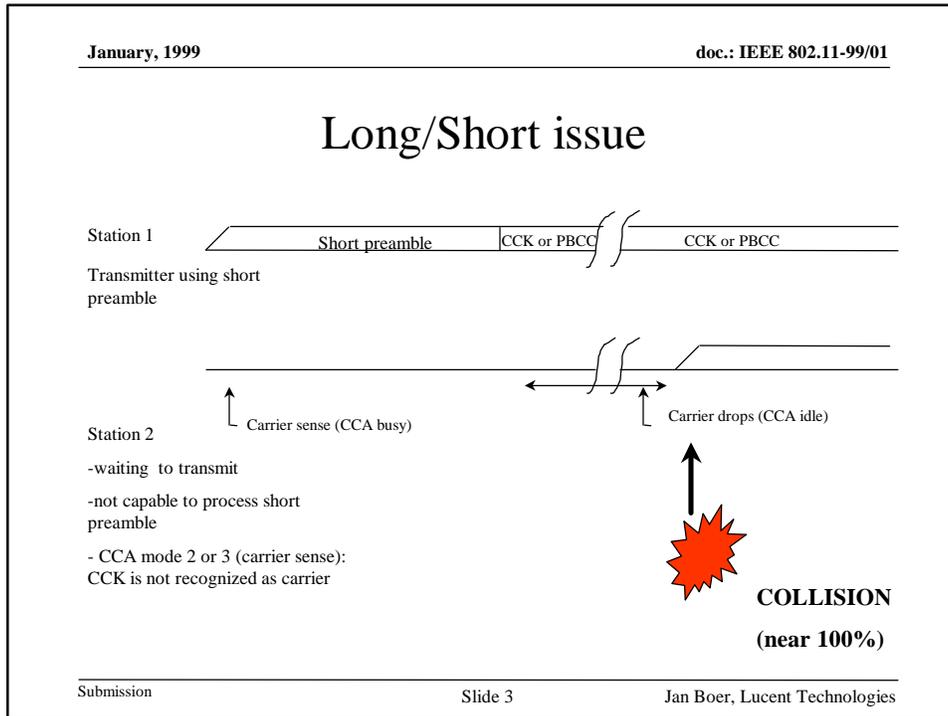# Improved Coexistence in the HS Standard

By Jan Boer

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and

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The problem: Long/Short preamble coexistence

- Station not supporting the short preamble option and station using short preamble at transmit are not coexistent
- Standard 'prescribes' to use only the short preamble, when all stations are capable of processing it
    - All stations in BSS, ESS ?
    - What about different co-located networks
        - how do you know ?
        - does a neighboring network force you to use the long preamble ?
    - Prescription raises many questions; no real solution for coexistence issue

Long/Short issue

Station 1

Short preamble   CCK or PBCC   CCK or PBCC

Transmitter using short preamble

↑ Carrier sense (CCA busy)   ↑ Carrier drops (CCA idle)

Station 2

-waiting to transmit

-not capable to process short preamble

- CCA mode 2 or 3 (carrier sense): CCK is not recognized as carrier

COLLISION

(near 100%)

Related issue

– When the CRC check fails or the carrier drops before validation of the header the exact same issue occurs, indifferent on a short or long preamble!

– The receiving station goes to the idle state and subsequently will sense the medium idle (no carrier detect on the CCK or PBCC part (MPDU))

– Again chance on a collision!

The resolution

– Keep CCA busy during the transmission of the CCK frame

Station 1 | Short preamble | CCK | CCK |

Station 2

Carrier sense (CCA busy)

Carrier drops

KEEP CCA BUSY

– HOW?

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IEEE802.11-1997 CCA MODES

CCA MODE 1

Receive Signal → **MEASURE STRENGTH** → RSSI → (+) Energy Detect

ED Threshold → (-)

- **Detects Signals with Sufficient Energy**
- **Cannot Discriminate Different Signal Types**
- **Fails to detect very weak 1 and 2 Mbps signals**

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IEEE802.11-1997 CCA MODES

CCA MODE 2

Receive
Signal → | BARKER CORR | → | MEASURE STRENGTH | → + / − → Carrier Sense

CS
Threshold

- **Detects Signal Containing BARKER Codes**
- **Ignores Other Signal Types**
- **Fails on CCK and PBCC**

IEEE802.11-1997 CCA MODES

- **Detect Only the Signals with Both Sufficient Energy and Containing Barker Codes**
- **Fails on CCK and PBCC**
- **Fails to detect very weak 1 and 2 Mbps signals**

CCA MODE 3

Receive
Signal → | MEASURE STRENGTH | RSSI → + / − → Energy Detect

ED
Threshold

→ | BARKER CORR | → | MEASURE STRENGTH | → + / − → Carrier Sense

CS
Threshold

→ Energy Detect and Carrier Sense

IEEE802.11-1997 CCA MODES

VIRTUAL CCA OPERATION

LONG PREAMBLE

PREAMBLE	HEADER	MPDU (Data)

SIGNAL	SERVICE	LENGTH	CRC

- If CRC failure does not occur, the packet length is known
- A known packet length is used to hold-off CCA

PROBLEMS WITH EXISTING CCA MODES

LONG PREAMBLE

PREAMBLE	HEADER	MPDU (Data)

- IEEE802.11--1997 Requires CCA 1 or CCA2 or CCA 3
- 5.5 or 11 Mbps MPDU (Data) is Not Recognized by CCA2 or CCA3
- Virtual CCA fails if Header CRC Error Occurs

SHORT PREAMBLE

PREAMBLE	HEADER	MPDU (Data)

- IEEE802.11--1997 Requires CCA 1 or CCA2 or CCA 3
- 5.5 or 11 Mbps MPDU (Data) is Not Recognized by CCA2 or CCA3
- Virtual CCA fails since short preamble is only an option

