The Short Preamble for 802.11 2.4 GHz WLANs
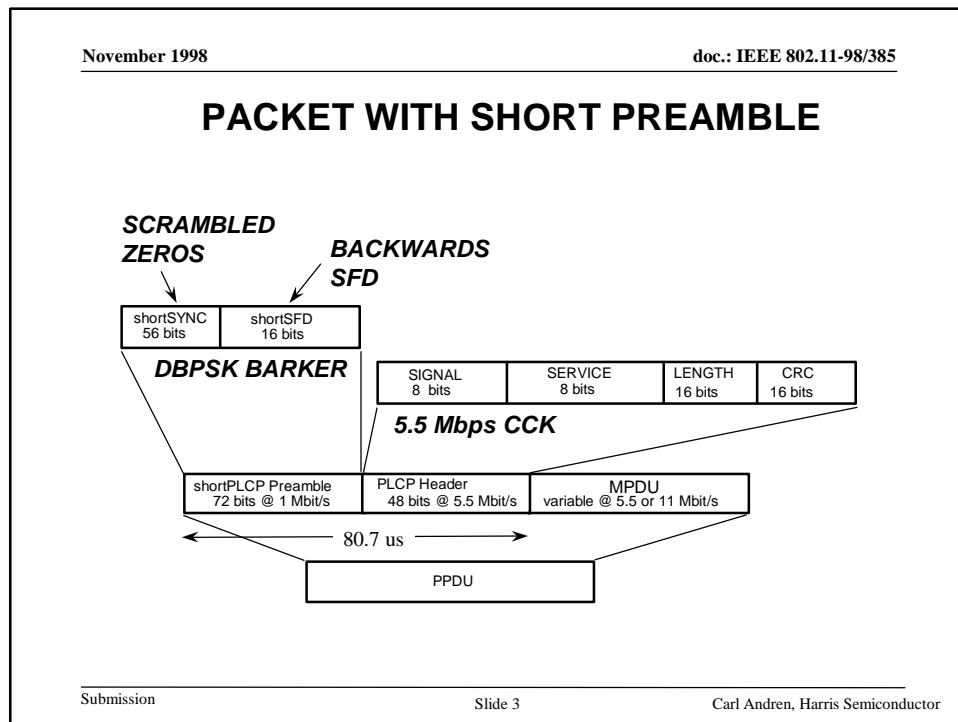
Carl Andren
Harris
Semiconductor

Summary

- A long preamble will allow both interoperability and co-existence with low rate LANs

- A short preamble will allow better throughput when the LAN does not need to contend with low rate PHYs.

- The preamble length has been designed to allow for AGC settling, antenna diversity selection, and equalizer training

