بسم الله الرحمن الرحیم

Mobile Networking

Mohammad Hossein Manshaei
manshaei@gmail.com

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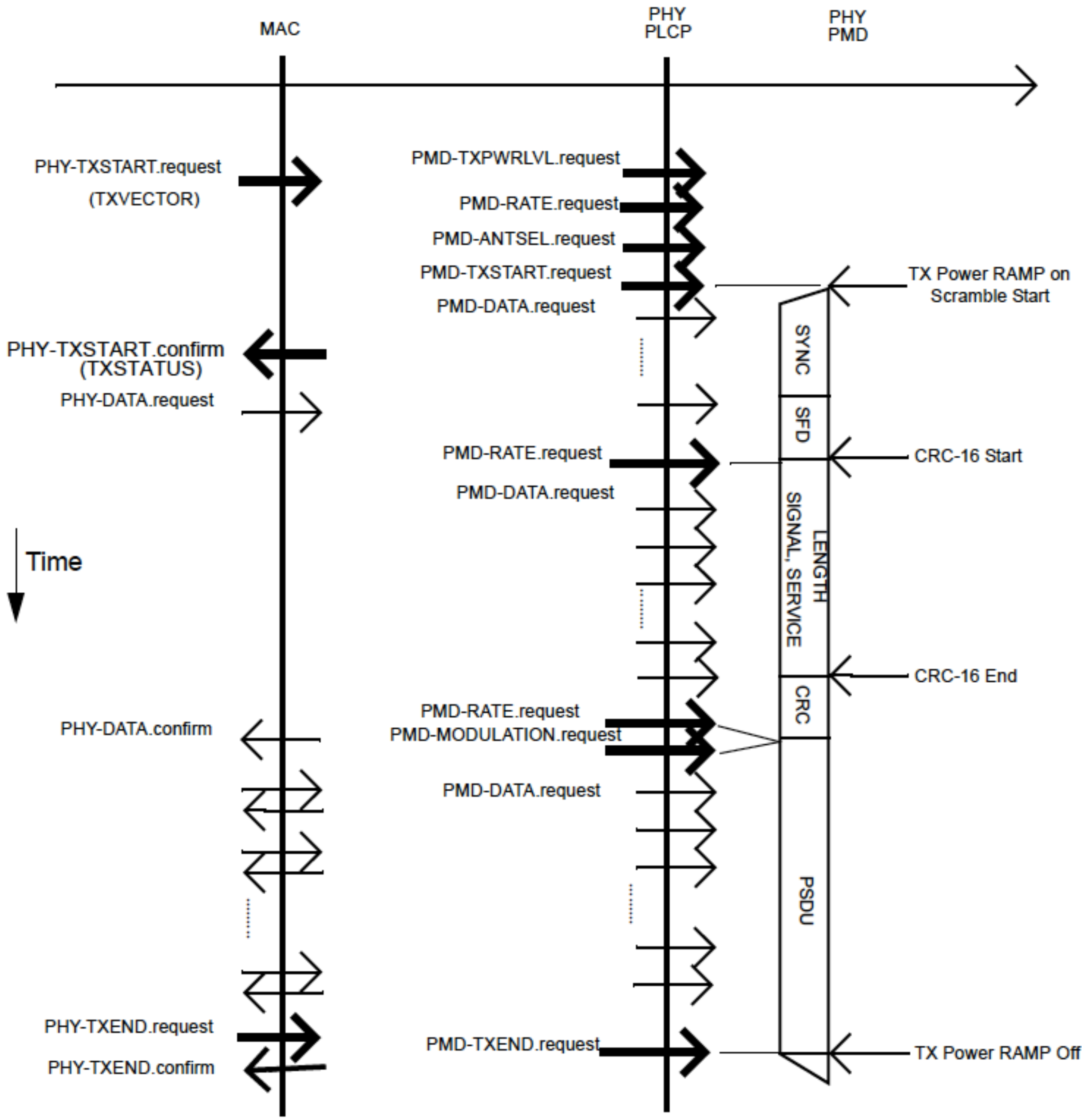
CRC, Scrambler, CCA, …

