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

Submission Title: [Introduction of Human Body Communication]
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Abstract: [This document presents BAN-related Communication method]

Purpose: [To introduce Communication method for BAN]

Introduction of Human Body Comm.

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Jan.2008

Purpose and Contents

- This document presents the comm. method for the BAN

- Contents
  - Introduction
  - Challenge
  - HBC System Review
  - Summary

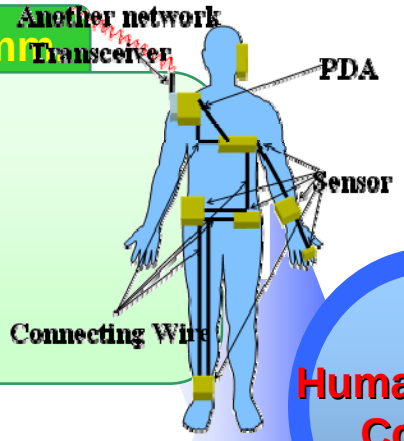
Introduction

What is HBC ?

- BAN Comm. Tech. to transfer information through a human body

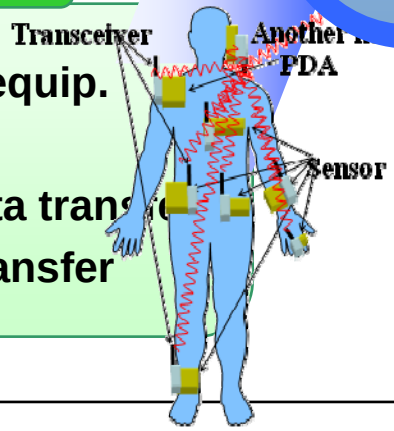
Wireline Comm.

- Heavy wiring
- High S/N ratio
- High data rate
- Uncomfortable

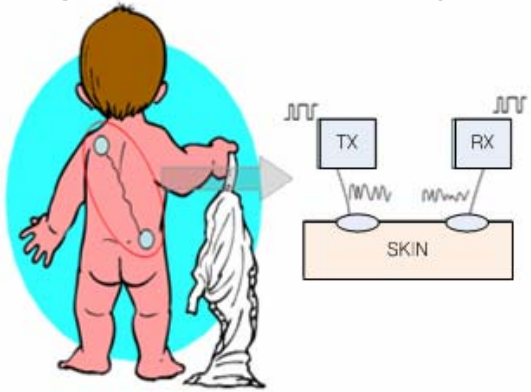


Wireless Comm.

- Heavy wireless equip.
- Uncomfortable
- Low efficient data trans
- Errors in data transfer



Human Body Comm.



- Less expensive
- No wiring
- Small size
- Small power consumption
- High data rates
- High signal to noise ratio