PACKET WITH SHORT PREAMBLE

*SCRAMBLED
ZEROS*

*BACKWARDS
SFD*

shortSYNC 56 bits	shortSFD 16 bits

DBPSK BARKER

SIGNAL 8 bits	SERVICE 8 bits	LENGTH 16 bits	CRC 16 bits

5.5 Mbps CCK

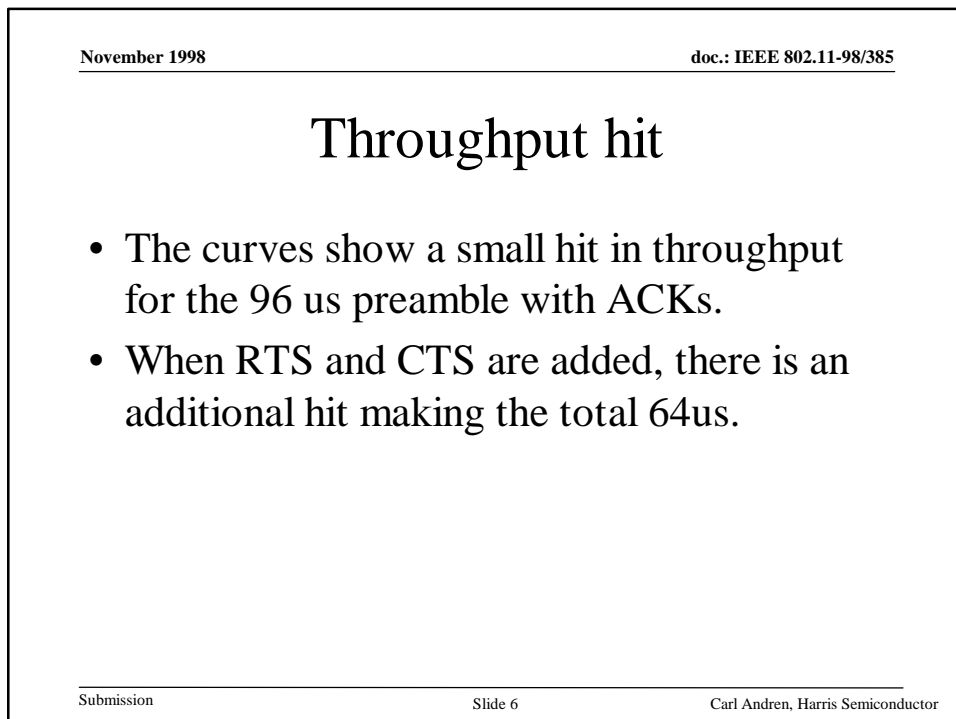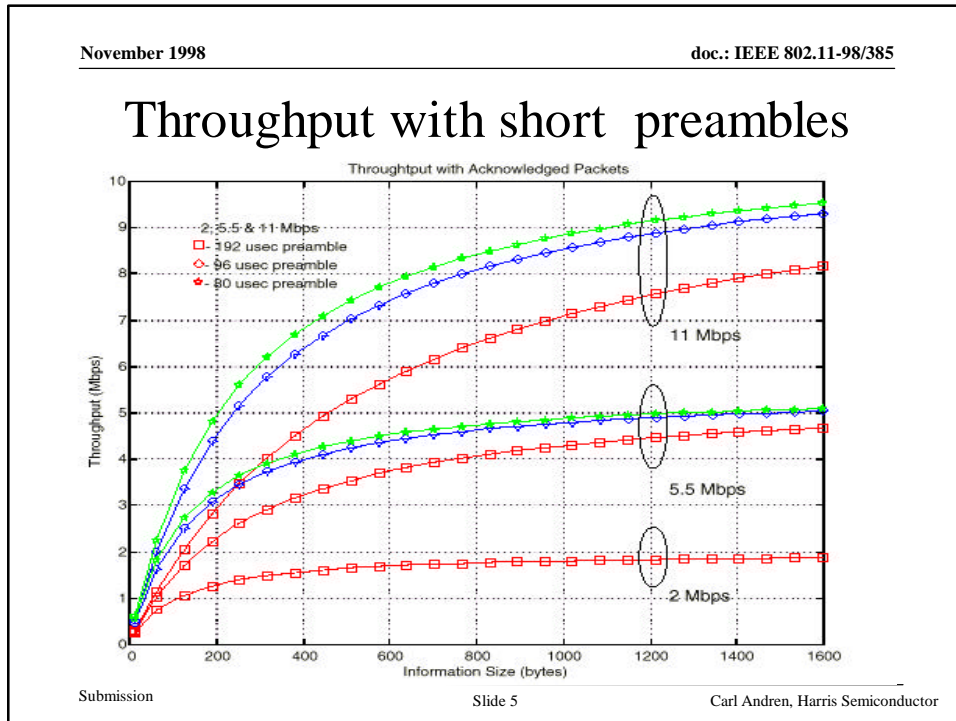| shortPLCP Preamble 72 bits @ 1 Mbit/s	PLCP Header 48 bits @ 5.5 Mbit/s	MPDU variable @ 5.5 or 11 Mbit/s

