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

Submission Title: [Coexistence of UWB-BANs with other Wireless Systems]

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Abstract: [The presentation shows some preliminary results on the coexistence of UWB-BAN devices with other wireless systems.]

Purpose: [Identifying when UWB-devices represent a serious degradation in performance sensitivity of other wireless systems.]

Coexistence of UWB-BANs with other Wireless Systems

NICT, Japan

Motivation

UWB as a potential candidate for on-body communications:

- *Low implementation complexity (critical for low power consumption)*
- *Low transmitting power (safety and low interference)*
- *It might allow bit rate scalability from LDR to HDR*

It is important to address the interference caused by/to UWB devices in order to guarantee not conflicting coexistence with other licensed or unlicensed wireless systems.

Motivation

Some results on the coexistence between UWB systems and existing wireless systems can be found in the literature and regulatory forums.

- *Caveat*: assumptions might give misleading conclusions, like UWB devices are assumed uncontrolled radiators transmitting 100% of the time at maximum power.

Victim terminals: FWA or WLL, PP, UMTS, WiMax.

Scenario

UWB devices are located indoor forming a hot spot

- those are placed at random on-body and from coordinator (on-body) to gateway.

Interference is evaluated taking into account:

- architecture (signal model), possible power control, traffic characteristics (activity factor) and superposition of UWB signals.

Interference Limits

An adopt criterion of coexistence (acceptable level of interference) is that victim operators accept r dB degradation in receiver sensitivity:

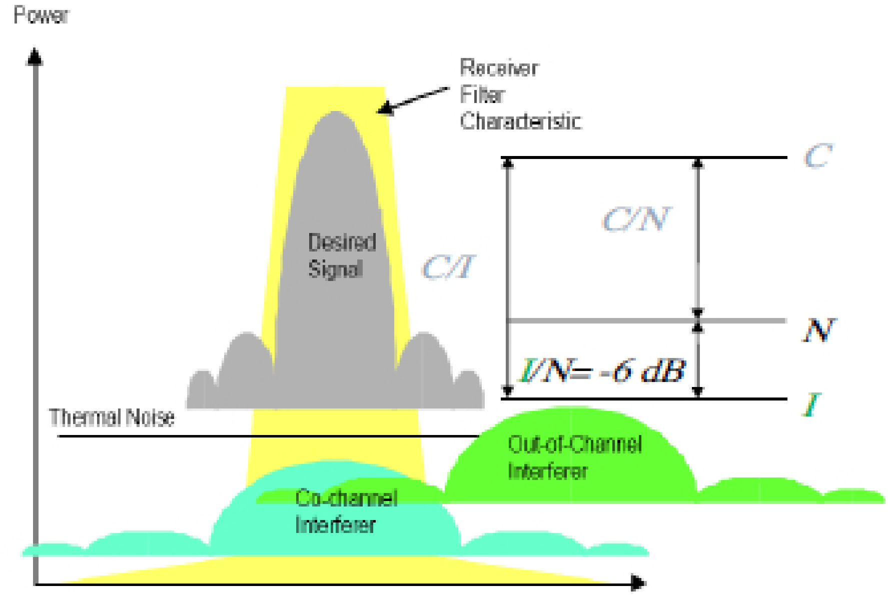
$$\left.\frac{C}{N}\right|_{\text{dB}} - \left.\frac{C}{N+I}\right|_{\text{dB}} = r \text{ dB}$$

$$\frac{N+I}{N} = 10^{r/10}$$

- $r = 1$ dB is chosen as reference and according to ITU Recommendation F.758-2 (long-term interference to fixed services), when considering interference from secondary services and unwanted emissions.
- This is equivalent to $I/N = -6$ dB.

Interference Limits

$r = 1\,\mathrm{dB}$ or $I/N = -6\,\mathrm{dB}$



Interference Limits

The victim terminal's thermal noise is given by

$$N = -174 \text{ dBm/Hz} + 10 \log_{10}(BW_v) \text{ Hz} + N_f + L_o \text{ (2 dB)}$$

Thus, the maximum allowed interference is given by

$$I_{\text{max}} = N + 10 \log_{10}(10^{r/10} - 1)$$

- I_{max} is the point of departure to ensure conflict-free coexistence.

