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

Submission Title: [NICT-YNU-Meiji Wideband PHY Proposal]

Date Submitted: [14 July 2009]

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Abstract: [The presentation shows a NICT-YNU-Meiji U. wideband PHY proposal based on IR-UWB.]

Purpose: [Call for participation for a common wideband architecture for on-body BANs.]

NICT-YNU-Meiji Wideband PHY Proposal

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Merged UWB PHY Features

Baseline Topic	*NICT*
Coherent and non-coherent transceivers.	Non-coherent is mandatory. Coherent is used to increase QoS and/or data rate in heavy delay spread scenarios.
Band plan	Same as IEEE 802.15.4a
Data rate scalability	100 kbps to 10 Mbps
Mandatory data rate	1 Mbps
Preamble	PBTS (usable for coherent and non-coherent architectures)
Channel model for evaluation	CM3 and CM4
Pulse shape	TBD (include chirp and other pulse shapes)
Modulation	BPM and DMPSK
Error control mechanism	Systematic RS(63,55). Hybrid ARQ for medical.

Motivation

We present a common Wideband PHY proposal for BANs.

- In order to guarantee quality of service of BAN applications in the wideband regime, coherent and non-coherent transceiver architectures are contemplated.
- As the data rate scales up, the signaling scheme faces strong ISI.
- Specifically, non-coherent architectures might fail to operate.
- On the other hand, non-coherent systems are more sensitive to MUI, NBI, co-channel and intra-channel interference than coherence systems.
- Thus, for high data rate or high QoS applications, coherent or differentially coherent architectures are preferable.
- We aim to harmonize coherent and non-coherent architectures.

Motivation

The systems' principles, parameters and performance have been presented already [1][2][3][4].

In order to harmonize coherent and non-coherent architectures:

- The idea is to incorporate BPM and MPSK symbols into the transmitting signal:

$$x(t) = \sum_m c_m \, w(t - g_m T_{BPM} - mT_{sym})$$

- where c_m is the MPSK symbol and g_m is the BPM symbol.

Motivation

- The basis function $w(t)$ can be a burst of short pulses or a short sequence of chirp waveforms.

$$x(t) = \sum_m c_m \, w(t - g_m T_{BPM} - m T_{sym})$$

$$w(t) = \begin{cases} \displaystyle\sum_{n=0}^{N_{cpb}-1} d_{m,n} \, p(t - nT_c) & \text{short pulse shape} \\ \displaystyle\sum_{n=0}^{N_c-1} d_{m,n} \, s(t - nT_c) & \text{chirp pulse shape} \end{cases}$$

Short Pulse Shape Option

$$x(t) = \sum_m c_m \sum_{n=0}^{Ncpb-1} d_{m,n}\, p(t - g_m T_{BPM} - nT_c - mT_{sym})$$

- A burst of N_{cpb} consecutive pulses with duration $T_{burst} = N_{cpb}T_c$ is transmitted.
- 1st bit of information is used for BPM (seen by coherent and non-coherent receivers).
- 2nd bit of information is used for DBPSK (seen by coherent receivers only).
- Moreover, $T_c = 1/\text{PRF}$, mean PRF=N_{cpb}/T_{sym}, $T_{BPM} = T_{sym}/2$.
- N_{burst} is an integer number of bursts in a symbol duration: $T_{sym} = N_{burst}T_{burst}$

Short Pulse Shape Option

- The UWB PHY parameters for the short pulse mode are given in Table 1 and the UWB PHY symbol structure is illustrated in Figure 1

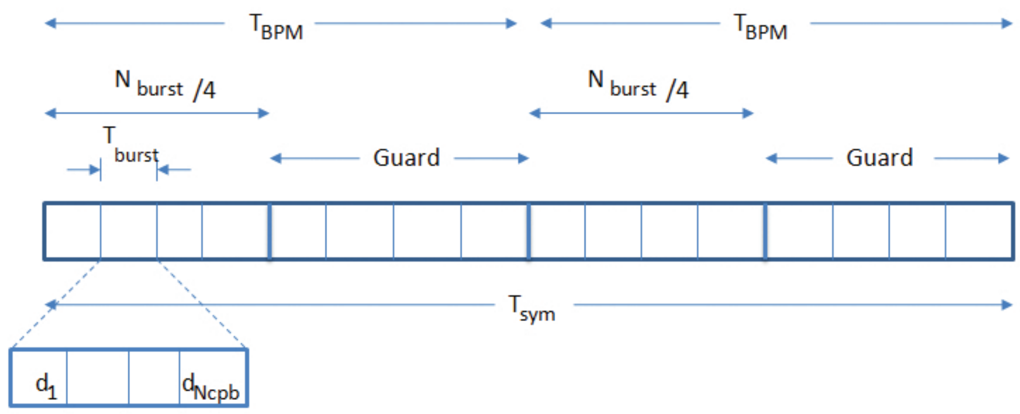


Figure 1: *UWB PHY symbol structure for the short pulse shape option.*

Short Pulse Shape Option

Table 1: UWB PHY parameters for short pulse mode

PRF (MHz)	Bursts per symbol, Nburst	Chips per burst, Ncpb	Burst duration Tburst (nsec)	Symbol duration Tsym (nsec)	Symbol rate Rs (MHz)	RS coding rate	Bit rate Rb (Mbps)	mean PRF (MHz)
499.2	32	128	256.41	8205.13	0.12	0.87	0.1044	15.6
499.2	32	16	32.05	1025.64	0.98	0.87	0.8526	15.6
499.2	32	2	4.01	128.21	7.8	0.87	6.786	15.6
499.2	32	1	2	64.10	15.6	0.87	13.57	15.6