80.7 us

PPDU

The Alantro Proposal

- Alantro proposes to modulate the header portion of the short preamble with 2 MBps instead of 5.5 MBps CCK.
  - This makes the Es/N0 more of a match to PBCC coding, helping their option
  - What this does is extend the length of the overhead by 16 us to 96 us, hurting throughput.
  - It does allow the equalizer training more time
- Harris/Lucent feels this is unnecessary for our approach

Throughput with short preambles

Throughput with Acknowledged Packets

2, 5.5 & 11 Mbps
□ - 192 usec preamble
◇ - 96 usec preamble
✦ - 80 usec preamble

11 Mbps

5.5 Mbps

2 Mbps

Throughput (Mbps)

Information Size (bytes)

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Throughput hit

- The curves show a small hit in throughput for the 96 us preamble with ACKs.
- When RTS and CTS are added, there is an additional hit making the total 64us.

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SHORT PREAMBLE TIME LINE

ANTENNA DIVERSITY: SIGNAL PRESENT AT BOTH ANTENNAS

CCA SLOT k   *CCA SLOT k+1*   *CCA SLOT k+2*

mSEC: 0   5   10   15   20   25   30   35   40   45   50   55   60

MPDU TAIL   SYNC   SFD

56 mSec

| Hit Ant A | No Hit Ant B | No Hit Ant A | Hit Ant B | Hit Ant A | AGC Ant B | CIR & Freq Estimate Ant B | AGC Ant A | CIR & Freq Estimate Ant A | Switch Ant. & SFD Search |