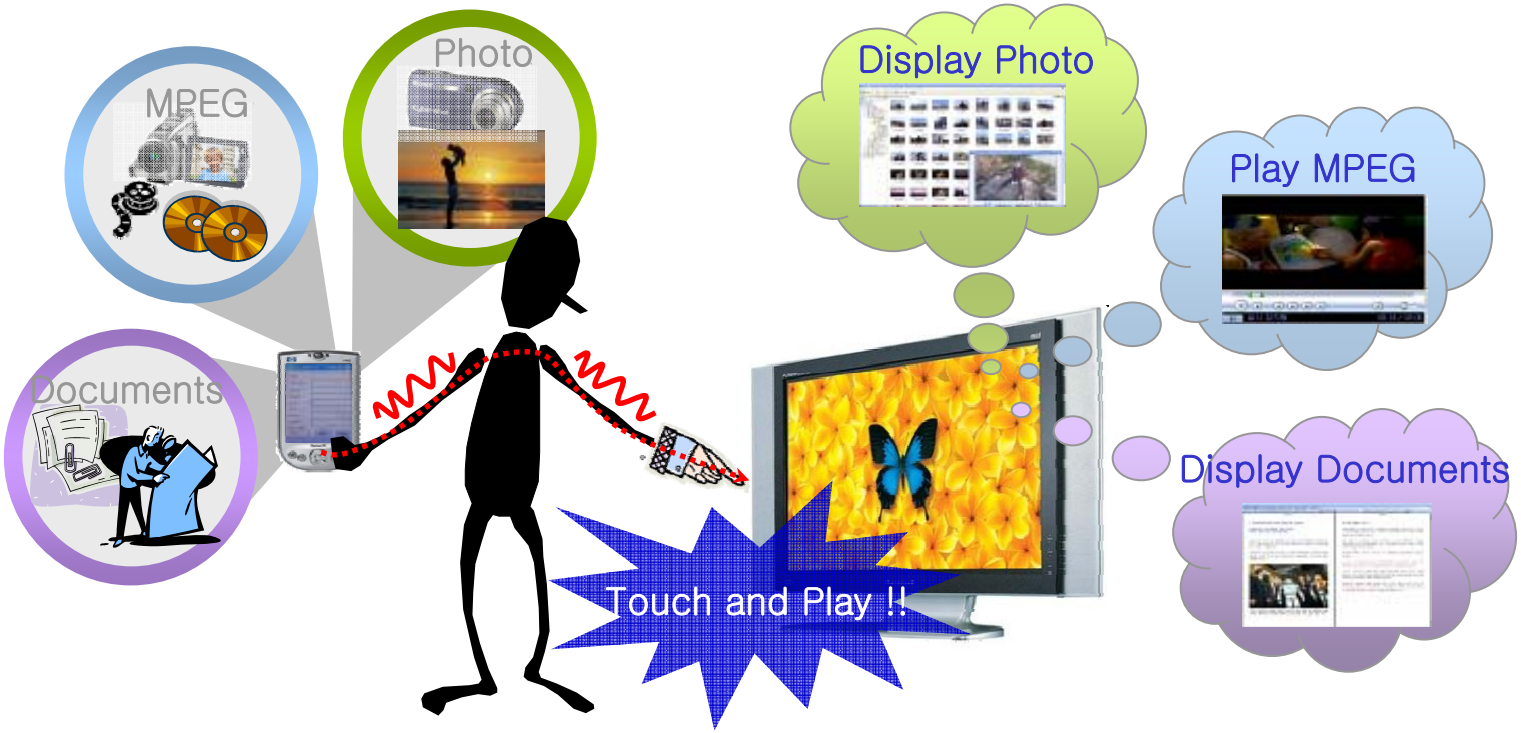
HBC Application

Introduction

- Build up Network among a lot of digital equipments
  - Loaded in Mobile phone, TV, MP3 Player, Digital Camera, Notebook, Printer, Smart Home Network, Endoscope, …
  - Support Ubiquitous Service by intuitive touching

HBC Application

Introduction



Introduction

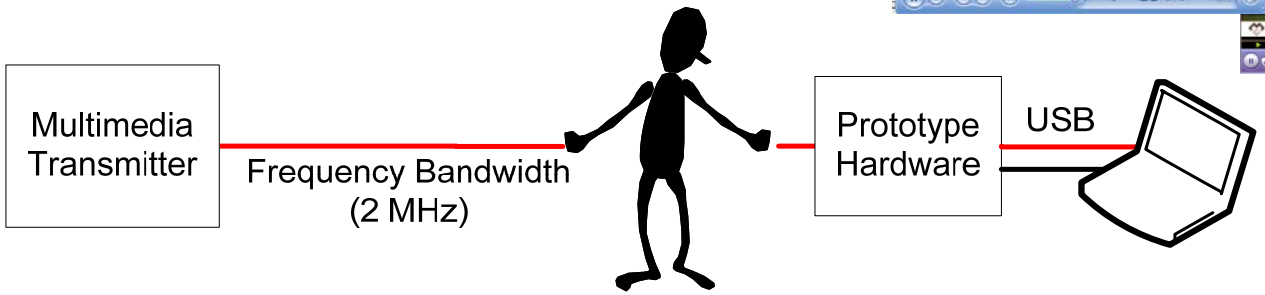
Why HBC ?

- Competition Service
  - Bluetooth, ZigBee, UWB, NFC …
  - Takes long times to setup a call
  - Power Consumption by using RF signaling
- Requirements…
  - Protocol:
    - Context Aware Service, Intuitive Service, Quick Development
    - Expandability, Coexistence with Other Technology
    - Ad hoc Sensor Monitoring
  - PHY
    - Low Power Consumption for Mobile Equipment
    - Support High Data Rate

Challenge

Human Body as a Channel?

