Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: [Support document for BC-GPPM proposal to 802.15.6]

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Re: [Contribution to IEEE 802.15.6 Meeting, January 2010]

Abstract: [Supplement to BC-GPPM]

Purpose: [To be considered in IEEE 802.15.6]

Supplement to BC-GPPM

ETRI

January, 2010

WBAN Requirements

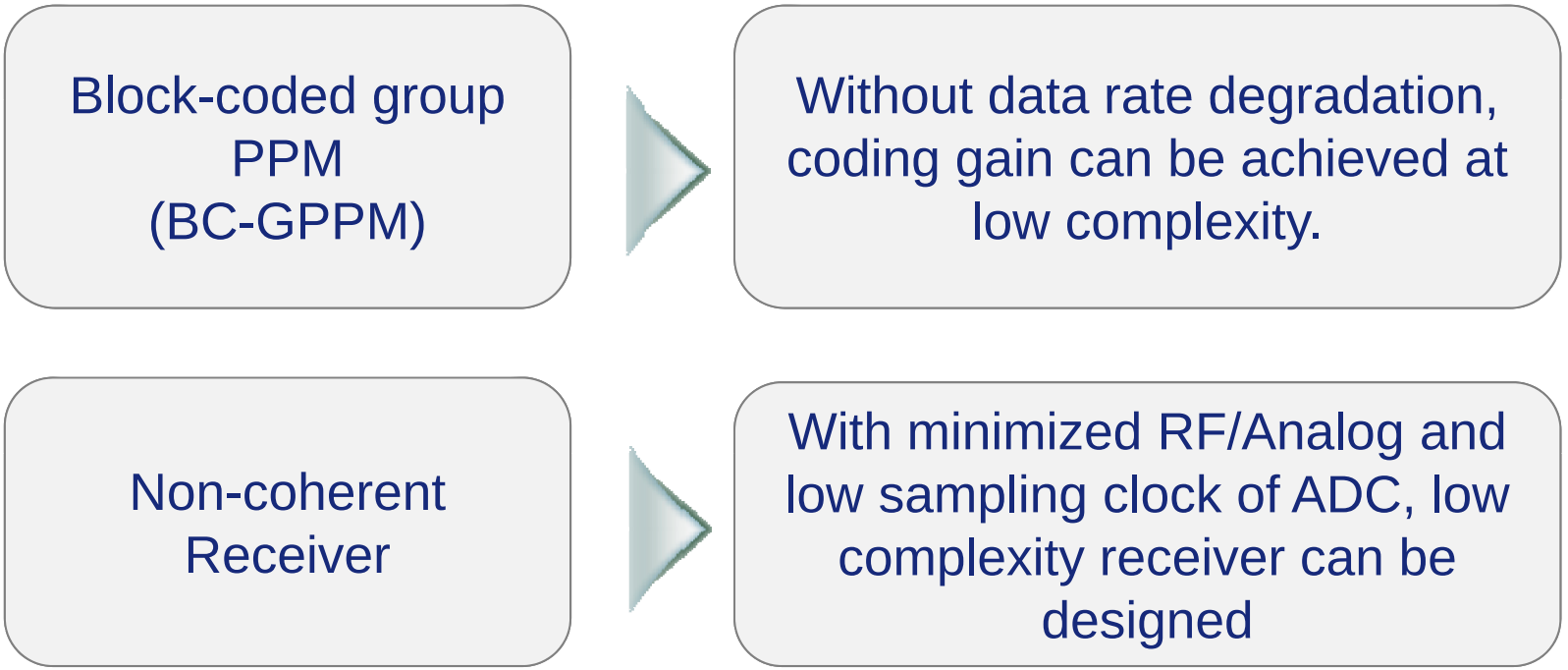
- Key Aspects of WBAN Systems
  - Low power consumption & complexity
  - Range: ≤ 3m
  - QoS: PER ≤ 10%
  - Scalable data rate

Key Points for WBAN System

- What makes it different WBAN standard from other wireless standards?
  - Low power consumption & complexity

