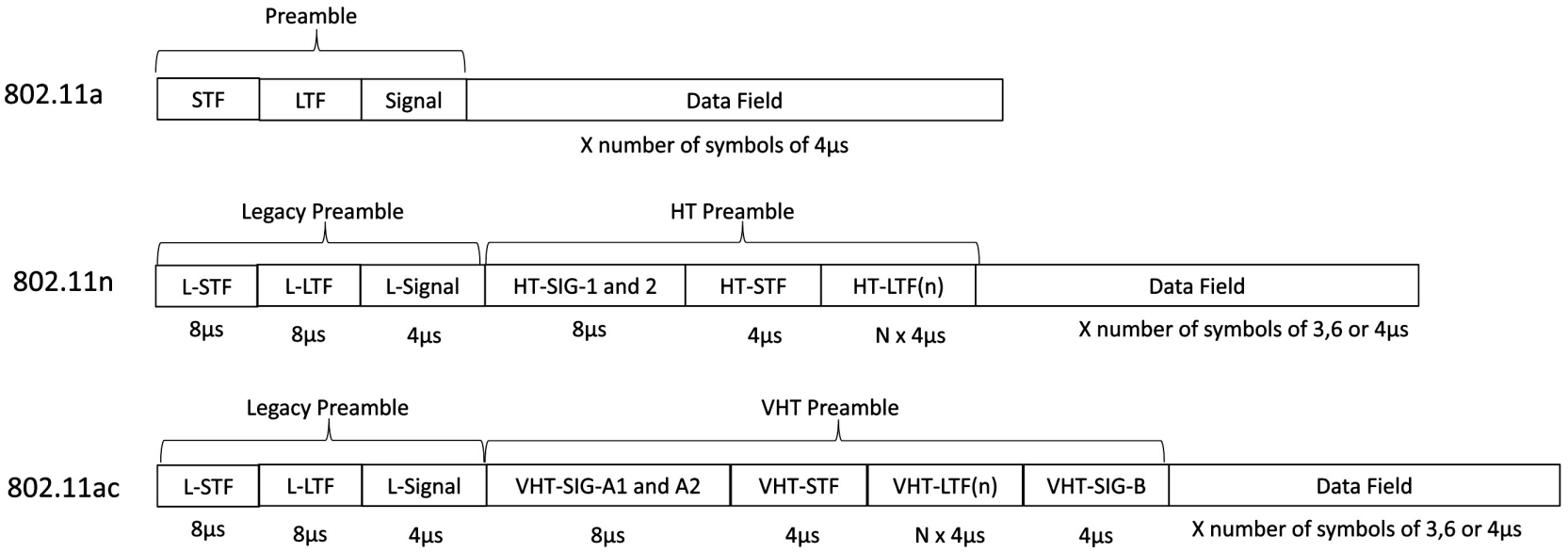
- CCA-PD (SD/CS) able to detect the start of a frame according to the standard at -82dBm more common to say 4 dB SNR

- CCA-ED 20 dB over CCA-SD, according to standard -62dBm

ON SECONDARY CHANNEL

- CCA-ED 20 dB over CCA-SD, according to standard -62dBm

OFDM FRAME FORMAT, 802.11A, .11N AND .11AC



NEW FEATURES IN 802.11AC (VHT) #1

- RTS/CTS exchange with bandwidth signaling
  - The initiating station, the TXOP holder, transmit an RTS frame replicated across the 20MHz subchannels making up the higher bandwidth channel the initiator intends to transmit data frame
  - The recipient station monitors the CCA conditions prior to the receiption of RTS
  - If the RTS indicate static bandwith operation, then the responder only returns the CTS if all the channels occupied by the RTS are clear

  - If the RTS indicate dynamic bandwith operation, then the responder returns the CTS on the clear channels (not discussed any more)

NEW FEATURES IN 802.11AC (VHT) #2

- Ability to detect a valid OFDM transmission (OBSS-SD)
  - The VHT-station can detect a valid OFDM transmission on secondary channels with guard interval autocorrelation
  - Because autocorrelation takes longer time than CCA-PD and CCA-ED, a period of 25µs was defined
  - The standards refers this time period as PIFS (PCF IFS)
  - This improves the channel sensitivity by 10dB, so the OBSS-PD level is -72dBm on secondary channels

