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

Submission Title: [A scheme to evaluate PHY performance by computer simulation]

Date Submitted: [September 15, 2006]

Source: [Hiroshi Harada[1], Ryuhei Funada[1], Ming Lei[1], Chang-Soon Choi[1], Shuzo Kato[1], Masamune Takeda[2], Ichihiko Toyoda[3] , Kazuaki Takahashi[4], Kenichi Kawasaki[5] , Hiroyuki Nakase[6]]

Company [NICT[1], Maspro[2], NTT[3], Panasonic[4], SONY[5] , Tohoku University[6]]

Address[1][3-4 Hikari-no-oka, Yokosuka-shi, Kanagawa 239-0847, Japan]

Address[2][Asada, Nissin-shi, Aichi 470-0194, Japan]

Address[3][1-1 Hikari-no-oka, Yokosuka-shi, Kanagawa 239-0847, Japan]

Address[4][4-12-4, Higashi-Shinagawa, Shinagawa-ku, Tokyo 140-8587, Japan]

Address[5][6-7-35 Kita-Shinagawa, Shinagawa-ku, Tokyo 141-0001, Japan]

Address[6][2-1-1 Katahira, Aoba-ku, Sendai-shi, Miyagi 980-8577, Japan]

Voice:[+81-46-847-5074[1], +81-52-802-2220[2], +81-46-859-2366[3] ,+81-3-6710-2029[4], +81-3-5795-7879[5] , +81-22-217-5531[6]]

FAX: [+81-46-847-5440[1], +81-52-802-1210[2], +81-46-855-1497[3] ,+81-3-6710-3915[4], +81-3-5795-7385[5], +81-22-217-5533[6]]

E-Mail:[harada@nict.go.jp[1], funada@nict.go.jp[1], minglei@nict.go.jp[1], cschoi@nict.go.jp[1], shu.kato@nict.go.jp[1], takeda3026@maspro.co.jp[2], toyoda.ichihiko@lab.ntt.co.jp[3], takahashi.kazu@jp.panasonic.com[4], Kenichi.Kawasaki@jp.sony.com[5] , nakase@riec.tohoku.ac.jp[6]]

Re: []

Abstract: [Proposing a simulation scheme and summarizing items to evaluate PHY performance]

Purpose: [To be considered in 15.3c technical requirement by computer simulation]

A Scheme to Evaluate PHY Performance by Computer Simulation

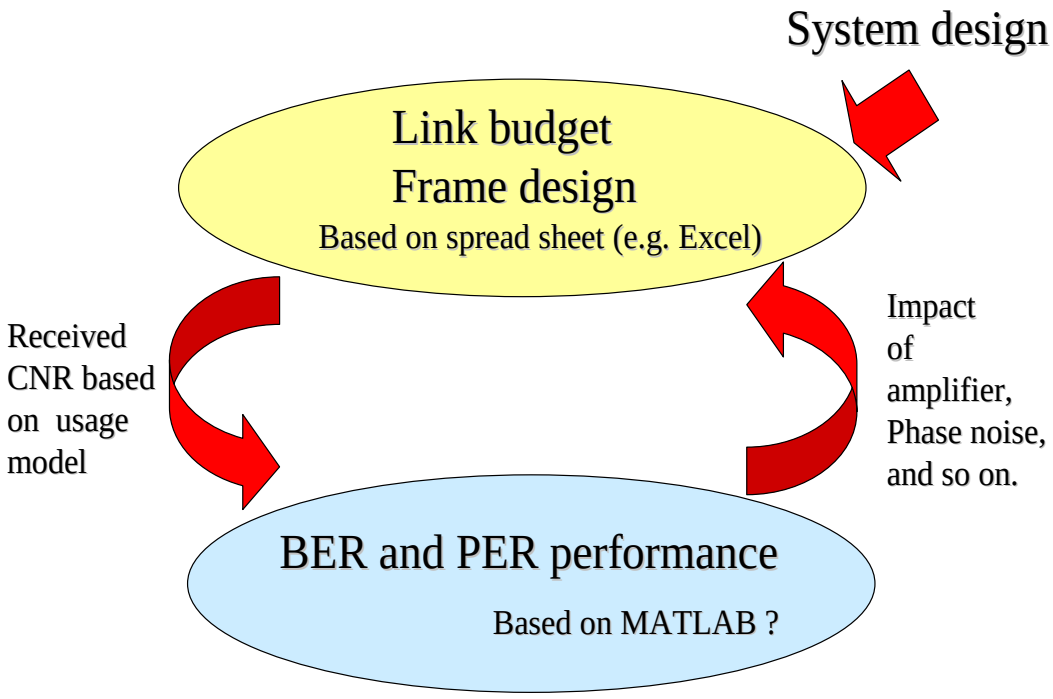
Hiroshi Harada, Ryuhei Funada, Ming Lei,
Chang-Soon Choi, Shuzo Kato (NICT),
Hiroyoshi Konishi (MASPRO), Kazuaki Takahashi (Panasonic),
Ichihiko Toyoda (NTT), Kenichi Kawasaki (Sony)
,and Hiroyuki Nakase (Tohoku University)