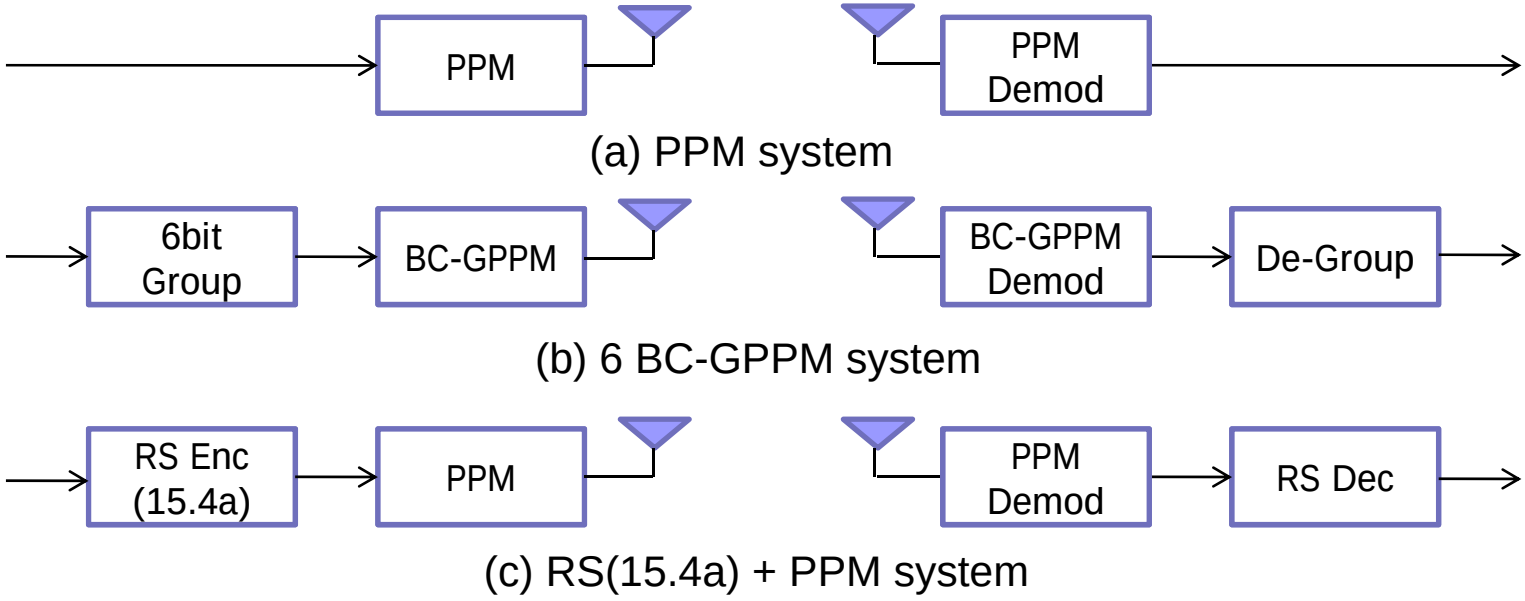
Approach

- Approach toward low-complexity WBAN



Comparisons (1)

- PPM(a) v.s. 6 BC-GPPM(b) v.s. RS(15.4a)+PPM(c)
- 255 Byte of information in payload
- 1MHz symbol rate is considered