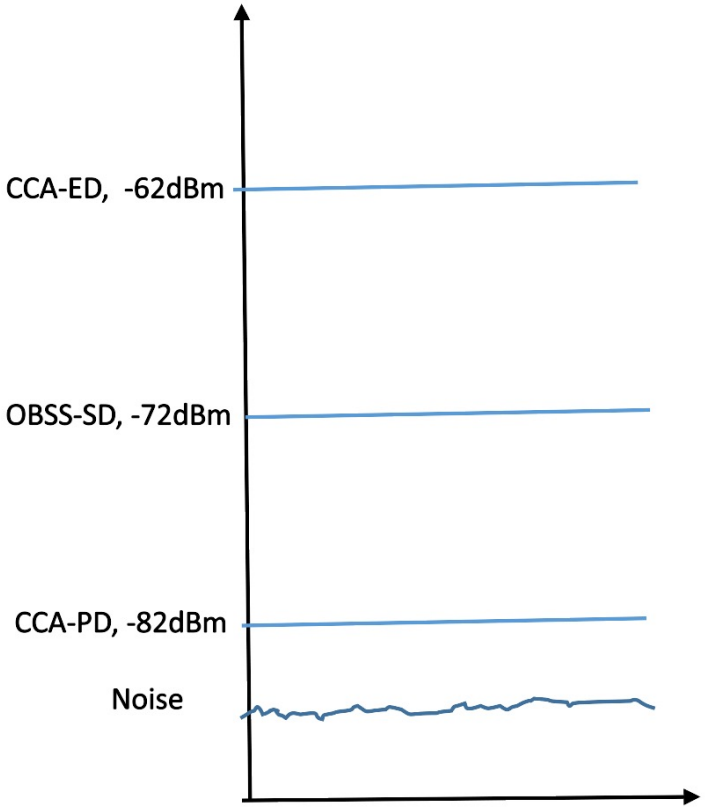
  - The 802.11ax draft 4.0 calls this OBSS_PD. I disagree. For me, this is OBSS-SD
    - SD: signal detection anywhere
    - PD: detection of the preamble or the start of a frame

THREE CCA-LEVELS

CCA-ED detect any signal

OBSS- SD detect a valid OFDM signal
secondary channels

CCA-PD detect the preamble (start of a f
on primary channel



WHICH CCA-METHOD FOR VHT-STATIONS?

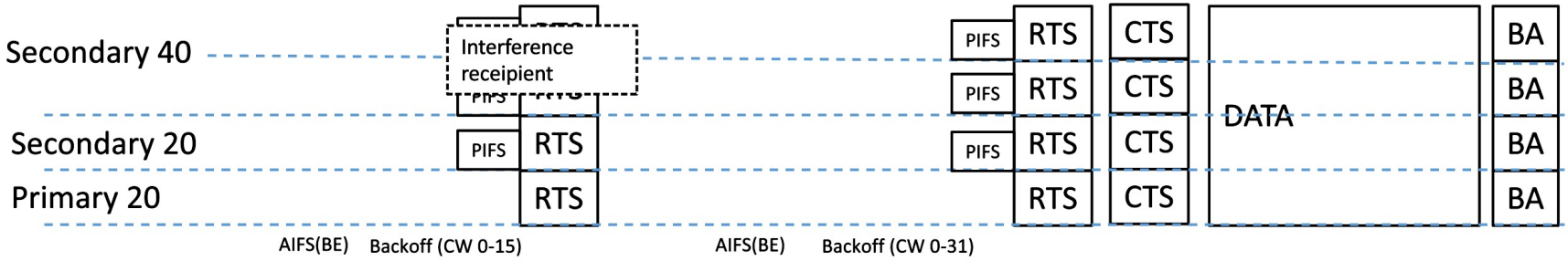
Channels	Receiver	Transmitter
Secondary 40 MHz	OBSS-SD, CCA-ED; prior to receiving	OBSS-SD, CCA-ED; prior to transmitting
	OBSS-SD, CCA-ED; prior to receiving	OBSS-SD, CCA-ED; prior to transmitting
Secondary 20 MHz	OBSS-SD, CCA-ED; prior to receiving	OBSS-SD, CCA-ED; prior to transmitting
Primary 20 MHz	CCA-PD	CCA-PD, CCA-ED during contention

80MHZ TRANSMISSION WITH BANDWIDTH SIGNALING RTS/CTS, #1

80 MHz BSS
Data frame sent with AC=BE

The transmitter prepares the TXOP

80MHZ TRANSMISSION WITH BANDWIDTH SIGNALING RTS/CTS, #2



CAPTURES ON PRIMARY CHANNEL, CHANNEL 36

- 80MHz BSS, 802.11ax stations
- Ping request and reply
- Captured with Jetson Nano 802.11ax