Interference Limits

System	*Parameters* ($r = 1$ dB)	f_l (GHz)	f_h (GHz)	$I_{\max}$ (dBm)
FWA []	$N_f = 5$ dB $BW_v = 50$ MHz $N_f = 5$ dB $BW_v = 14$ MHz	3.475	3.525	-95.88 -101.4
PP []	$N_f = 6$ dB $BW_v = 50$ MHz	4.4	5.0	-95.87
UMTS []	$N_f = 9$ dB $BW_v = 50$ MHz	2.165	2.170	-101.88
WiMax []	$N_f = 4.6$ dB $BW_v = 3.5$ MHz $N_f = 4.6$ dB $BW_v = 10$ MHz	3.4	3.8	-107.42 -103.27

Interference Computation

Scenario

- UWB devices are located indoor and on-body plus from coordinator (on-body) to gateway, communicating with TDD (uplink).
- UWB antennas with 0 dBi gain.
- Victim terminals are either inside or outside the hot spot.

Signal model

- UWB signal model corresponds to any UWB candidate.
- For the sake of illustration TH-UWB is considered.

Interference Computation

TH-UWB

$$x(t) = \sum_k b_k \, p_k(t - kT)$$

$$p_k(t) = \sum_{n=0}^{N_f - 1} w(t - nT_f - c_{k,n}T_c)$$

- The pulse waveform $w(t)$ is either baseband or passband. So, $x(t)$ is carrier or carrierless.
- The transmitting power of $x(t)$ has to satisfy a regulatory spectral mask. It might change depending on the frequency band, but as worst case scenario a PSD of -41.3 dBm/MHz is considered.

$$Pt = 10 \log_{10} \left(\int_0^\infty |X(f)|^2 \, df \; \cdot 10^{-41.3/10} \right) \tag{1}$$

Interference Computation

- Transmitting antenna and radio-front-end are assumed to introduce negligible distortion.
- Interference capture by a victim terminal is given by

$$Pr_v = 10\,\mathbf{log}_{10}\left(\int_{BW_v} |X(f)|^2\, df \;\; \cdot 10^{-41.3/10}\right)$$

Interference Computation

- **The aggregate interference on a victim terminal**

$$I_{\text{UWB}} = \sum_m Pr_v^m \, \chi_m \, Gr_v \, L(d_m)$$

- χ_m **is the activity factor of the** m**th UWB device. So, traffic can be modeled by different bit rates and activity factors.**

Path loss

The propagation can be either indoor or outdoor, but for the sake of simplicity indoor (BAN) path loss is assumed

$$L(d) = P_0 + n \log_{10}(d/d_0)$$

- $P_0 = 50.5$ **dB,** $n = 7.2$ **and** $d_0 = 0.1$**.**

MCL

A conventional way to deal with coexistence is to compute zones around UWB hot spots, where victim receivers would not exceed a certain level of interference.

- Thus, computing the minimum distance required between a UWB device and a victim receiver to ensure the maximum allowed interference I_{max} is not exceed (MCL).
- Minimum Coupling Loss:

$$MCL = P_t + G_t - L_o + Gr_v - I_{\text{max}}$$

$$\widehat{d} = \arg\min_{d} L(d) \geq MCL$$

MCL

Example

- **As example, $x(t)$ employs a Gaussian pulse and a carrier signal spanning 2 GHz bandwidth around 4–9 GHz.**
- **From Equation 1 computed numerically, $P_t = -10.6$ dBm.**
- **For simplicity $Gr_v = 0$ dBi, and $I_{\max}$ values are taken from the previous Table.**

Preliminary Results

system	I_{max} (dBm)	MCL (dBm)	$L(d)$ (dBm)	d (m)
FWA (50 MHz)	-95.88	83.28	87.85	0.3
FWA (14 MHz)	-101.4	88.8	92.67	0.35
WiMax (3.5 MHz)	-107.82	95.22	99.11	0.43
WiMax (10 MHz)	-103.27	90.67	94.41	0.31

Still a work in progress

To be done: propagation outdoors, power control, computing I_{UWB}, impact of interference from other services to UWB-BAN systems, etc.