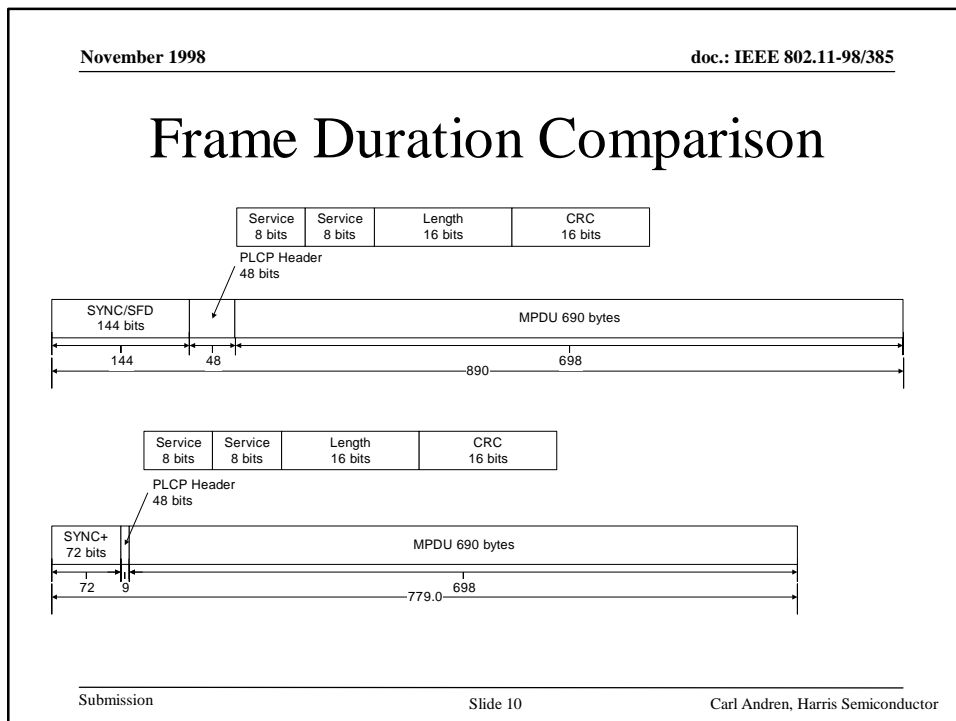*SWITCH DUE TO TRANSPORT LAG*   *AGC LOCK ON ANT B*   *AGC LOCK ON ANT A*   *ANTENNA SELECT*
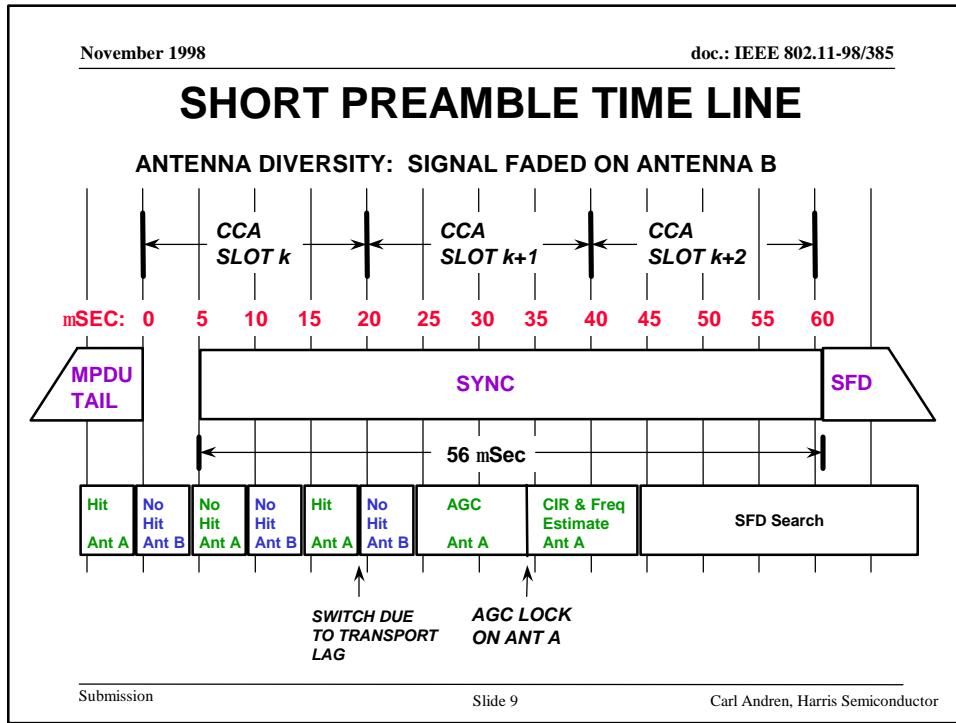