Summary of this document

- Propose a scheme to evaluate PHY performance by computer simulation in TG3c
  - Link budget
  - Frame design
  - BER (and/or) PER performance
- Propose parameters to evaluate PHY performance
  - Impact of power amplifier
  - Impact of phase noise
  - Impact of AD/DA converters
- Clarify items described in contributed document that shows PHY performance
- Propose two simulation procedures to reduce simulation time
  - Handling of angles of TX and RX antennas

Propose a scheme to evaluate PHY performance by computer simulation in TG3c

- Two evaluations for system design
  - Calculation of link budget
    - Clarify received CNR when considered usage model discussed in TG3c
  - Frame design
    - Confirm that transmission rate at PHY-SAP satisfies the requirement specified in usage model
- BER and/or PER performance
  - Show CNR v.s. BER/PER
    - Clarify transmission performance at several CNR
    - Clarify transmission impact of power amplifier, phase noise, channel model, coding, and so on
    - How many dB must be gained/reduced to/from link budget when the above impact is considered (feed back to calculation of link budget)



An example of link budget calculation

Distance	1	3	5	m
Carrier bit rate	2			Gbps
TX power	10			dBm
Tx antenna gain	10			dBi
Frequency band	59-66			GHz
Center frequency	62.5			GHz
wavelength	4.8			mm
Path loss	68.35939	77.90182	82.33879	dB
RX Antenna gain	10			dBi
Boltzmann constant	1.38065E-23			
Temperature	300			K
Rx Noise figure	10			dB
Eb/N0	32.45826	22.91583	18.47886	dB
	BPSK	QPSK	DQPSK	
Required Eb/N0 for BER=10^-5	9.5	9.5	12	dB
Required Eb/N0 for BER=10^-12	14	14	16.2	dB

This is an example and the data shown in this sheet is NOT equal to the proposal for PHY model from contributors.

An example of frame design

System Bandwidth (Bt)	7	GHz
Number of channels (Nch)	3	
Maximum band width/channel	2.333333	GHz
M-ary modulation level	2	
Symbol rate	1.6	GHz
Roll off rate (a)	0.35	
Band width	2.16	GHz
PSDU in one packet	2048	byte
PSDU Coding rate	3/4	
PSDU transmission time	6826.667	ns
PSDU data transmission rate	3.2	Gbps
PLCP Header	25	byte
PLCP Coding rate	1/2	
PLCP Header duration	125	ns
PLCP Data transmission rate	3.2	Gbps
PLCP Preamble duration	100	ns
Shared ratio	0.968093	
PSDU transmission rate(PHY-SAP)	2.323422	Gbps