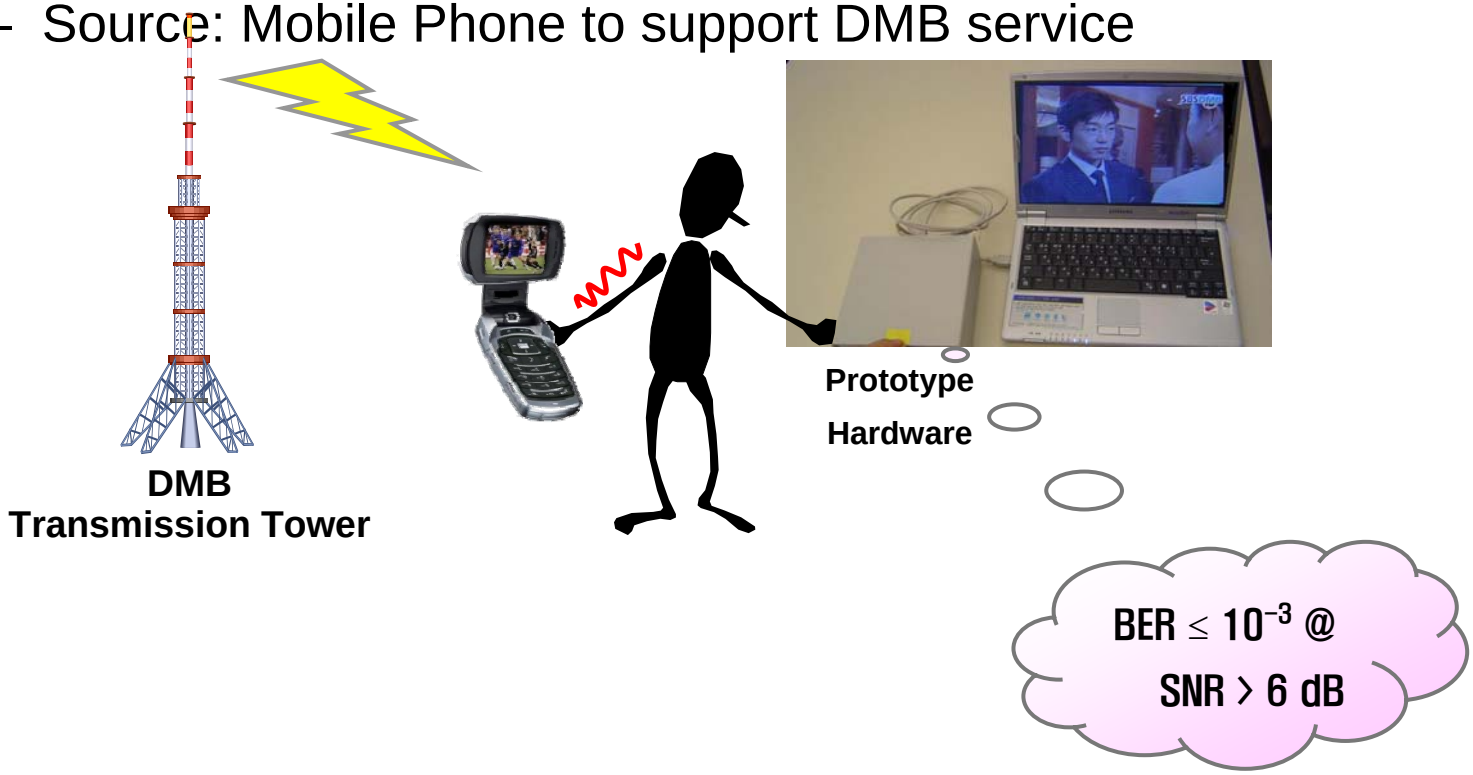
- The First Try…
  - Source: Multimedia Transmiter
  - Connect IF Signal of Multimedia Transmitter to the Human Body
  - Play the received Movie at Notebook
    - Data Rate: 2Mbps
    - BER: 4.7 x 10^{-6} @ SNR = 16.7 dB



Challenge

Human Body as a Channel?