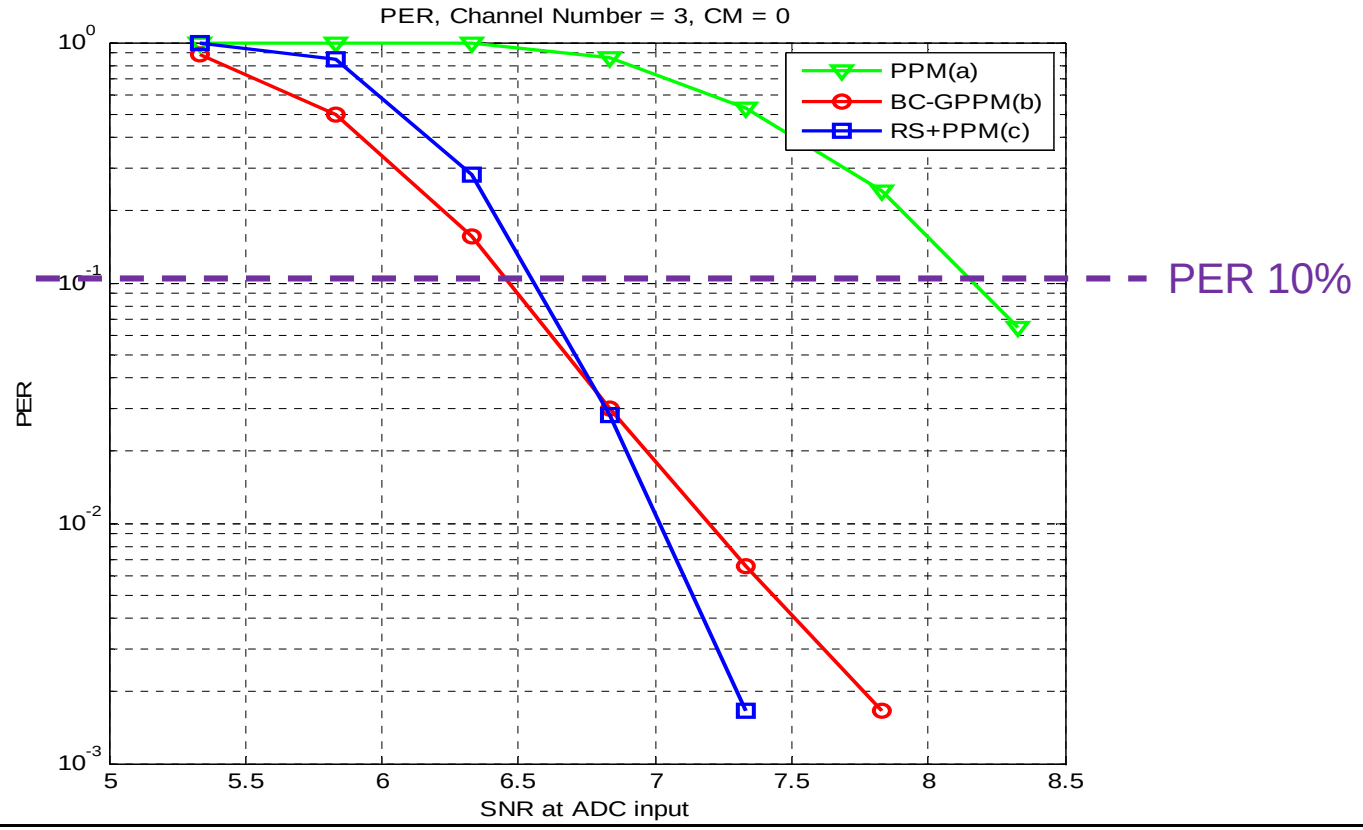
Comparisons (2)

- Throughput aspect
  - PPM and 6 BC-GPPM have the same throughput
  - RS+PPM has reduced throughput due to RS code

	(a) PPM	(b) BC-GPPM	(c) RS+PPM
# of symbols to transmit a payload(255byte)	2,040	2,040	2,378
One payload duration @ same 1MHz symbol rate	2,040 usec	2,040 usec	2,378 usec
Transmission energy loss per pulse @ same power consumption per payload	0	0	0.7 dB

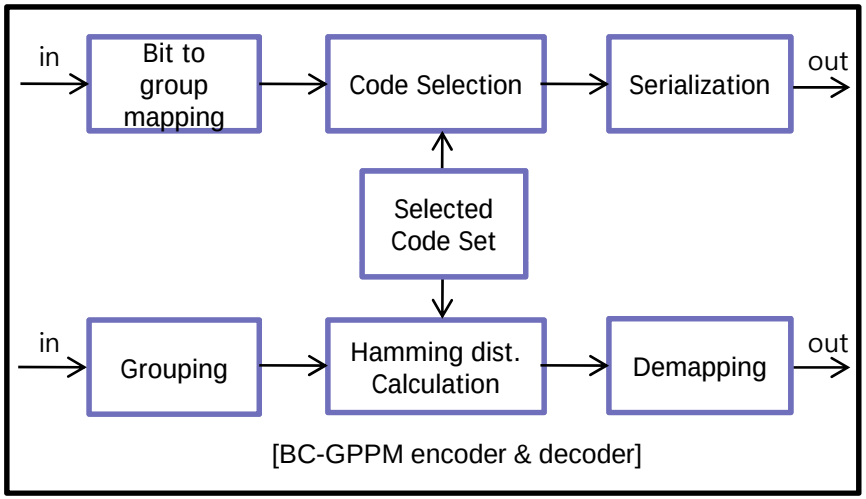
Comparisons (3)

