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

Submission Title: [Status of Statistical Channel Modeling for 400 MHz and UWB BANs]

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Abstract: [The presentation illustrates the progress of statistical channel models for UWB and 400 MHz.]

Purpose: [The development of statistical channel models for evaluation of different PHY/MAC proposals.]

Status of Statistical Channel Modeling for 400 MHz and UWB BANs

NICT, Japan

Motivation

Channel modeling for BANs is specially challenging

- Channel model must integrate the dynamics of the antennas and bodies.
- The radio wave propagation in BANs is complex to be described analytically.
- The radio channel need to be characterized by empirical results and complex simulations (FDTD).
- Solving Maxwell equations by numerical methods are complex and impractical.

Motivation

Channel modeling for BANs is specially challenging

- From a communications design perspective, Shannon proofed that a statistical channel characterization is enough for design.
- All propagation's phenomena are embedded in a "*simple*" model.
- Moreover, reproducing statistics in a computer is fairly straight forward. Recall the success of the IEEE UWB 4a channel model throughout the World.
- A simple, but not simpler, approximation to characterize and to compare different PHY/MAC approaches. In order to get a sense of what approaches are worth pursuing.

Motivation

Caveats

- The description of physical mechanisms by probabilistic models has some degree of inaccuracy.
- We can control confidence intervals, but it depends on the size of sample population.
- It is highly desirable other Groups engage in measurement campaigns and to release those.

Measurements

Measurements based on the linearity of the channel impulse response

- $$y(t) = \int x(t-\tau)\, h(t,\tau)\, d\tau$$

- and the approximation (quasistatic channel):

$$Y(f) \approx H(f_0, t_0)\, \delta(f - f_0)$$

- then, the radio channel is in terms of S_{21} delivered by a network analyzer
- Complexities of solving Maxwell equations are reduced to an input/output relation.

Measurements

Radio channel parameters

- Large scale fading: path loss under a conventional power decay law.
- Small scale fading: RMS delay spread and power delay profile.
- Introduction of autoregressive spectral estimation for the transfer function.

Model

- UWB

$$h(t,\tau) = \sum_i \alpha_i(t)\,\delta(t-\tau_i(t))$$

- 400 MHz baseband equivalent channel

$$h_b(t,\tau) = \sum_i \alpha_i^b(t)\,\delta(t-\tau_i(t))$$

$$\alpha_i^b(t) = \alpha_i(t)\,e^{-j2\pi f_c \tau_i(t)}$$

- A path loss model (UWB and 400 MHz) was presented in Orlando.

Measurements

Discrete-time (baseband) channel (after subtracting path loss)

- Input waveform bandlimited to W, (baseband equivalent $W/2$).

$$y[m] = \sum_l h_l[m]\, x[m-l]$$

$$h_l[m] = \sum_i \alpha_i[m] \mathrm{sinc}[l - \tau_i[m]W] \;\; ; \;\; l = m - n$$

- $h_l[m]$ is the lth channel tap at time m.

Measurements

Statistical channel model

- $h_l[m]$ taps are measured (an aggregate of multipaths).
- We need: how many taps are necessary, how quickly they change, and much they vary.
- There are mechanisms how to achieve those through statistical fitting and statistical tests.

Caveats

- Time consuming, and requires a large sample population (many measurements).

Propagation around the human body II

Alternative approach

- The dynamics of antenna and human body on the radio propagation are embedded in $H(f, x)$.
- Idea: use autoregressive spectral estimation
- Let $H(f, x)$ be a random process, then
- $H(f_n, x)$ is the realization of an autoregressive process of order p.

$$H(f_n, x) = \sum_{i=1}^{p} a_i \, H(f_{n-i}, x) - V(f_n)$$

$$V(f_n) \sim \mathcal{N}_C(0, \sigma^2) \quad ; \quad \{a_i\} \text{ solutions to Yule-Walker equations}$$

- Thus, the channel frequency response will be identified with p AR parameters.
- The value of p is determined by the AIC on the experimental data.

Propagation around the human body II

Alternative approach

- Then

$$h(t;\tau) = \mathrm{IFFT}(\widehat{H}(f,x)) - PL$$

- Then, it is possible to characterize the power delay profile, amplitude distribution of resolvable multipaths, and correlation between adjacent bins if needed.

Progress

- Currently, I am processing data (distributions fitting and statistical tests).

Comments

It seems new parties started working on BAN channel modeling recently.

It seems there are not reliable BAN channel models (tested and approved) so far.

What is the rush to close channel model proposals by the end of this month then?