- The Second Try…
  - Source: Mobile Phone to support DMB service

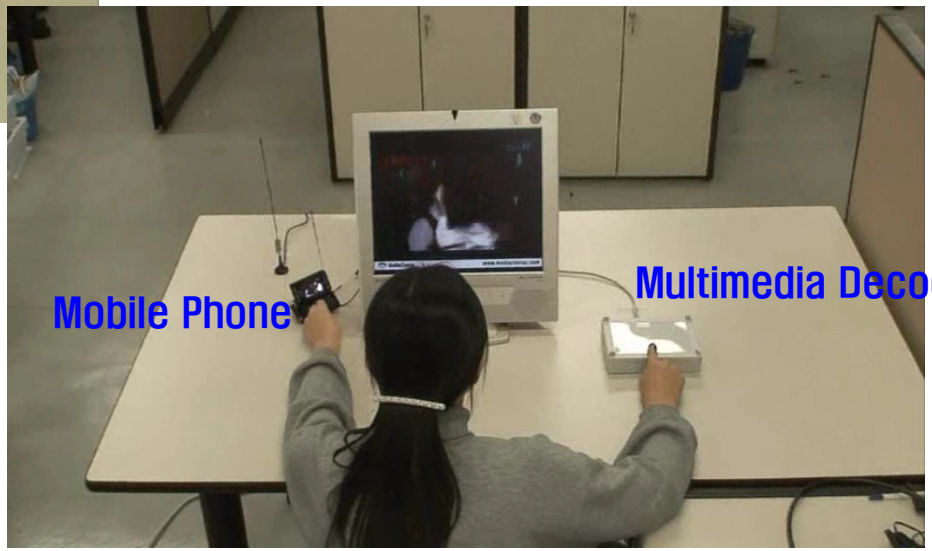


Challenge

Demo

Multimedia Decoder

There is the DMB transmitter under the table.



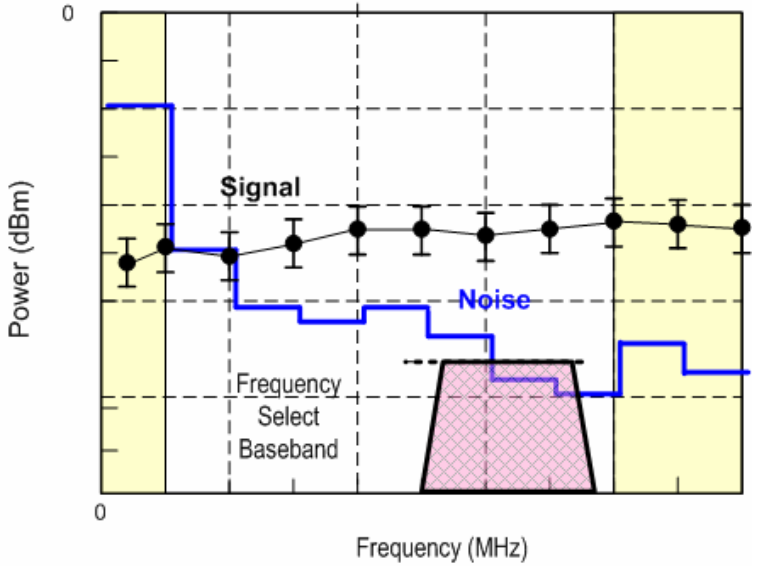
Mobile Phone

Multimedia Decoder

HBC System Review

Characteristics of Signal and Noise

- Noise
  - Heavy amount noise in Low Frequency,
  - Need to escape Low Frequency Band
- Signal
  - Emit Bigger power outside body as Frequency increase
  - Body become antenna
  - Need to specify the effective band



HBC System Review

Characteristics of Walsh 64

Sub-group 0 (W_0~W_{15})

W0	0000000000000000000000000000000000000000000000000000000000000000
W1	0000000000000000000000000000000011111111111111111111111111111111
W2	0000000000000000111111111111111111111111111111110000000000000000
W3	0000000000000000111111111111111100000000000000001111111111111111
W4	0000000011111111111111110000000000000000111111111111111100000000
W5	0000000011111111111111110000000011111111000000000000000011111111
W6	0000000011111111000000001111111111111111000000001111111100000000
W7	0000000011111111000000001111111100000000111111110000000011111111
W8	0000111111110000000011111111000000001111111100000000111111110000
W9	0000111111110000000011111111000011110000000011111111000000001111
W10	0000111111110000111100000000111111110000000011110000111111110000
W11	0000111111110000111100000000111100001111111100001111000000001111
W12	0000111100001111111100001111000000001111000011111111000011110000
W13	0000111100001111111100001111000011110000111100000011111000011111
W14	0000111100001111000011110000111111110000111100001111000011110000
W15	0000111100001111000011110000111100001111000011110000111100001111

Sub-group 1 (W_{16}~W_{31})