- PER aspect
  - 6 BC-GPPM has the best performance at PER 10%

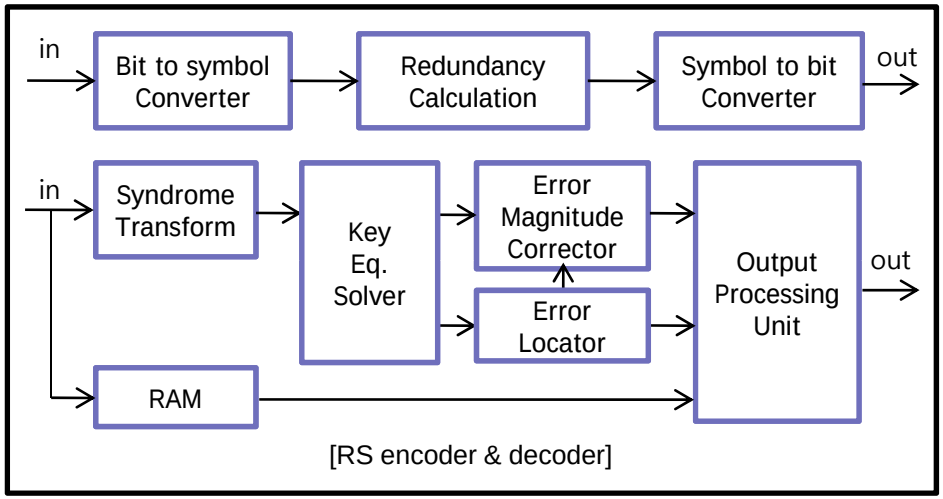


Comparisons (4)

- Complexity aspect: implemented in FPGA EP2S130



[BC-GPPM encoder & decoder]



[RS encoder & decoder]

	Combinational ALUTs	Registers	Memory Bits	Logic Utilization
RS Codec (only codec)	1,773	2,449	1,536	3%
6 BC-GPPM (block codec + mod/demod)	434	385	0	0.5%
RS : BC-GPPM	4 : 1	6.36 : 1		6 : 1

Comparisons (5)

- Latency aspect
  - In general, the system equipped with RS decoder has long latency due to RS decoding processing time.
  - Throughput at the layer (e.g., MAC) that requires retransmission will be reduced

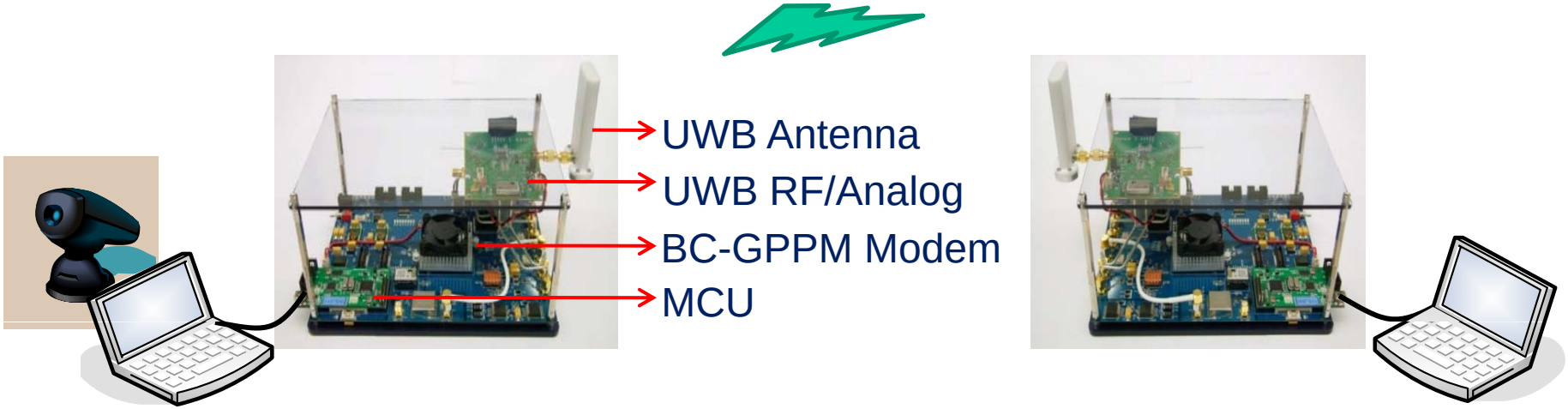
Conclusions

- BC-GPPM for Low Complexity
  - Without throughput degradation, BC-GPPM achieves best performance at PER 10%
  - BC-GPPM(Block codec + mod/demod) has much less complexity than RS codec itself
  - The hardware latency of BC-GPPM is negligible