Long Pulse Shape Option

$$x(t) = \sum_{m} c_m \sum_{n=0}^{Nc-1} d_{m,n}\, s(t - g_m T_{BPM} - nT_c - mT_{sym})$$

- A burst contains a long pulse (chirp) waveform with duration T_{burst}.
- A bit of information might be used for BPM (seen by non-coherent receivers only) ($c_m = 1$).
- A bit of information might be used for DMPSK (seen by coherent receivers only) ($g_m = 0$).
- Moreover, $T_c = 1/\text{PRF}$, mean PRF=N_c/T_{sym}, $T_{BPM} = T_{sym}/2$ and $T_c >> T_{burst}$.
- N_{burst} is an integer number of bursts in a symbol duration: $T_{sym} = N_{burst}T_{burst}$

Long Pulse Shape Option

- The UWB PHY parameters for the long pulse mode are given in Table 2 and the UWB PHY symbol structure is illustrated in Figure 2.
- Notice that under this format, there is not ISI for differentially coherent architectures at any data rate even in CM4 (worst case scenario).

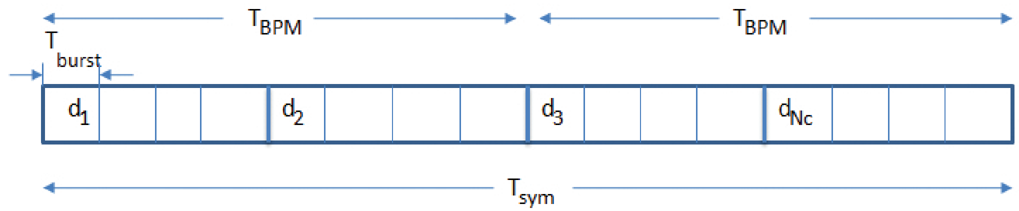


Figure 2: *UWB PHY symbol structure for the long (chirp) pulse shape option.*

Long Pulse Shape Option

Table 2: UWB PHY parameters for long pulse mode (chirp)

PRF (MHz)	Nburst[1]	Nc[2]	Tburst [3] (nsec)	Tsym[4] (nsec)	Symbol rate Rs (Msps)	RS coding rate	Mod.	Bit rate Rb (Mbps)	Mod.	Bit rate (Mbps)	mean PRF (MHz)
0.9804	16	8	64	8160	0.122	0.87	DBPSK	0.1061	BPM	0.1061	0.9804
0.9804	16	4	64	4080	0.2451	0.87	DBPSK	0.2132	BPM	0.2132	0.9804
0.9804	16	2	64	2040	0.4902	0.87	DBPSK	0.4264	BPM	0.4264	0.9804
0.9804	16	1	64	1020	0.9803	0.87	DBPSK	0.8528	BPM	0.8528	0.9804
0.9804	16	1	64	1020	0.9803	0.87	DQPSK	1.705	BPM	0.8528	0.9804
1.9531	16	1	32	512	1.9531	0.87	DBPSK	1.7	BPM	1.7	1.9531
1.9531	16	1	32	512	1.9531	0.87	DQPSK	3.4	BPM	1.7	1.9531
3.9062	16	1	16	256	3.9062	0.87	DQPSK	6.8	BPM	3.4	3.9062
5.2083	16	1	12	192	5.2083	0.87	DQPSK	9.06	BPM	4.53	5.2083

[1] Bursts per symbol.

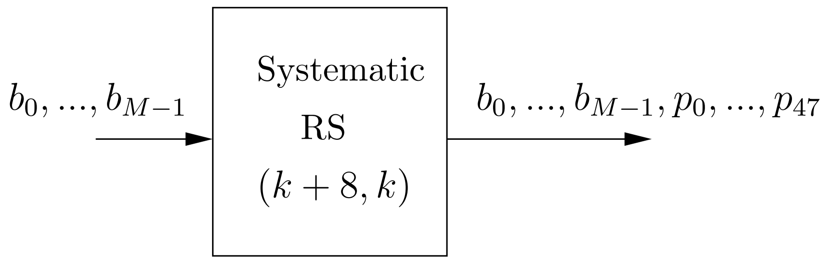
[2] Chips per symbol.

[3] Burst (chirp) duration.

[4] Symbol duration.

Channel coding

- A systematic RS(63,55) over GF(2^6) with irreducible polynomial $1 + x + x^6$ is suggested.
- This encoding scheme appends 48 parity bits to a block of M systematic (or information) bits (RS rate=0.87)
- Hence, decoding is optional at the receiver (in uncoded schemes, receivers just ignore parity bits)



References

[1] I. Dotlić, R. Kohno, "NICT PHY Solution: Part 1: Chirp Pulse Based IR-UWB Physical Layer", IEEE 15-09-0354-01-0006.

[2] M. Hernandez, R. Kohno, "NICT's Wideband PHY Proposal Part 2: IR-UWB", IEEE 15-09-0320-00-0006.

[3] T. Ikegami, "Meiji University UWB PHY Proposal for Body Area Network", IEEE 802.15-0355-01-0006.

[4] R. Kohno, et.al., "YNU PHY and MAC design for WBAN IEEE P802.15.6", IEEE 802.15-09-0353-01-0006.