MORE ON 802.11B PHY LAYER

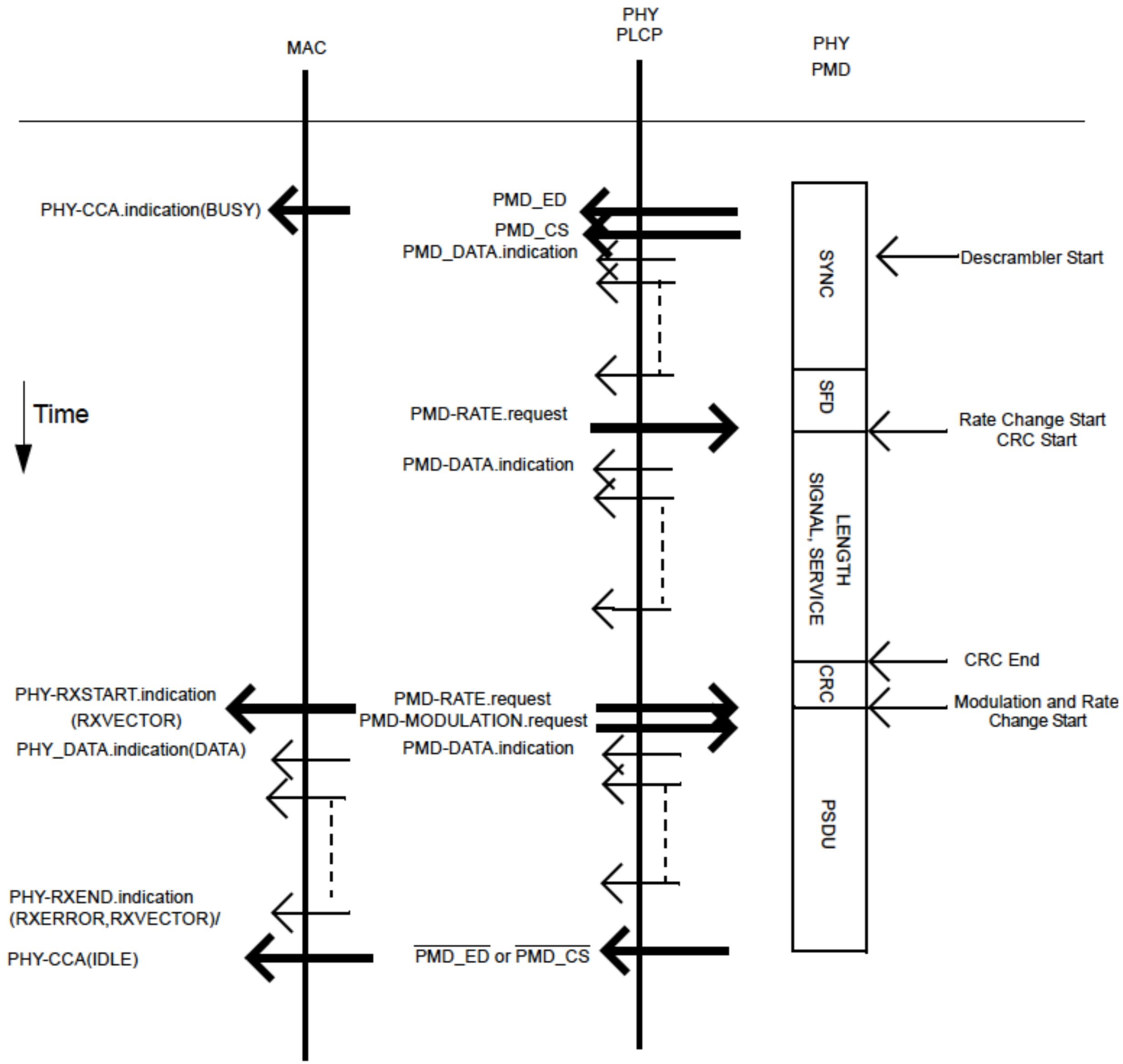
Contents

- PLCP Transmission/Reception Procedure
- Cyclic Redundancy Check (CRC)
- Scrambler and Descrambler
- Clear Channel Assessment (CCA)
- 802.11b Specifications