Demonstration of BC-GPPM System

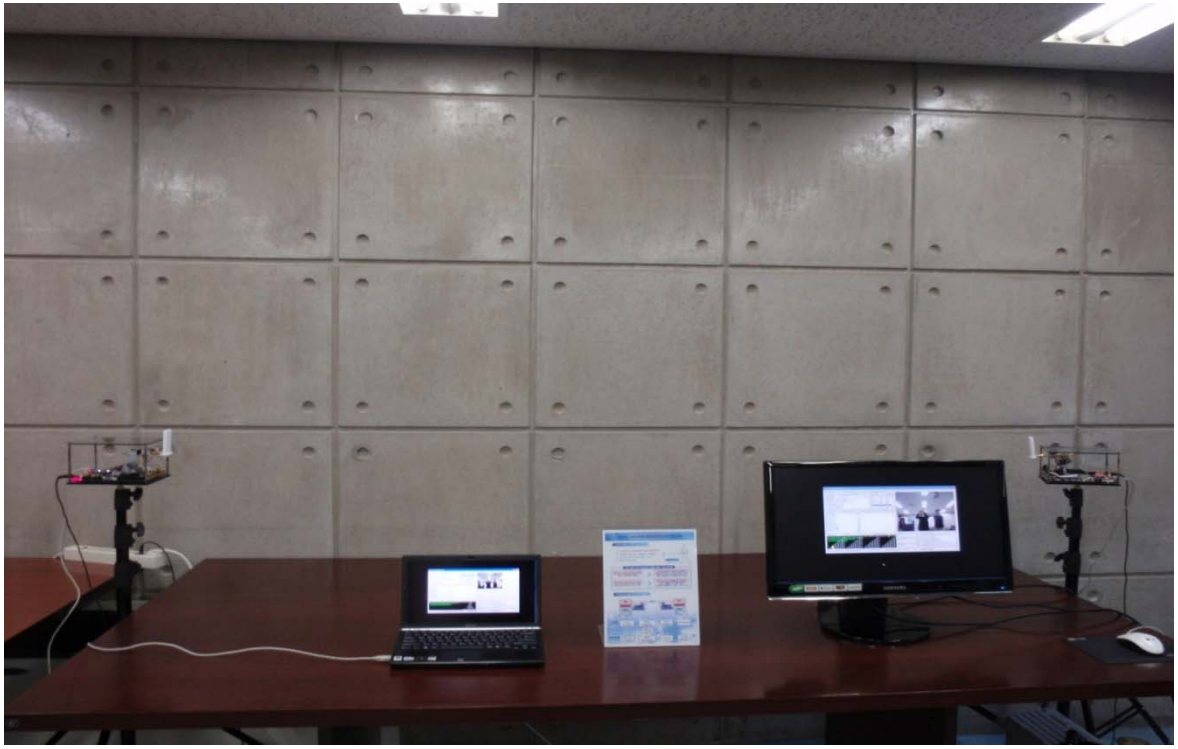
System Setup

- BC-GPPM: FPGA level verification
- Scalable Data Rate: 6 modes up to 10Mbps



Demonstration

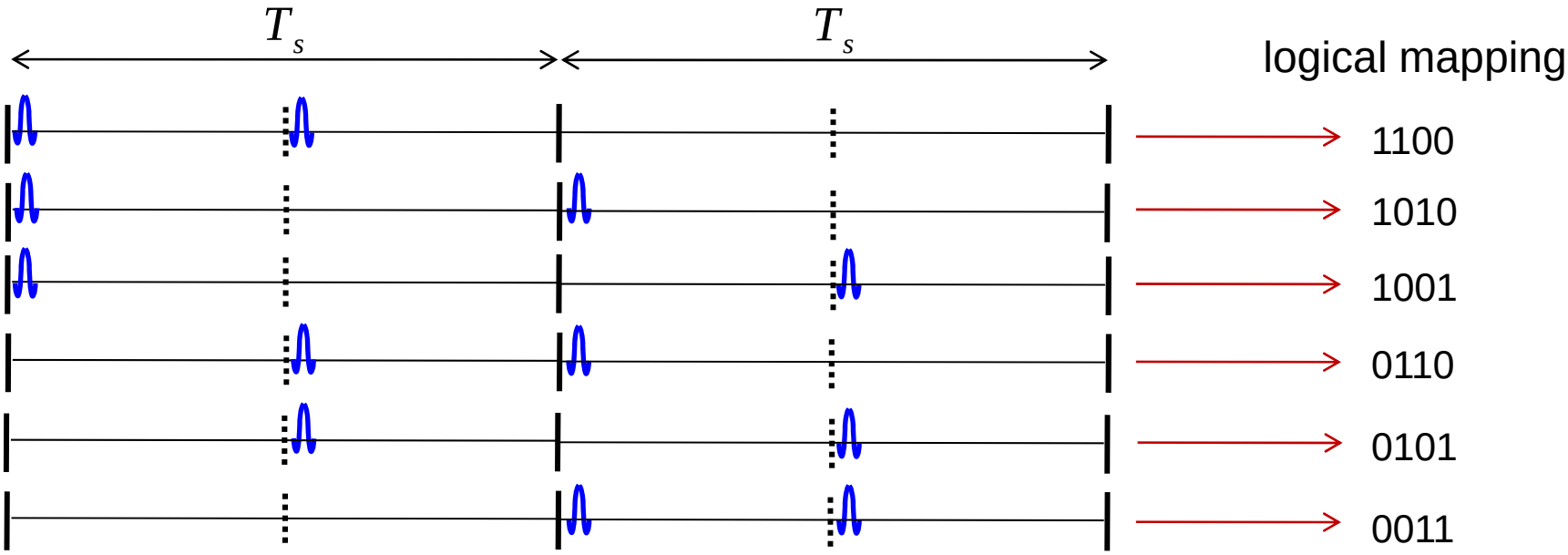
- Real-time webcam image transmission with 10Mbps data rate



Implementation of BCGPPM and PPM