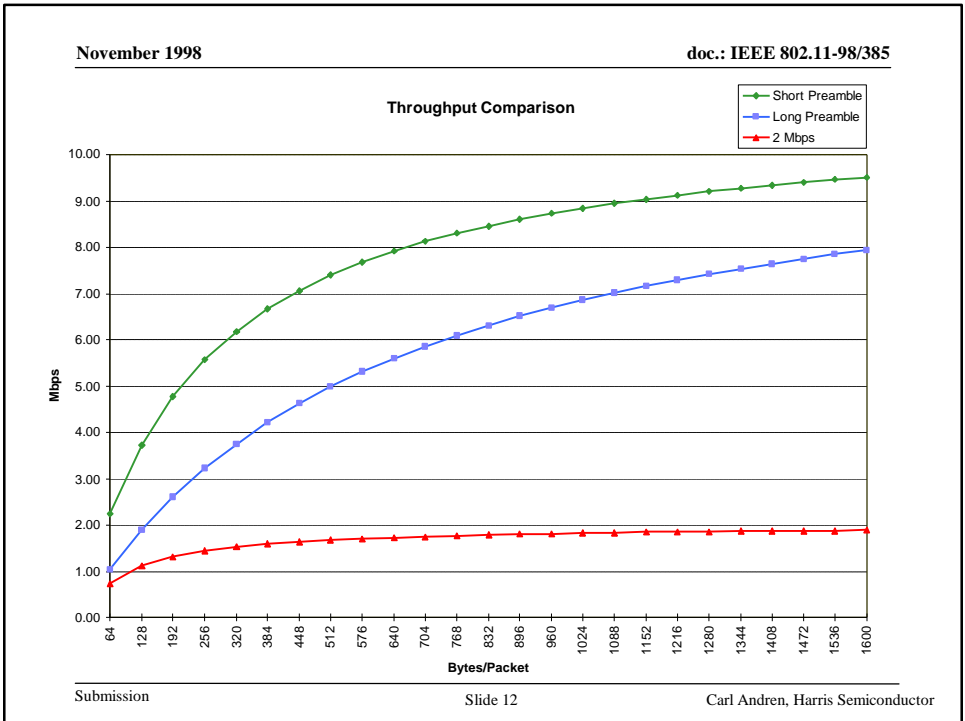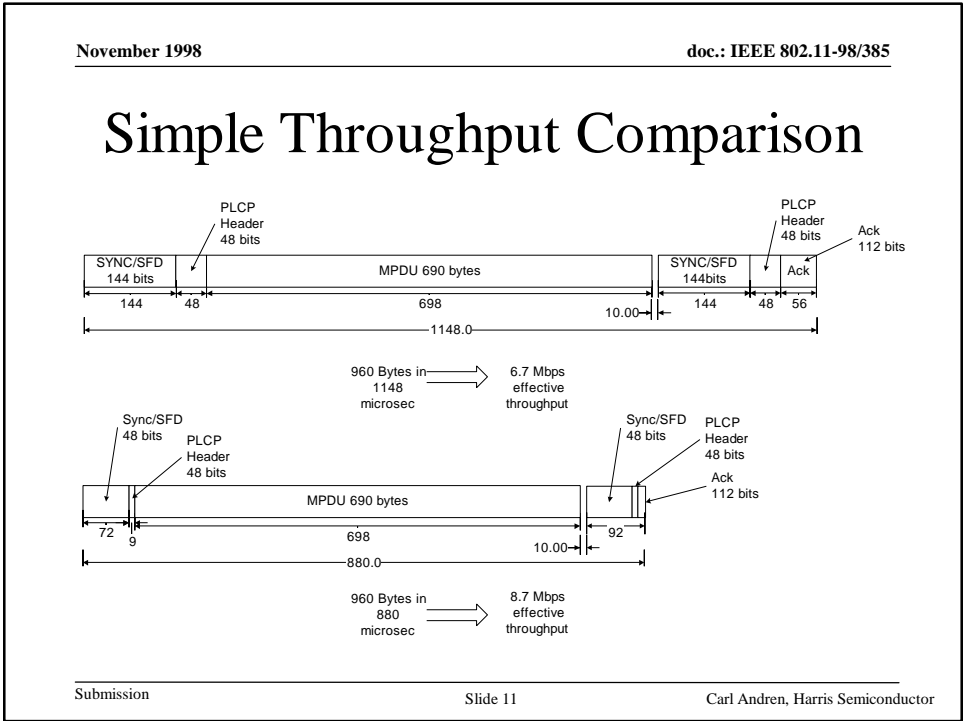Submission   Slide 7   Carl Andren, Harris Semiconductor