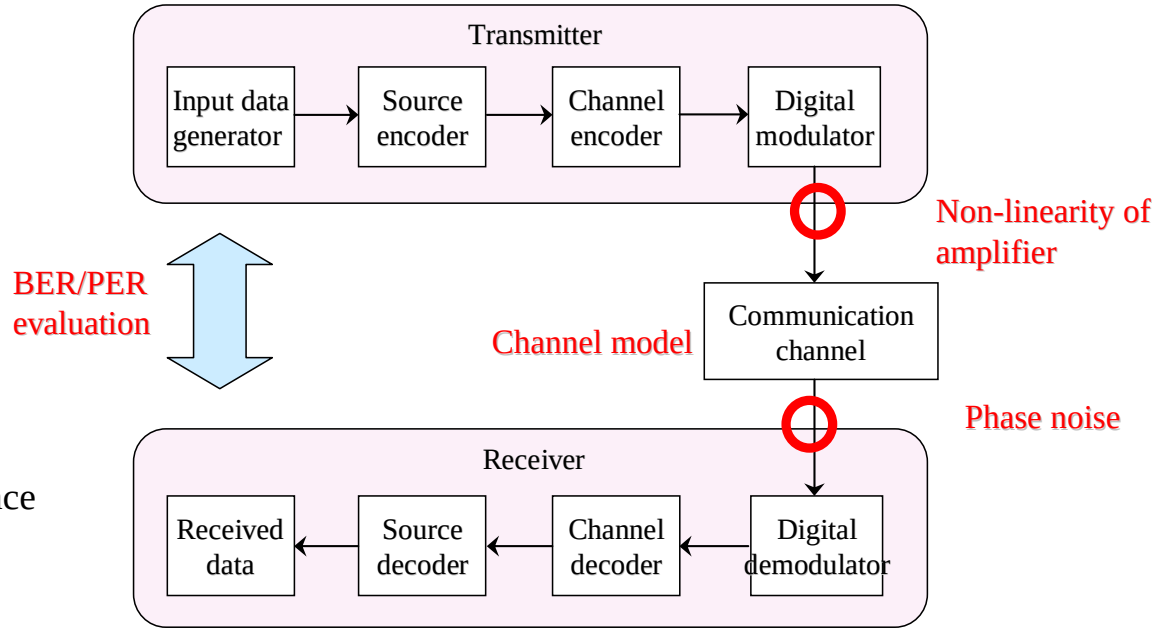
Packet configuration

This is an example and the data shown in this sheet is NOT equal to the proposal for PHY model from contributors.

BER and PER performance by MATLAB

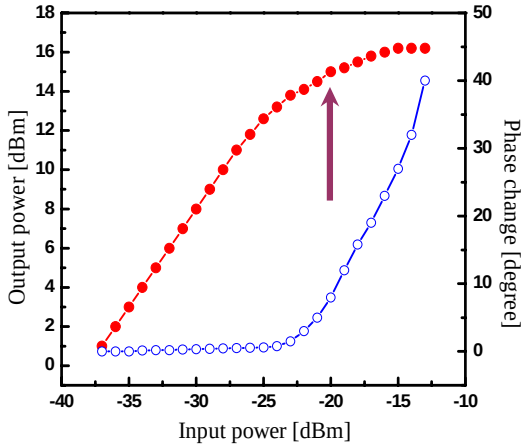
- Functions in the simulation program
  - Data generation
  - Frame (Packet) configuration
  - Modulation
  - Power amplifier
  - Channel
  - Phase noise
  - Demodulation
  - Evaluation
- Evaluation issue
  - Packet synchronization performance
  - BER (dependent on UM)
  - PER (dependent on UM)
  - Interference to adjacent channel
  - Tolerance to interference from adjacent channel

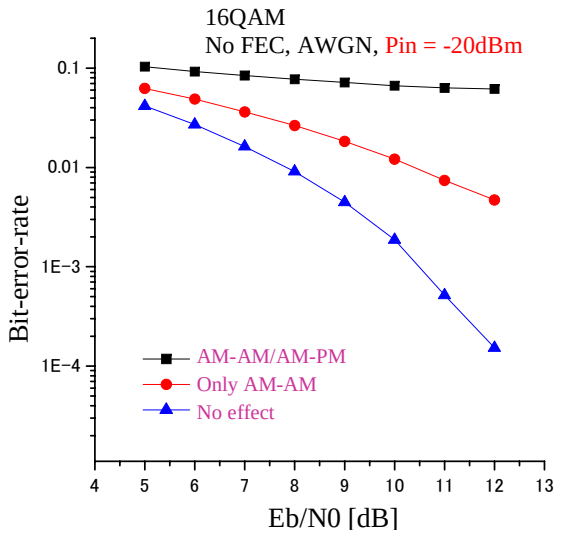
Must be common ?