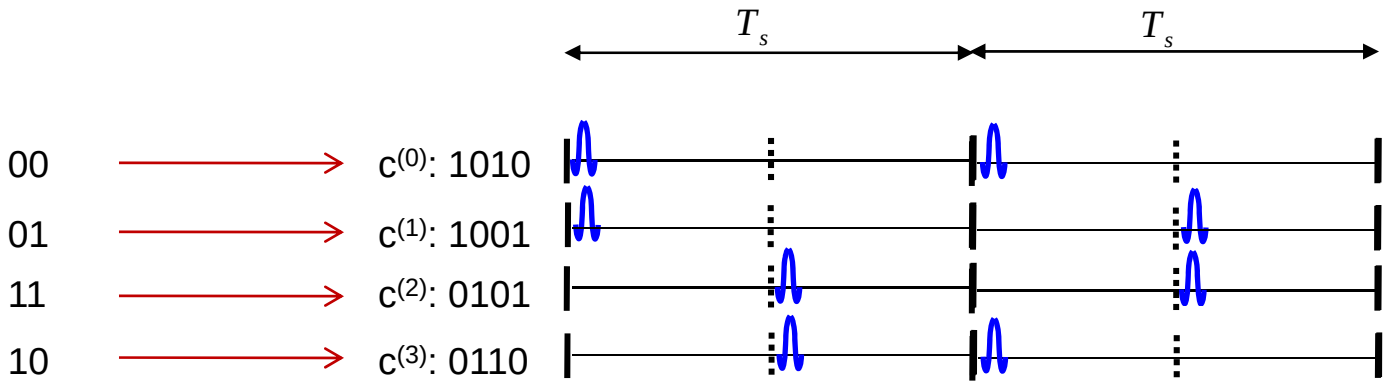
Implementation of BCGPPM and PPM

- When transmitting a number of bits together?
  - For example: 2-bit transmission together
  - Instead of choosing 1 pulse position among 4 slots as in 4-ary PPM, what if 2 pulse positions are selected among 4 slots to transmit 2 bits?
  - Then, total ${}_4C_2=6$ cases are occurred