Timeline Considerations

- As you can see from the slide, the time line is tight, so a shorter sync field is not acceptable
- Antenna selection must occur enough before the SFD comes along to allow descrambler seeding
- Not all of the SFD has be used if the SNR is high enough
- AGC settling takes 10 us and the AGC is locked down during the packet to keep it from thwarting the equalizer

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SHORT PREAMBLE TIME LINE

ANTENNA DIVERSITY: SIGNAL FADED ON ANTENNA B

CCA SLOT k   *CCA SLOT k+1*   *CCA SLOT k+2*

nSEC: 0 5 10 15 20 25 30 35 40 45 50 55 60

MPDU TAIL   SYNC   SFD

56 nSec

| Hit Ant A | No Hit Ant B | No Hit Ant A | No Hit Ant B | Hit Ant A | No Hit Ant B | AGC Ant A | CIR & Freq Estimate Ant A | SFD Search |

SWITCH DUE TO TRANSPORT LAG

AGC LOCK ON ANT A

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Frame Duration Comparison

| Service 8 bits | Service 8 bits | Length 16 bits | CRC 16 bits |

PLCP Header 48 bits

| SYNC/SFD 144 bits | MPDU 690 bytes |

144   48   698   —890—

| Service 8 bits | Service 8 bits | Length 16 bits | CRC 16 bits |

PLCP Header 48 bits

| SYNC+ 72 bits | MPDU 690 bytes |

72   9   698   —779.0—

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Simple Throughput Comparison

PLCP Header 48 bits

PLCP Header 48 bits

Ack 112 bits

| SYNC/SFD 144 bits | MPDU 690 bytes | | SYNC/SFD 144bits | Ack |

144   48   698   10.00   144   48   56

1148.0

960 Bytes in 1148 microsec → 6.7 Mbps effective throughput

Sync/SFD 48 bits

PLCP Header 48 bits

Sync/SFD 48 bits

PLCP Header 48 bits

Ack 112 bits

| MPDU 690 bytes | |

72   9   698   10.00   92

880.0

960 Bytes in 880 microsec → 8.7 Mbps effective throughput

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Throughput Comparison

- Short Preamble
- Long Preamble
- 2 Mbps

Mbps

10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00

64 128 192 256 320 384 448 512 576 640 704 768 832 896 960 1024 1088 1152 1216 1280 1344 1408 1472 1536 1600

Bytes/Packet

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RTS CTS Effect on Throughput

- 802.11 has the advantage of utilizing the RTS/CTS mechanism to reduce collisions due to hidden nodes (virtual carrier sense)
- The extra transaction on each packet reduces the overall throughput
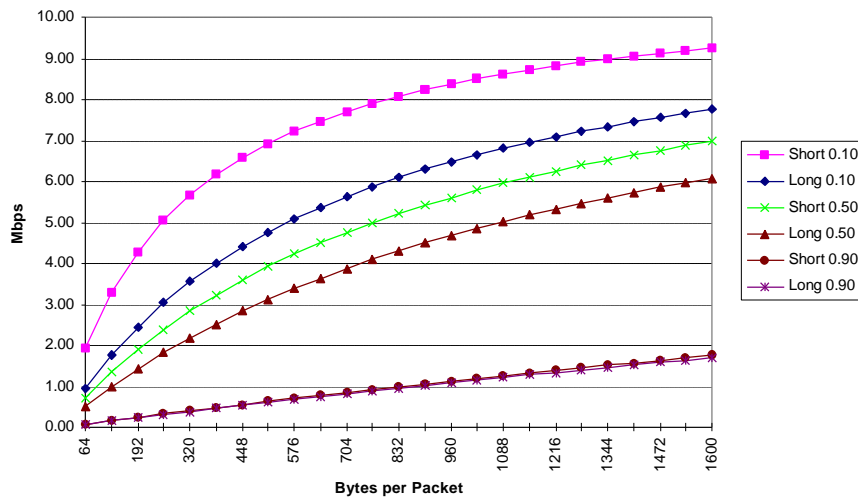- Adding 16 us more to each preamble costs 4 times that much for the whole transaction

Effective Throughput with RTS/CTS
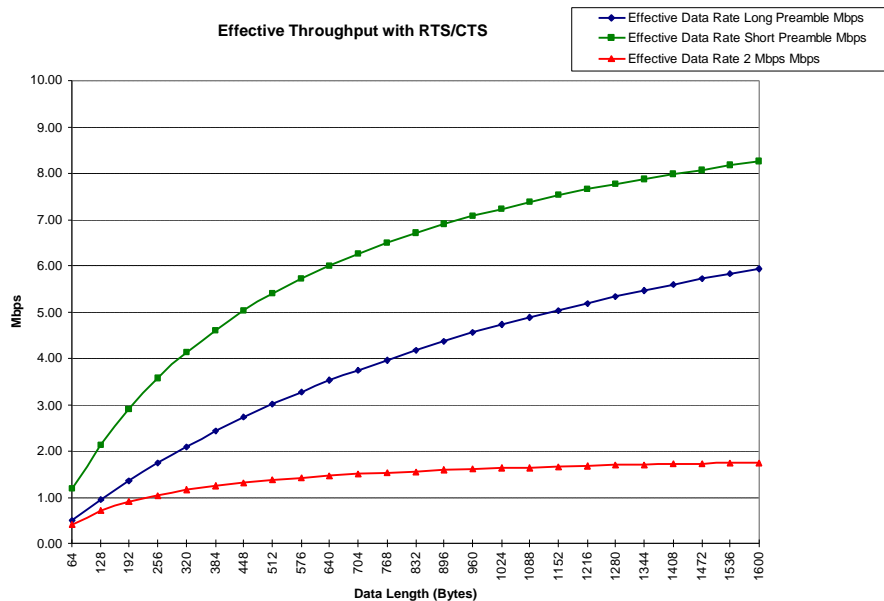
Comparison with Loading