W16	0011111000011110000111100001111000011110000111100001111000011110
W17	0011110000111100001111000011110011000011110000111100001111000011
W18	0011110000111100110000111100001111001100001111000011110000111100
W19	0011110000111001100001111000011001111000011110011000011110000111
W20	0011110011000011110000110011110000111100110000111100001100111100
W21	0011110011000011110000110011110011000011110011000011110000110011
W22	0011110011000011001111001100001111000011001111001100001100111100
W23	0011110011000011001111001100001100111100110000110011110011000011
W24	0011001111001100001100111100110000110011110011000011001111001100
W25	0011001111001100001100111100110011000011001111001100001100111001
W26	0011001111001100110000110011111001100001100111001100001111001100
W27	0011001111001100110000110011001100111100110011001100001100111001
W28	0011001100110011110011001100001100110011001111001100110011001100
W29	0011001100110011110011001100110011001100001100111001100001100111
W30	0011001100110011001100110011001111001100110011001100110011001100
W31	0011001100110011001100110011001100110011001100110011001100111001

Sub-group 2 (W_{32}~W_{47})

W32	0110011001100110011001100110011001100110011001100110011001100110
W33	0110011001100110011001100110010100110011001100110011001100110011
W34	0110011001100110100110011001100110011001100110011001101001100110
W35	0110011001100110100110011001100101100110011001100110100110011001
W36	0110011010011001100110010110011001100110100110011001100101100110
W37	0110011010011001100110010110011010011001100110011001100101100101
W38	0110011010011001011001101001100110011001100101100110100110011001
W39	0110011010011001011001101001100101100110011010011001100101100101
W40	0110100110010110011010011001011001101001100101100110100110010110
W41	0110100110010110011010011001011010010110011010011001011001101001
W42	0110100110010110100101100110100110011010011001011010010110011010
W43	0110100110010110100101100110100101100110011001011010010110011001
W44	0110100101101001100101101001011001101001011010011001011010010110
W45	0110100101101001100101101001011010010110100101100101101001101001
W46	0110100101101001011010010110100110010110100101101001011010010110
W47	0110100101101001011010010110100101101001011010010110100101101001

Sub-group 3 (W_{48}~W_{63})

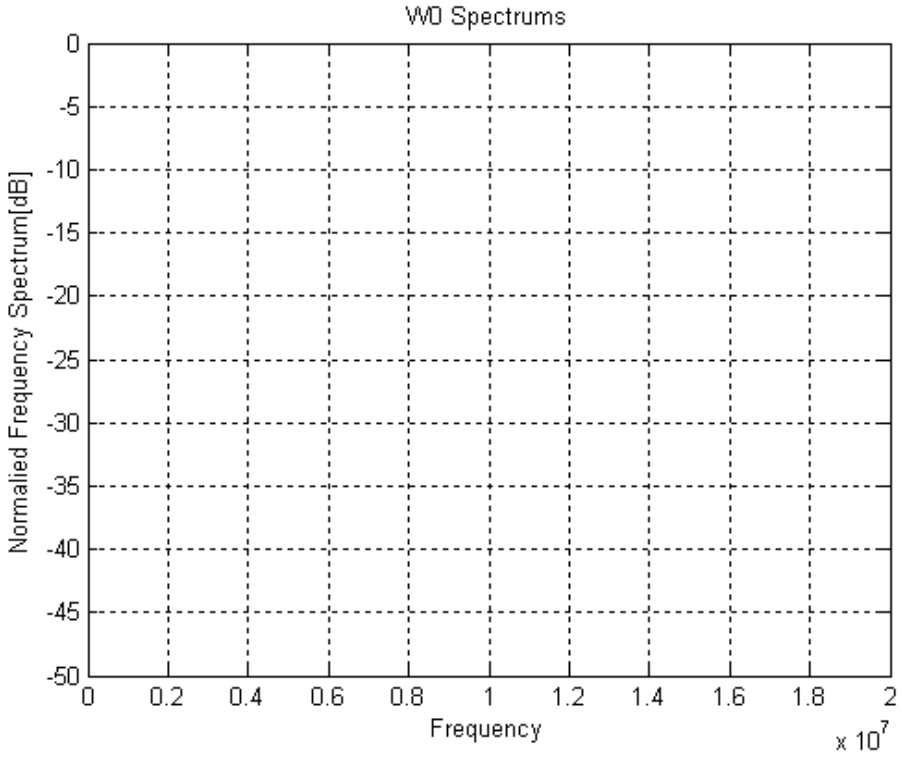
W48	0101101001011010010110100101101001011010010110100101101001011010
W49	0101101001011010010110100101101010100101101001011010010110100101
W50	0101101001011010100101101001011010010110100101101001011010100101
W51	0101101001011010101001011010010101011010010110100101001011010101
W52	0101101010100101101001010110100101101010010110100101010110100101
W53	0101101010100101101001010110101001010110100101101001010110100101
W54	0101101010100101010110101010010110100101011010100101010110100101
W55	0101101010100101010110101001010101101001010110101001010101101001
W56	0101010110101010010101011010010101011010010101101001010101101010
W57	0101010110101010010101011010101010101001010101101010100101010101
W58	0101010110101010101010010101011010010101010101101001010101011010
W59	0101010110101010101010010101010101010110101010101010010101010101
W60	0101010101010101101010101010101001010101010101101010101010101010
W61	0101010101010101101010101010101010101010101010010101010101010101
W62	0101010101010101010101010101011010101010101010101010101010101010
W63	0101010101010101010101010101010101010101010101010101010101010101