Channel	Data rate	data Bandwidth/RU allocation	data MCS	Starting Sequence Number	Duration	Signal strength (dBm)	Info
36	24				174	-62 d…	Request-to-send,
36	24				130	-52 d…	Clear-to-send, Fl
36	1080,9	80	0xa		48	-64 d…	Echo (ping) reque
36	24			3631	0	-52 d…	802.11 Block Ack,
36	24				177	-52 d…	Request-to-send,
36	24				133	-62 d…	Clear-to-send, Fl
36	1020,8	80	0xa		48	-52 d…	Echo (ping) reply
36	24			525	0	-62 d…	802.11 Block Ack,

CAPTURES ON SECONDARY 20MHz, CHANNEL 40

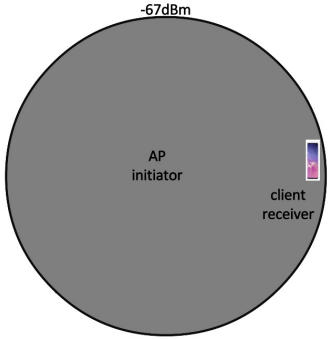
- A 20 MHz capture on the secondary 20 MHz channel, ch 40
- Captured with MacBook Pro and Airtool, 802.11ac adapter
- The data frame is categorized as «Fragmented IEEE 802,11 frame»
- ax-data frame captured on a ac-adapter

Channel	Data rate	data Bandwidth/RU allocation	data MCS	Starting Sequence Number	Duration	Signal strength (dBm)	Info
40	24				174	-65 d…	Request-to-send, Flags=.....
40	24				130	-69 d…	Clear-to-send, Flags=.....
40	6				6875	-66 d…	Fragmented IEEE 802.11 frame
40	24			3631	0	-69 d…	802.11 Block Ack, Flags=....
40	24				177	-69 d…	Request-to-send, Flags=.....
40	24				133	-65 d…	Clear-to-send, Flags=.....
40	6				18120	-69 d…	Fragmented IEEE 802.11 frame
40	24			525	0	-64 d…	802.11 Block Ack, Flags=....

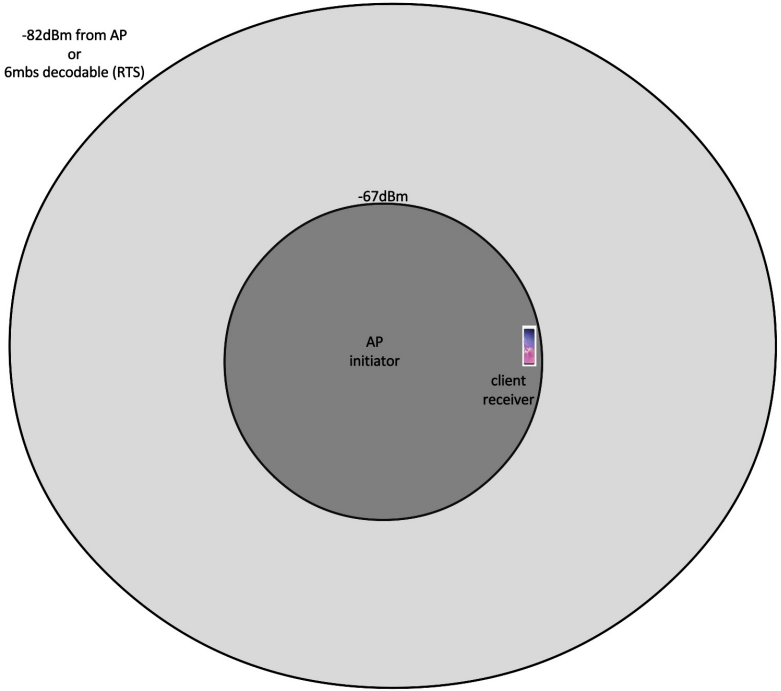
DISTRIBUTING THE NAV IN DUPLICATE RTS/CTS

- Legacy operation:
  - RTS/CTS on the primary channel distributes the NAV to all stations in its own BSS and all other stations on the primary channel
- With duplicate RTS/CTS:
  - NAV is distributed to all stations that have its primary channel at one of our the secondary channels
- Difference
  - Legacy operation: Protection only on the primary channel
  - Duplicate RTS/CTS: Protection on all the channels