Implementation of BCGPPM and PPM

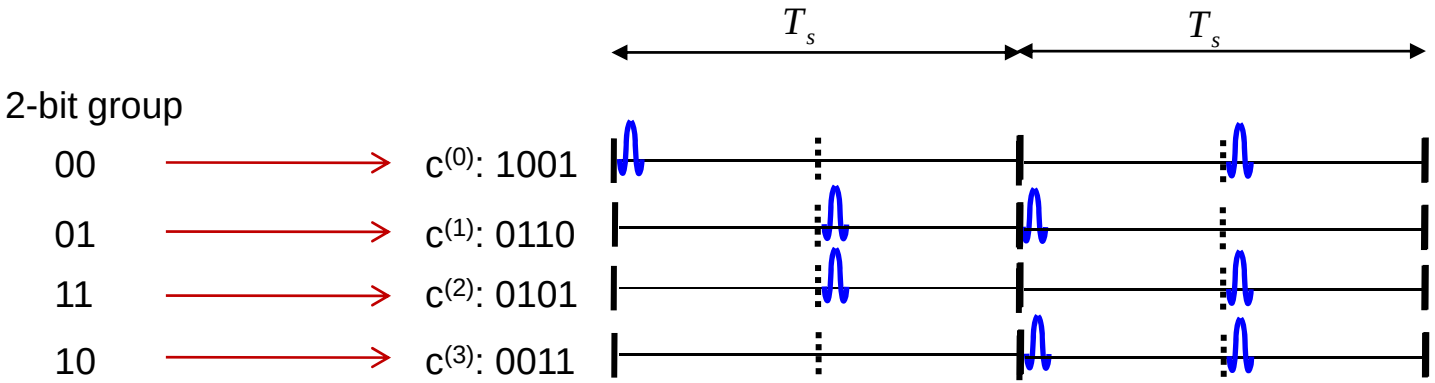
- How to choose 4 cases (for 2-bit transmit)?
  - Selection of {1010,1001,0110,0101} gives a simple 2-ary PPM scheme, but those are not optimized in the sense of error correction.



[Simple 2-ary PPM]

Implementation of BCGPPM and PPM

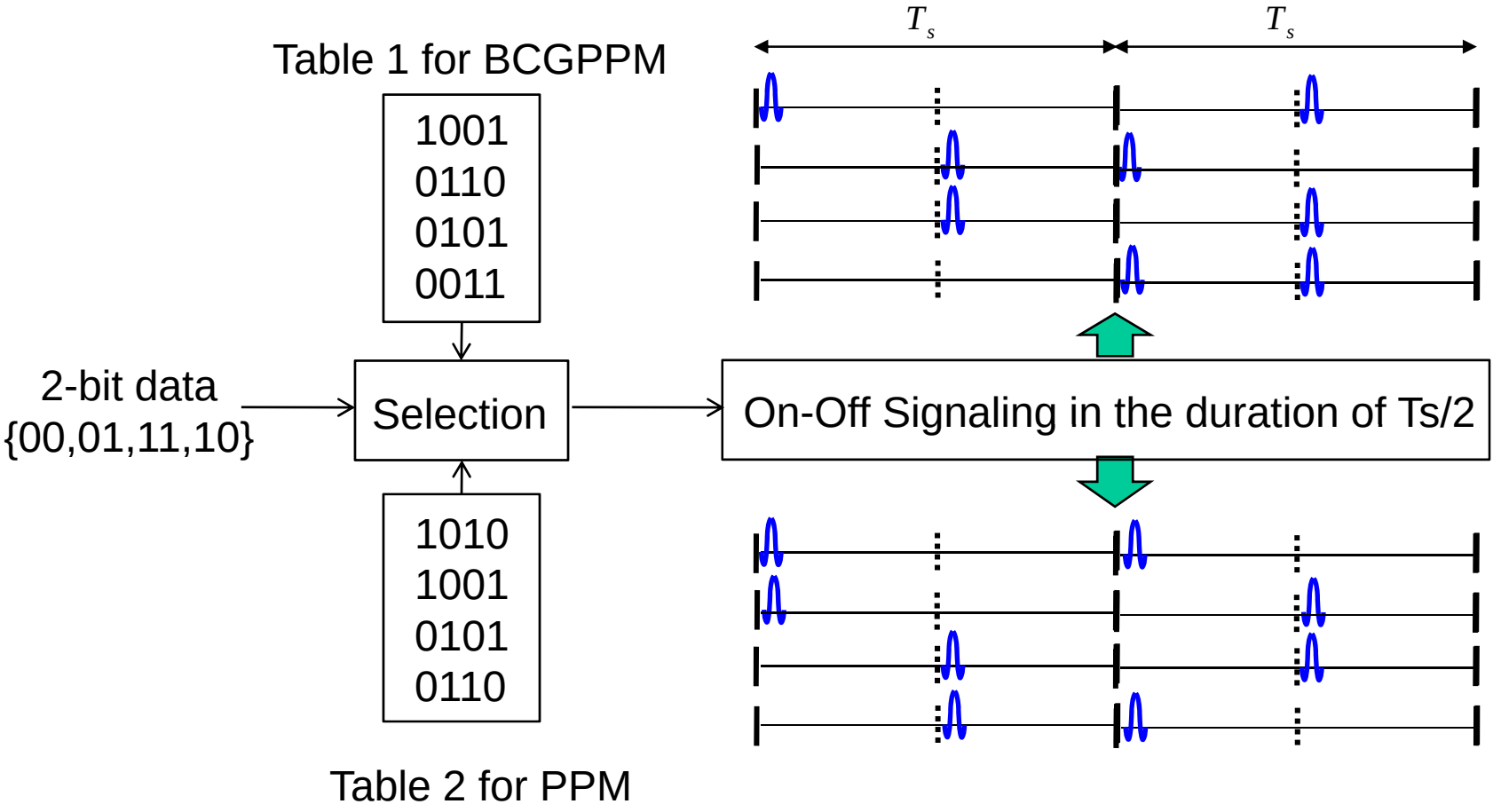
- How to choose 4 cases (for 2-bit transmit)?
  - Selection of C={0011,0101,0110,1001} which can maximize the minimum Hamming distance among 6 cases gives BC-GPPM and it has error correction capability.