PLCP Transmission Procedure



PLCP Receiving Procedure



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Cyclic Redundancy Check (CRC)

$$J = Q\,x^{n\text{-}k} + F$$

Q: k bits	F: n-k bits

- Q : *k* bits long frame to be transmitted
- F : FCS (Frame Check Sequence) of $\mathrm{n} - \mathrm{k}$ bits, which would be added to Q
- J :The result after cascading *Q* and *F*
- P :The CRC-generating polynomial
- We need to define F such that *J* would be exactly divisible by *P*

The Main Idea

The receiver divides the *n* received bits (J) by *P*. If the remainder is ***nonzero***, the receiver knows that **an error has occurred**; otherwise the data is accepted as being correct

Cyclic Redundancy Check (CRC)

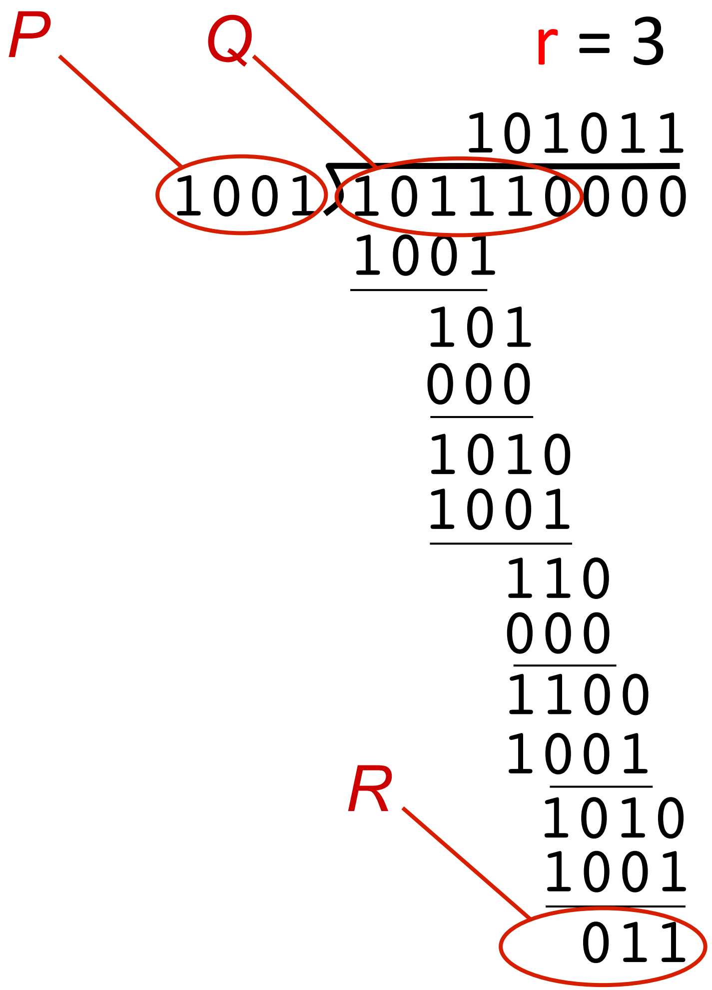
$$\frac{Q \cdot x^{n-k}}{P} = W + \frac{R}{P}$$

- R: A reminder of dividing $Q\,x^{n\text{-}k}$ by P

Hence ➔ $$J = Q \cdot x^{n-k} + R$$

– *In other words, This value of J would yield a zero remainder for J /P.*

CRC Example

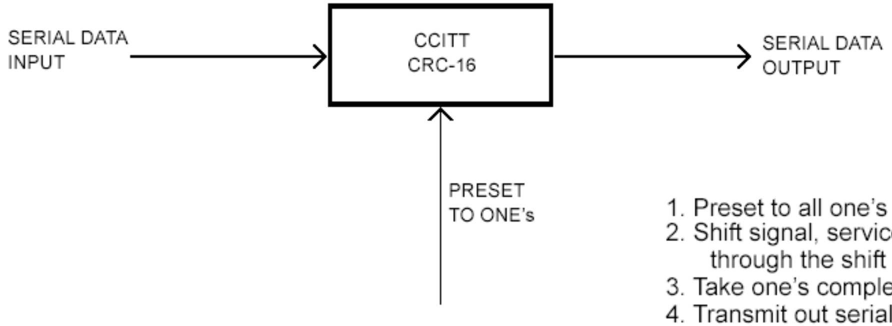

P
Q
r = 3
101011
1001
101110000
1001
101
000
1010
1001
110
000
1100
1001
1010
1001
R
011