Spectrum Analysis → Walsh64_spectrum (Hyperlink)

HBC System Review

Characteristics of Walsh 64

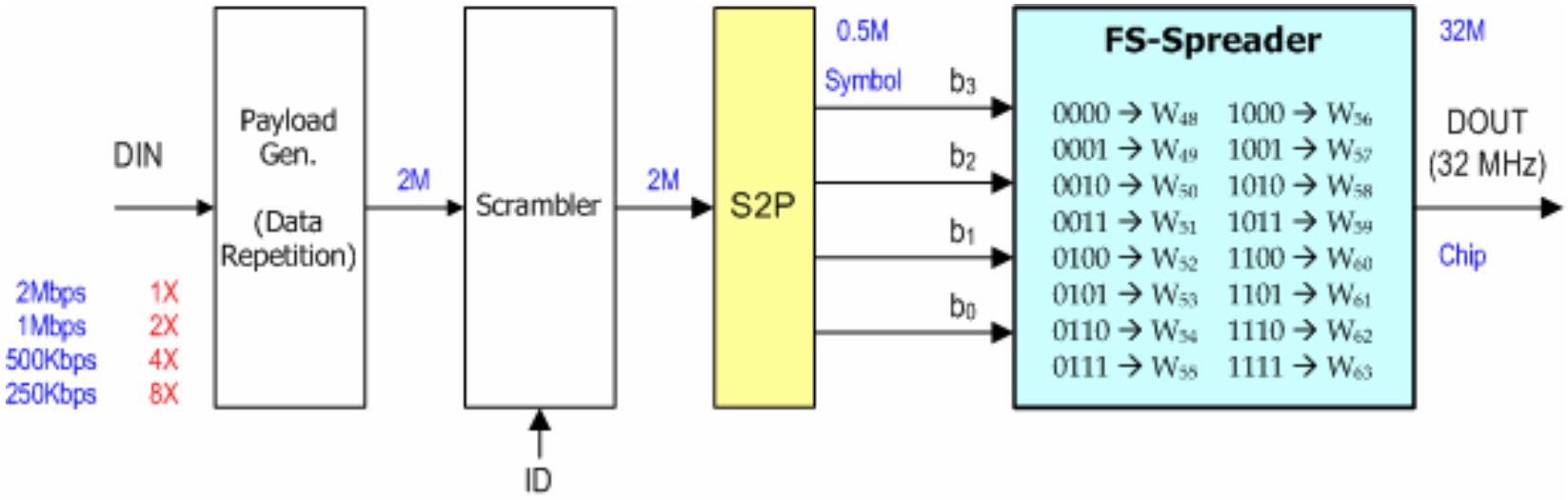
- Each Walsh Code has the major frequency components
- Select the 4th sub-group of Walsh 64



HBC System Review

FS-CDMA

- Method to transfer the baseband signal by using the characteristics of Walsh code
- S2P make 4bit symbols, then the symbols become the index of Walsh code
- FS-Spreader output the one code of the 4th sub-group



