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]

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Introduction of Human Body Comm.

Hyung-il Park and SungWeon Kang

ETRI

Jan.2008
Purpose and Contents

• This document presents the comm. method for the BAN

• Contents
  – Introduction
  – Challenge
  – HBC System Review
  – Summary
Introduction

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

**What is HBC?**

- **Wireline Comm.**
  - Heavy wiring
  - High S/N ratio
  - High data rate
  - Uncomfortable

- **Wireless Comm.**
  - Heavy wireless equip.
  - Uncomfortable
  - Low efficient data transfer
  - Errors in data transfer

- **Human Body Comm.**
  - Less expensive
  - No wiring
  - Small size
  - Small power consumption
  - High data rates
  - High signal to noise ratio
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
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 Transmitter
  – Connect IF Signal of Multimedia Transmitter to the Human Body
  – Play the received Movie at Notebook
  • Data Rate: 2Mbps
  • BER: $4.7 \times 10^{-6}$ @ SNR = 16.7 dB
Challenge

Human Body as a Channel?

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

BER $\leq 10^{-3}$ @
SNR $> 6$ dB
Challenge

There is the DMB transmitter under the table.
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 (W0~W13)

Sub-group 1 (W16~W31)

Sub-group 2 (W32~W47)

Sub-group 3 (W48~W63)

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

- Method to transfer the baseband signal by using the characteristics of Walsh code
- S2P makes 4bit symbols, then the symbols become the index of Walsh code
- FS-Spreader outputs the one code of the 4th sub-group
# HBC System Review

## Physical Parameter

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

Block Diagram of HBC PHY
HBC System Review

Frame Structure

Frame (10 ms)

<table>
<thead>
<tr>
<th>DL Subframe</th>
<th>UL Subframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preamble 128 bits</td>
<td>Header 64 bits</td>
</tr>
<tr>
<td>4 us</td>
<td>2 us</td>
</tr>
<tr>
<td>128 us</td>
<td>128 us</td>
</tr>
<tr>
<td>7,864 us</td>
<td>1,864 us</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DL Subframe</th>
<th>UL Subframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header 64 bits</td>
<td>Data Max, 9,728 bits</td>
</tr>
<tr>
<td>4,864 us</td>
<td>4,864 us</td>
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<td>Data Max, 15,728 bits</td>
</tr>
<tr>
<td>7,864 us</td>
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</tr>
</tbody>
</table>

Submission

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HBC System Review

Demo of Video transmission

Player

Source
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!