Most Commonly Used CRC

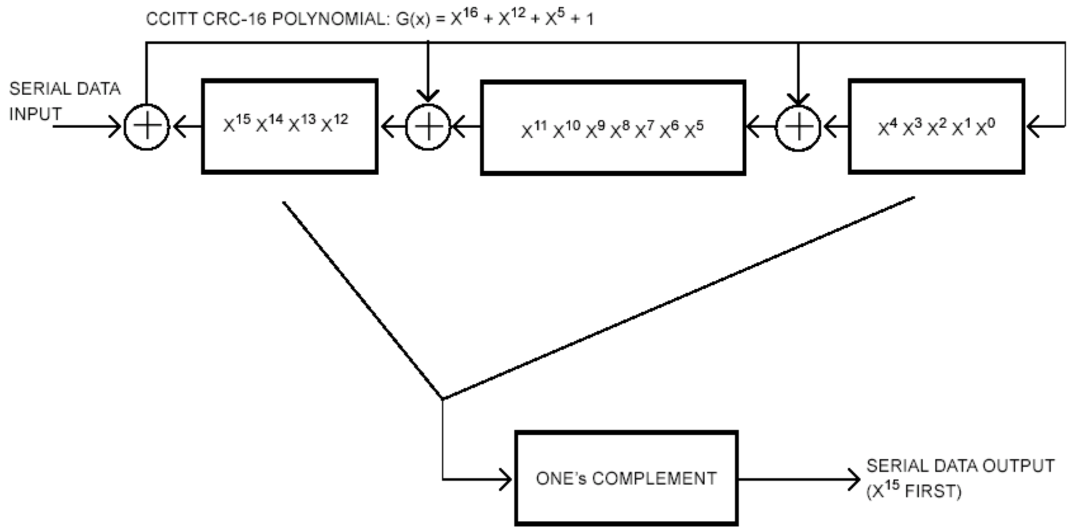
CRC-12	$x^{12}+x^{11}+x^3+x^2+x+1$
CRC-16	$x^{16}+x^{15}+x^2+1$
CRC-CCITT	$x^{16}+x^{12}+x^5+1$
CRC-32	$x^{32}+x^{26}+x^{23}+x^{22}+x^{16}+x^{12}+x^{11}+x^{10}+x^8+x^7+x^5+x^4+x^2+x+1$

CRC-CCITT and CRC-32 are used by 802.11

CRC Implementation in IEEE 802.11



1. Preset to all one's
2. Shift signal, service length fields through the shift register
3. Take one's complement of the remainder
4. Transmit out serial X^{15} first



Data	CRC registers MSB … LSB	
	1111111111111111	; initialize preset to ones
0	1110111111011111	
1	1101111110111110	
0	1010111101011101	
1	0101111010111010	
0	1011110101110100	
0	0110101011001001	
0	1101010110010010	
0	1011101100000101	
0	0110011000101011	
0	1100110001010110	
0	1000100010001101	
0	0000000100111011	
0	0000001001110110	
0	0000010011101100	
0	0000100111011000	
0	0001001110110000	
0	0010011101100000	
0	0100111011000000	
0	1001110110000000	
0	0010101100100001	
0	0101011001000010	
0	1010110010000100	
1	0101100100001000	
1	1010001000110001	
0	0101010001000011	
0	1010100010000110	
0	0100000100101101	
0	1000001001011010	
0	0001010010010101	
0	0010100100101010	
0	0101001001010100	
0	1010010010101000	
	0101101101010111	