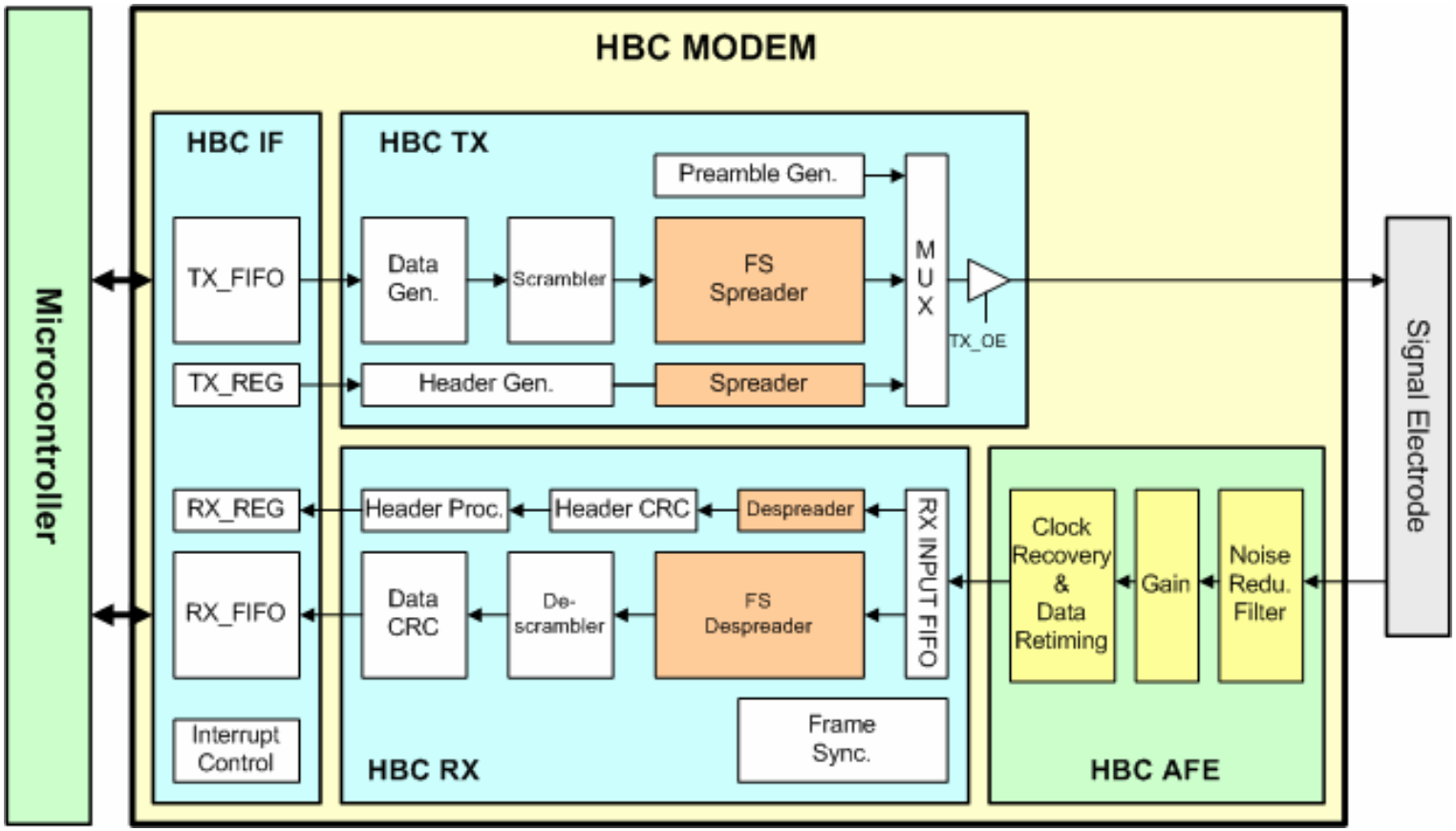
HBC System Review

Physical Parameter

Parameters	Values
Bandwidth	Frequency Selective Baseband (12 MHz ~ 16 MHz)
Comm. Env.	Intra Body Communication
TX Method	Direct Digital Transmission
Duplex	TDD
Frame Length	10 ms
Preamble	$P(z) = z^6+z^5+1$
Scrambling	32bit PRBS generator : $P(z) = z^{32}+z^{31}+ z^{11}+ 1$
Spreading	Frequency Selective 64 chip Walsh Modulation
Data Rate	2 Mbps ~ 250 Kbps