[BC-GPPM]

Implementation of BCGPPM and PPM

- We have two tables at the transmitter



Implementation of BCGPPM and PPM

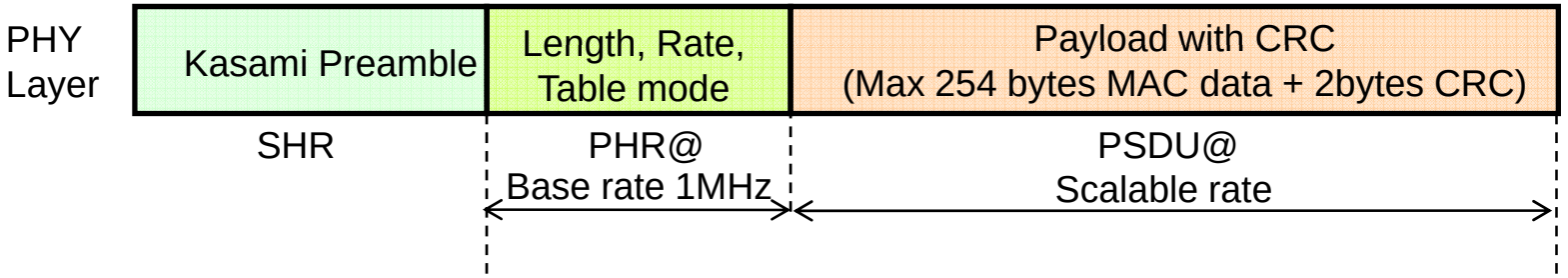
- At the receiver
  - BCGPPM mode
    - BCGPPM detection scheme with error correction is used
  - PPM mode
    - Normal PPM detection scheme is used

Implementation of BCGPPM and PPM

- For 6-bit group transmission?
  - We also construct two tables for BCGPPM and PPM
  - Each table has 64 cases with length 12

Scalable Data Rate

- PHY data rate is same for BCGPPM and PPM



Mod-Type	Chip rate (Fc)	# of chips per symbol (Ncps)	# of chips for pulse-on duration (Ncpo)	Symbol Rate (MHz)	Bit Rate (Mbps)
000	499.2MHz	1024	16	0.49	0.49
001	499.2MHz	512	16	0.98	0.98
010	499.2MHz	128	16	3.9	3.9
011	499.2MHz	64	16	7.8	7.8
100	499.2MHz	48	16	10.4	10.4