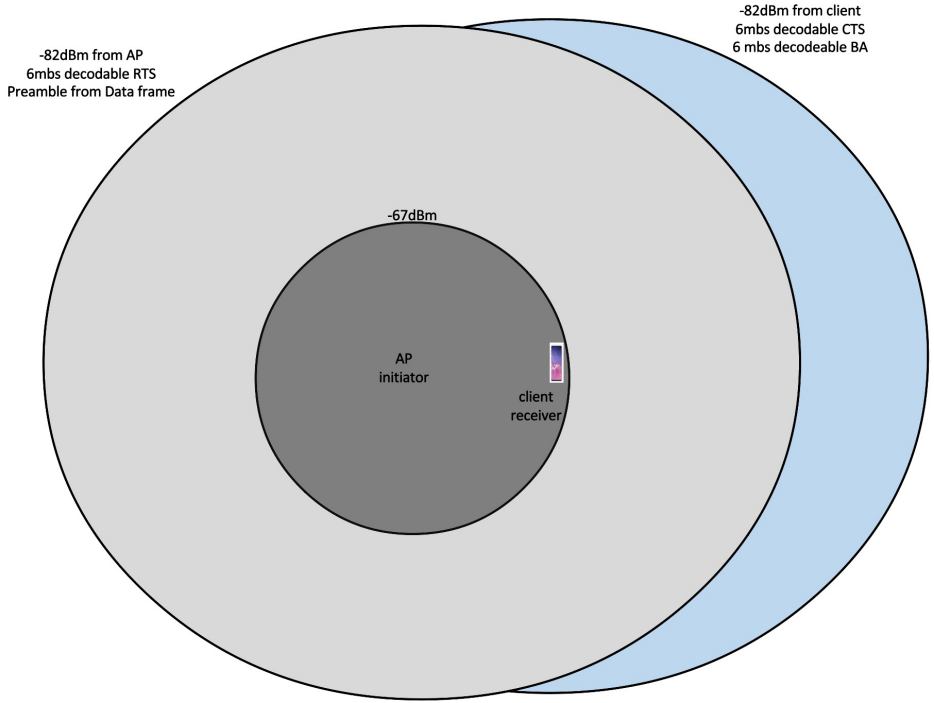
COVERAGE AREA FOR RTS/CTS AT 6MBS AND THE PREAMBLE, #1 -67DBM CELL SIZE



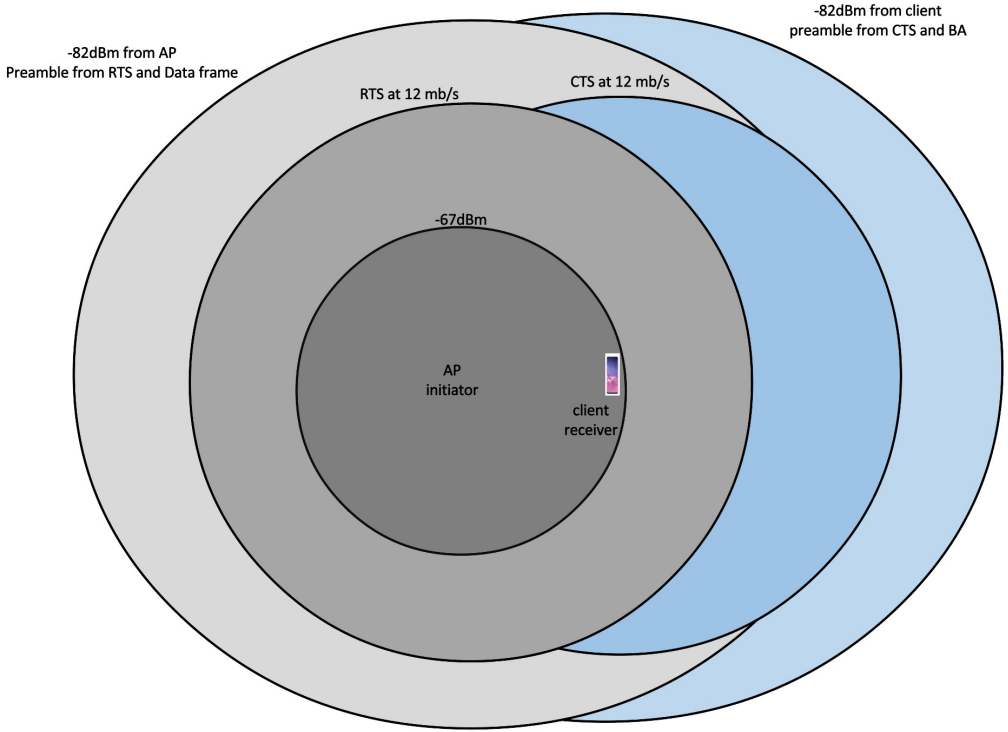
COVERAGE AREA FOR RTS/CTS AT 6MBS AND THE PREAMBLE, #2, CCA-PD OR -82DBM FROM INITIATOR