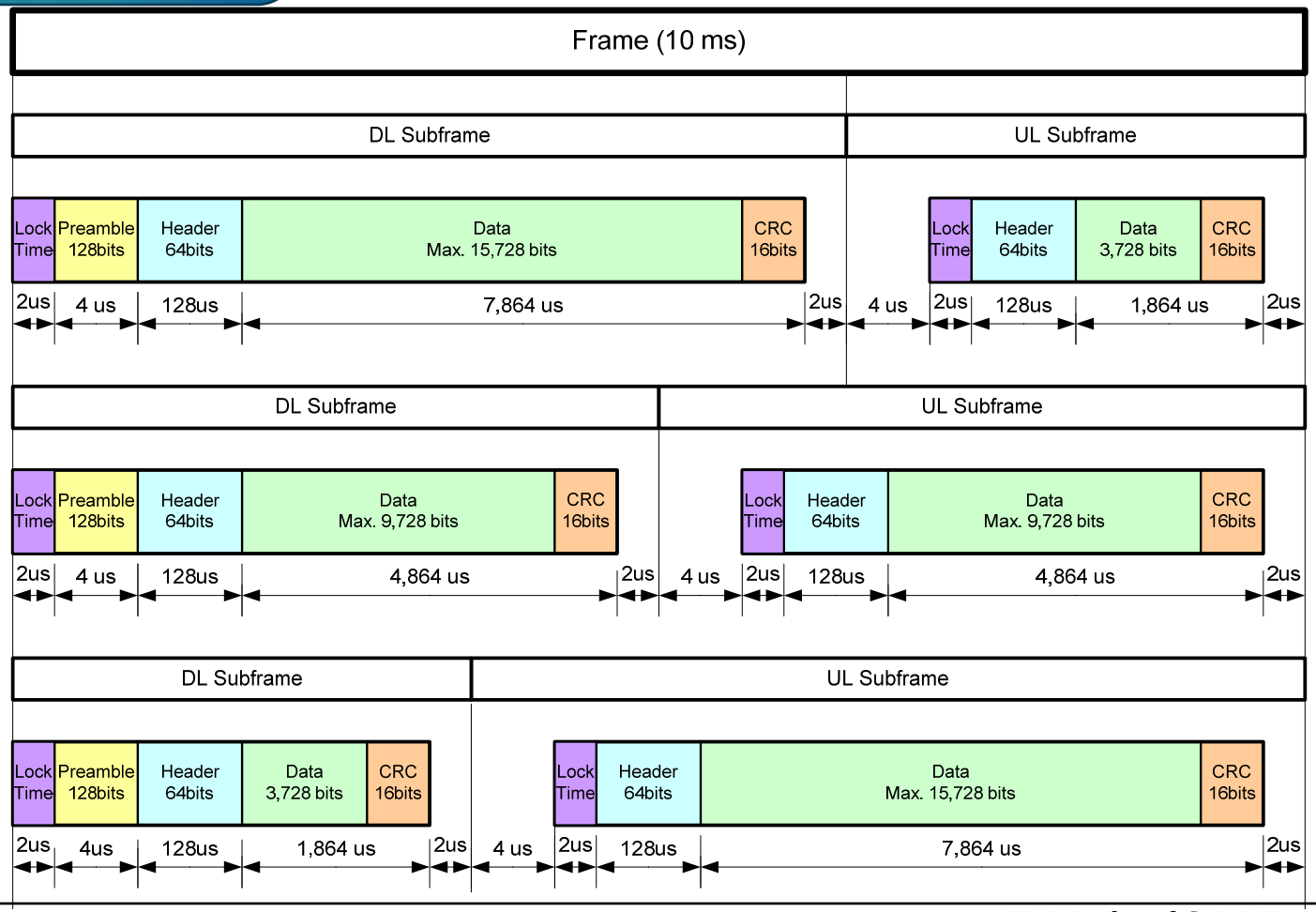
HBC System Review

Block Diagram of HBC PHY



HBC System Review

Frame Structure



HBC System Review

Demo of Video transmission

Currently Status

- 2Mbps HBC Controller
  - Developed the Modules of HBC Controller
  - Obtained BER of 10^{-6}
  - Verified some applications: transfer Video, transfer high quality Picture, transfer photograph from UMPC to Printer, …
  - Developed the chips of HBC Controller, being verified by some applications

- 10Mbps HBC Controller
  - Developed the Modules of HBC Controller
  - Being verified by some applications

- Safety Researches
  - Have been carrying out the safety researches for 3 years based on its standards

Summary

- **What is Human Body Communication?**
  - BAN Comm. Tech. to transmit information through a human body
- **Human body as a channel?**
  - It is possible to transfer digital signals through a human body
- **HBC System Review**
  - Specify the effective Band
  - Use Walsh Code to minimize interference → FS-CDMA
- **Currently Status of HBC System**
  - Developed The 2Mbps modules and chips
  - Developed The 10Mbps modules

Thank you for your attentions!