DOES ANY CCA TECHNIQUE NOT FAIL, IF USED? -- YES

SUCCESSFUL CCA METHOD #1

Receive Signal → MEASURE STRENGTH → RSSI

+ / -

ED Threshold

Energy Detect

CCA TRUE

RSSI Above Threshold

CCA DEFER

RSSI Below Threshold

- **Same as TGa CCA**
- **Ignores Carrier Sense**
- **Detects Signals with Sufficient Energy**
- **Cannot Discriminate Signal Types**
- **CCA Inhibited by Strong Interference**
- **Fails to detect very weak 1 and 2 Mbps signals**

DOES ANY CCA TECHNIQUE NOT FAIL, IF USED? -- YES

SUCCESSFUL CCA METHOD #2

CCA TRUE

Carrier Sense

CCA DEFER

RSSI Below Threshold or Timer Expires

- **Initiated by Carrier Sense (legacy CCA Mode 2)**
- **Drops on RSSI-low (legacy CCA Mode 1) or Timer Expiration (New)**
- **Detects Signals with Sufficient Energy**
- **Identifies BARKER-Code Based Signal Types**
- **Not Inhibited by Strong Interference**
- **Fails to drop CCA defer on very weak 1 and 2 Mbps signals**

DOES ANY CCA TECHNIQUE NOT FAIL, IF USED? -- YES

SUCCESSFUL CCA METHOD #3

CCA TRUE

Carrier Sense and RSSI Above Threshold

CCA DEFER

RSSI Below Threshold or Timer Expires

- **Initiated by Carrier Sense and RSSI High (legacy CCA Mode 3)**
- **Drops on RSSI-low (legacy CCA Mode 1) or Timer Expiration (New)**
- **Detects Signals with Sufficient Energy and BARKER Codes**
- **Not Inhibited by Strong Interference**
- **Fails to detect very weak 1 and 2 Mbps signals**

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DOES ANY CCA TECHNIQUE NOT FAIL, IF USED? -- YES

SUCCESSFUL CCA METHOD #4

Carrier Sense and RSSI Below Threshold

CCA TRUE

Carrier Sense and RSSI Above Threshold

CCA DEFER

CCA DEFER

CS Drops or Timer Expires

RSSI Below Threshold or Timer Expires

- **Initiated by Carrier Sense and RSSI High (legacy CCA Mode 3)**
- **Drops on RSSI-low (legacy CCA Mode 1) or Timer Expiration (New)**
- **Detects Signals with Sufficient Energy and BARKER Codes**
- **Not Inhibited by Strong Interference**
- **Successfully detects very weak 1 and 2 Mbps signals**

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Proposal

– It is proposed to replace the legacy CCA modes by the improved modes (modes 1,3 and 4; mode 2=mode 3)

– Mode used and threshold settings is the implementers choice; thresholds are not required to be fixed

   • depending on network configuration/topology

       – cell size, distance, throughput

– It is proposed to maintain the minimal requirements for the thresholds of IEEE 802.11-1997

– Conformance will be demonstrated by also applying a HR/DSSS signal with short preamble

   • requirement: CCA stays busy during the whole frame

Watchdog timer

– When CCA mode 1 is forced in a interfered environment CCA will remain busy also after the DSSS (CCK or PBCC) signal

– Therefor a watchdog timer is proposed to overcome this situation. When the timer is expired the CCA mode will go back to its original state.
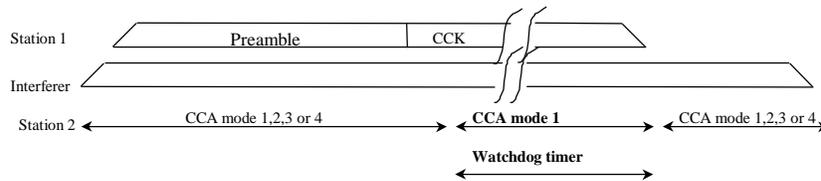
– The timer is set to the longest anticipated frame (2400 bytes @ 1 Mbit/s = 19.5 ms

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REMAINING PROBLEM : LEGACY SYSTEMS

DILEMMA
- TGb PAR was contingent on not changing 1 and 2 Mbps DSSS standard
- TGb PAR was contingent on not changing MAC
- Hence, **cannot impose** any **Successful CCA Method** on legacy systems
- Legacy systems can never be forced to CCA
  on either CCK, PBCC or short preamble
- What is solution to dilemma?

PAR VIEWPOINT

**High-Rate Modes
Built Upon
Legacy
Low-Rate Modes**

5.5 and 11 Mbps

1 and 2 Mbps

**Legacy DSSS
(IEEE802.11-1997)**

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PROPOSED ALTERNATIVE PAR VIEWPOINT

TWO RATE SYSTEM

- 1 and 2 Mbps DSSS only
- IEEE802.11-1997
- In the future, two-rate sytems would still be developed only to IEEE802.11-1997
- It is recommended to implement Improved CCA (not in conflict with legacy CCA)

1 and 2 Mbps

FOUR RATE SYSTEM

- 1, 2, 5.5 and 11 Mbps implementations
- 1, 2, 5.5 and 11 Mbps Bound Together With Improved CCA
- Four-rate systems now fully coexistent
- Two-rate systems will eventually be phased out in the market place
- Two-rate systems only causes problems with long-preamble if CRC error occurs

5.5 and 11 Mbps

1 and 2 Mbps

Bound Together With Improved CCA

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Additional Short option requirement

- It should not be the network operators or users concern whether a station, capable of receiving a short preamble, is receiving a frame with a short or long preamble

- It should be required that a station
  - with the short preamble option implemented
  - configured to send only long preambles

  AUTODETECTS a short preamble

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