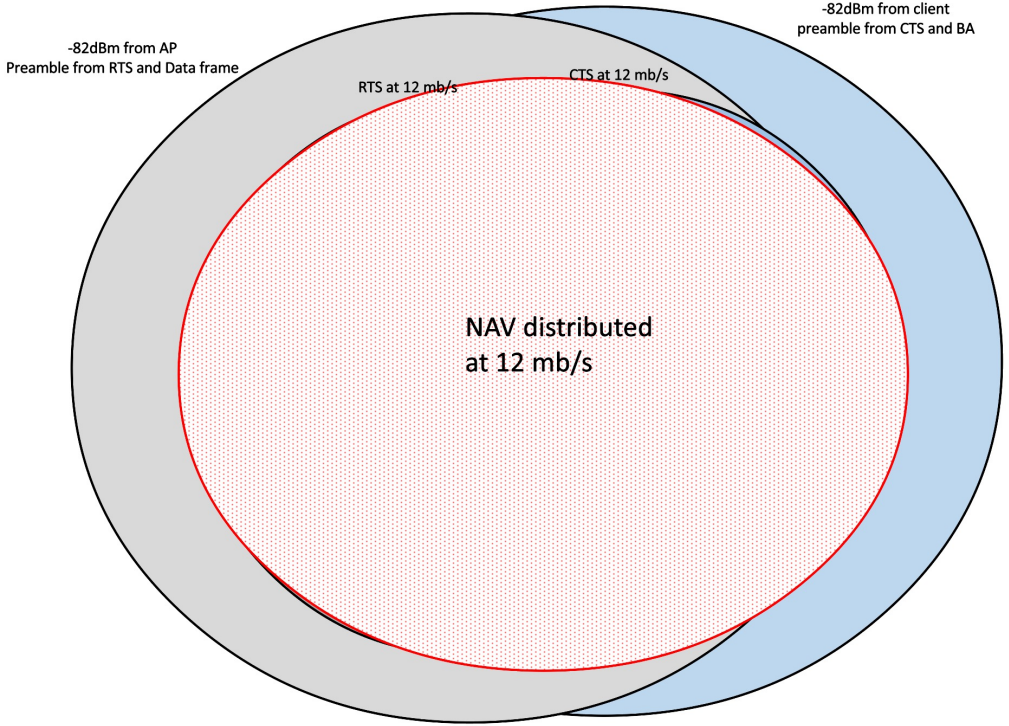
COVERAGE AREA FOR RTS/CTS AT 6MBS AND THE PREAMBLE, #3, CCA-PD OR -82DBM FROM BOTH IN AN TXOP



COVERAGE AREA FOR RTS/CTS AT 12MBS AND THE PREAMBLE, #4.



COVERAGE AREA FOR RTS/CTS AT 12MBS AND THE PREAMBLE, #5



WHAT HAVE WE LEARNED

- The receivers search for the special STF pattern above CCA-PD to detect the start of a frame
- If preamble (STF) is not detected, the energy must be over CCA-ED to prevent other stations to start transmitting
- In 802.11ac and newer PHYs, the station can detect a valid OFDM transmission better than -72dBm on their secondary channels. Called OBSS-SD.
- Three energy levels
  - CCA-PD (preamble detect): detect the start of a frame
  - OBSS-SD (signal detect): detect a valid OFDM transmission
  - CCA-ED (energy detect): any signal or energy on the channel
- Duplicate RTS/CTS can be sent for bandwidth signaling. This, together with OBSS-SD, gives a more sensitive monitoring on all the intended

CLOSING REMARKS

- If a station has CCA-PD level lower than -82 dBm, will it adjust the OBSS-SD and CCA-ED likewise?
- How often is OBSS-SD measured? It drains energy from the device.
- Can the ability to detect a valid OFDM transmission be used on the primary channel in later amendments

OBSS-SD: 802.11ax (HE) use the term OBSS-PD and it is a feature regarding BSS Coloring, Spatial Reuse, duals NAVs.

This presentation is made based of the the 802.11-2016 standards, but is these features
implemented in all the devices.

LITERATURE

802.11-2016 standard, 21.3.18.5 CCA sensitivity (clause 21, VHT)

The Next Generation Wireless LANs, chapter 11.4; Channel Access in Wider Channels

The Next Generation Wireless LANs, chapter 4.1; 11a Packet Structure Review

QUESTIONS AND ANSWERS

Thank you!

go.7signal.com/tour
Every Friday at 12 pm Eastern