- Simulates the effect of back-off's on the throughput with short and long preamble
- Effect of preamble length is less pronounced with increasing load

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Comparison of Throughput with Loading

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CCA mechanism and
Co-Channel signal detection time

- Measure the correlated signal energy in the preamble over 5 us dwells beginning when the receiver is enabled and compare that to a threshold
- The detection time is less than the slot time by enough to include diversity
- FH detection is done on clock energy in similar dwells.

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Interoperability

- The CCK receiver can recognize both long and short preambles. If the CCK receiver detects a short preamble it trains on the short. If the receiver detects the long preamble it trains on the long preamble. This allows the receiver to better process the channel impulse response.

- **Scenario:** CCK starts with a short preamble. Legacy DSSS modems defer on that preamble. It is normally received by the CCK modems that have the option to receive a short preamble. The CCK modem can receive both CCK (short and long) and legacy DSSS transmissions. If reception is poor (or there is, for whatever reason, a coexistence problem with IEEE modems), the transmitter falls back to 5.5 Mbit/s or to the long preamble. The long preamble is also recognized by the legacy DSSS only modems, making use of the IEEE imbedded multi-rate capability.

- **Result:** CCK modems send, if circumstances allow, the short preamble, making full use of the higher throughput capabilities. They are at all times interoperable with legacy DSSS modems, recognizing the long preamble, receiving (and sending) at the low rates. If there are coexistence problems the CCK modems falls back to the long preamble.

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Coexistence

- **Low rate and high rate PHYs will coexist within the same network.**

- **Short preambles will be used only within networks of exclusively high rate capable PHYs**

- **Short and long preambles may be intermingled on the same network as long as all PHYs are high rate capable and the MAC software is configured to allow mingling.**

- **All (rate) PHYs will perform CCA on either long or short preambles**

- **Performing CCA in the middle of a packet on CCK is problematic.**

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Coexistence Philosophy

- Coexistence means that short preamble CCK defers for legacy DSSS (and long CCK) and vice versa.
- legacy DSSS Receiver
  - detects short preamble (carrier or energy); CCA reports channel busy;
  - waits for Start frame delimiter but will not find it.
  - It is not prescribed in the standard what action the receiver has to take, there are several possibilities:
  - once the CCK signal starts after the preamble, the receiver will lose code lock and cause CCA to go to the channel IDLE state. The receiver returns to the RX idle state and starts looking for a carrier, which it does not see (because of CCK). This might result in a collision or the receiver being out of slot sync.
  - The receiver times out on the SFD. This also leads to out of sync and possible collision
  - CCA reports channel busy until the ED drop of the CCK signal. In this case the DSSS receiver stays in slot sync.
  - It is clear that the third implementation (ED) is the best guaranty for coexistence.

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Coexistence Philosophy

- CCK receiver
  - configured to process a short preamble, the receiver will also detect the long preamble and process the legacy DSSS frame. The CCK receiver can see the legacy transmitter CS in the middle of a message and defer if necessary.
  - On the CCK portion of the packet, the CCK receiver also loses the CS if it is based on Barker correlation and will not behave properly in a network. Therefore, it too could perform better if it had an improved CCA measure like an ED that works or a time out feature.