Submission Title: [Frame Synchronization to Combat In/Out Interference in WBAN]

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Re: [Contribution to IEEE 802.15.6 Meeting, March 2008]

Abstract: [Propose frame synchronization method to avoid interference problems]

Purpose: [Proposal]

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Frame Synchronization to Combat In/Out Interference in WBAN

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Issues in WBAN Work Scope

Arrange Requirements
- List up user requirements
- Check realizability
- If no, reduce requirements

Check Stumbling Blocks
- In-body / Out-body Interference
- Multiple MAC or Single MAC ?
- Compromise power & speed
- Medical / Non-medical support

Choose existing technique
- Select good chip
- Enhance antenna matching
- Reduce system size & Good design
- Add process gain for medical use ?

<table>
<thead>
<tr>
<th>APP</th>
<th>Medical</th>
<th>Non-medical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very high QoS</td>
<td>High Speed</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>MAC</th>
<th>Full Single MAC</th>
<th>Hybrid</th>
<th>Dual MAC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Independent</td>
<td>Multiple</td>
<td>MAC</td>
</tr>
<tr>
<td></td>
<td>400MHz ~ Kbps</td>
<td>2.4GHz ~ Mbps</td>
<td>UWB ~ 10Mbps</td>
</tr>
</tbody>
</table>

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Process Gain for Medical Use

![Diagram showing process gain for medical and non-medical use with a difference of approximately 7 dB.]
Major Challenges of WBAN MAC (1)

1. In-body / Out-body Mutual Interference
   - In-body transmission fatally obstructs reception from out-body
   - Conventional techniques (CSMA, LBT) helpless
   - Any solution to overcome the In/Out problem?

2. Multiple PHY & Single MAC
   - Inevitable to use multiple PHYs, yet a single MAC is desired.
   - Any solution to support multiple speeds with a single MAC?
Major Challenges of WBAN MAC (2)

3. Power Consumption vs Speed & Duty Cycle
   - Higher Speed needs Higher power consumption
   - What will be the speed limit to compromise power consumption ?

4. Medical / Non-Medical Dual support
   - Medical : Low speed (~Kbps) ;
     - high QoS ( BER < 10^{-10} )
   - Non Medical : Higher Speed is Better ;
     - Reasonable QoS ( BER < 10^{-3} )
   - Any solution to support dual purpose ?
In-body / Out-body Interference

Search Frequency

Tx : 0dbm

Spurious : -60dbm

Rx : -80dbm

Rx : -80dbm

Tx : 0dbm

O1

O2

I2

I1

I3

Frequency

f_{12}

f_{O2}

UWB

60dB

40dB

80dB

In-body / Out-body Interference

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Submission
In / Out Interference

Diagram showing the interaction between different nodes labeled M, I_1, I_2, I_3, O_1, and O_2. The diagram illustrates the transmission (Tx) and reception (Rx) of signals between these nodes, including interference points marked with red and blue symbols.
Synchronized Frames

Unified Frame

M

I_1

I_2

I_3

O_1

O_2

submission
Synchronized (Super-)Frame

- Frame
- Super-Frame

Control Packet

- User Packet #1
- User Packet #2
- …
- User Packet #n

- Sync Pattern
- Frequency Set
- Direction (Tx or Rx)
- Control Data
- Frame Type

- Sync Pattern (?)
- Frequency (?)
- Packet Type
- User Data (Payload)
- Process Gain
WBAN Selection Process

Start

Choose PHY

In/Out Problem?

yes

Syn Uni Frame

Single MAC?

yes

no

Compromise Speed?

yes

Medical Non-medical Dual Use?

no

Add Process Gain

Stop

no

Multi MAC
Conclusion

- In-body / Out-body Interference is fatal in WBAN.

- MAC with Synchronized Frames can solve the In/Out Problem.

- Synchronized frames may also facilitate multiple payload speeds with a novel control packet design
  - Thus realizing a single MAC with multiple PHY

- Synchronized frames for both In/Out Interference Avoidance and Multiple Speeds