; ones complement, result = CRC FCS parity

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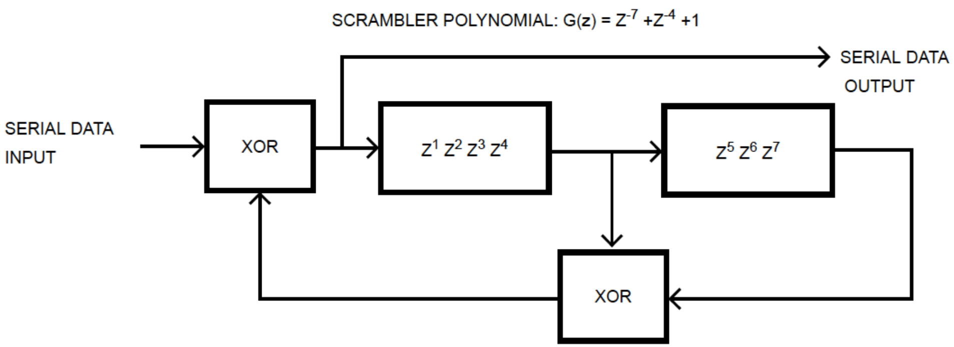
Data Scrambler/Descrambler: Main Idea

- Long string of binary zeros or ones in a transmission can degrade system performance

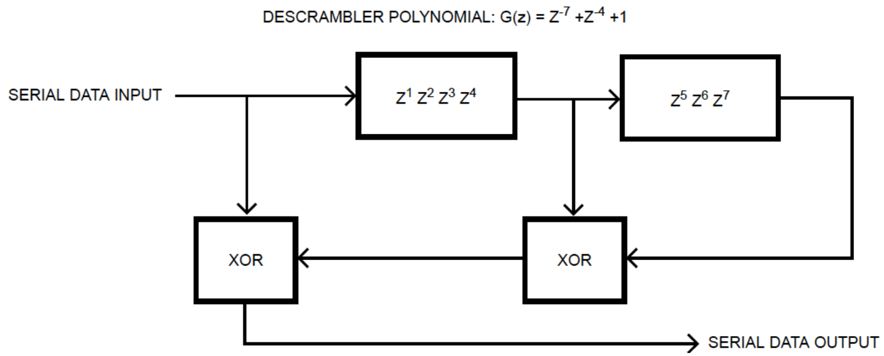
- Other transmission properties, such as spectral properties, are enhanced if the data are more nearly of a random nature rather than constant or repetitive

- Scrambling will improve the signal quality by making the data appears more random

Data Scrambler/Descrambler in 802.11



Data Scrambler



Data Descrambler

- All bits transmitted/received by the DSSS PHY are scrambled/descrambled
- The input is divided by polynomial G to produce the scrambled sequence
- At the receiver the received scrambled signal is multiplied by the same polynomial to reproduce the original input

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Clear Channel Assessment

- **Five methods：**
  1. **CCA mode 1:** Energy above threshold (detect energy) (11b-HR, 11g-ERP)
  2. **CCA mode 2:** Carrier sense only (detect DSSS signal)
  3. **CCA mode 3:** Carrier sense with energy above threshold (2Mbps)
  4. **CCA mode 4:** Carrier sense with timer (11b-HR)
     1. 3.65ms is the duration of the longest possible 5.5Mbps PSDU
  5. **CCA mode 5:** Carrier sense (detect DSSS signal) with energy above threshold (5.5Mbps, 11Mbps) (11b-HR, 11g-ERP)

Clear Channel Assessment

- *Energy detection function of TX power in modes 1 & 3*
  - **Tx power > 100mW**: -80 dBm (-76dBm in mode 5)
  - **Tx power > 50mW :** -76 dBm (-73dBm in mode 5)
  - **Tx power <= 50mW:** -70 dBm (-70dBm in mode 5)
- Correct PLCP header → CCA busy for full (intended) duration of frame as indicated by PLCP Length field

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DSSS Specification Summary
Some Numbers

- Slottime: 20 us
- TX to Rx turnaround time: 10 us
- Rx to Tx turnaround time: 5 us
- Operating temperature range
    - Type 1: 0 - 40 °C
    - Type 2: -30 - 70 °C
- Tx Power Levels
    - 1000 mW USA (FCC 15.274)
    - 100 mW Europe
    - 10 mW/MHz Japan
- Minimum Transmitted Power 1 mW
- Tx power level control required above 100 mW
  - four power levels