Propose parameters to evaluate PHY performance (1) Impact of power amplifier (PA)

- PA model
  - System performance of 60GHz WPAN is degraded by PA non linearity
  - Spectrum of 60GHz WPAN is also expanded by non-linearity of PA
  - Not only AM-AM model but also AM-PM must be needed because the degradation by AM-PM characteristics is larger than that by AM-AM.
- To prepare PA model
  - Correct or call for data-sheet of AM-PM performance of PA
  - Based on such sheet, a MATLAB code for the simulation needs to be prepared.

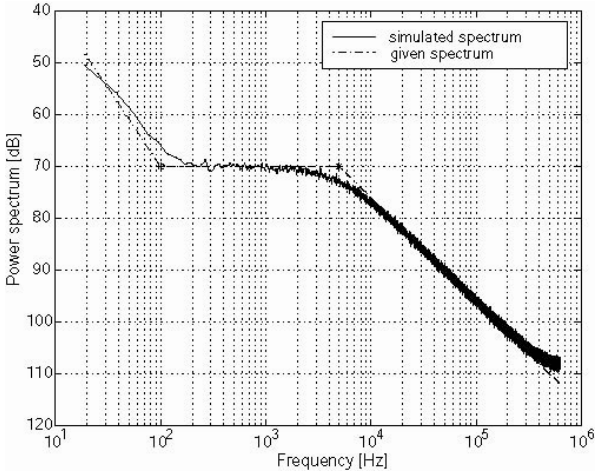


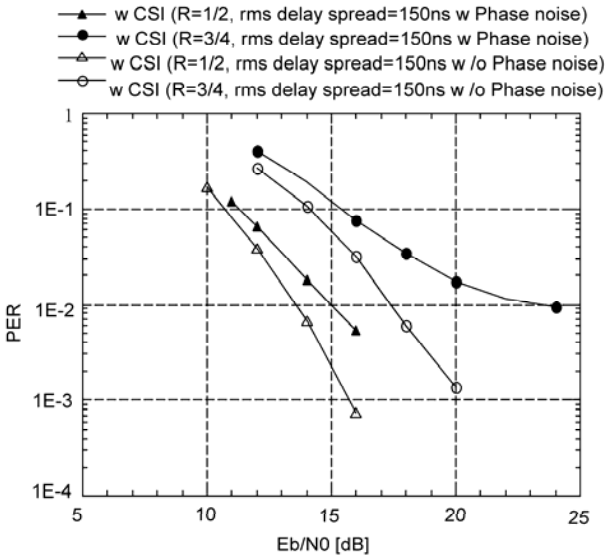


Right figures show AM-AM and AM-PM model of a 60GHz power amplifier and BER performance to take the PA model (input power = -20dBm) into simulation.

Propose parameters to evaluate PHY performance (2) Impact of phase noise (PN)

- Phase noise model
  - System performance of 60GHz WPAN is degraded by PN
  - Phase noise affects signal generators of TX and RX
  - For the simulation, relative phase noise must be considered at receiver side
- To prepare PN model
  - Call for data-sheet of phase noise performance
  - Based on such sheet, a MATLAB code for the simulation needs to be prepared.





Right figures show an example of modeling of PN and the impact of the PN to the PER (1.5kB) @5GHz band Hyper-LAN2. The above shows the comparison simulated phase noise v.s. actual phase noise and the below shows PER performance to include the PN.

Propose parameters to evaluate PHY performance (3) Impact of AD/DA converters

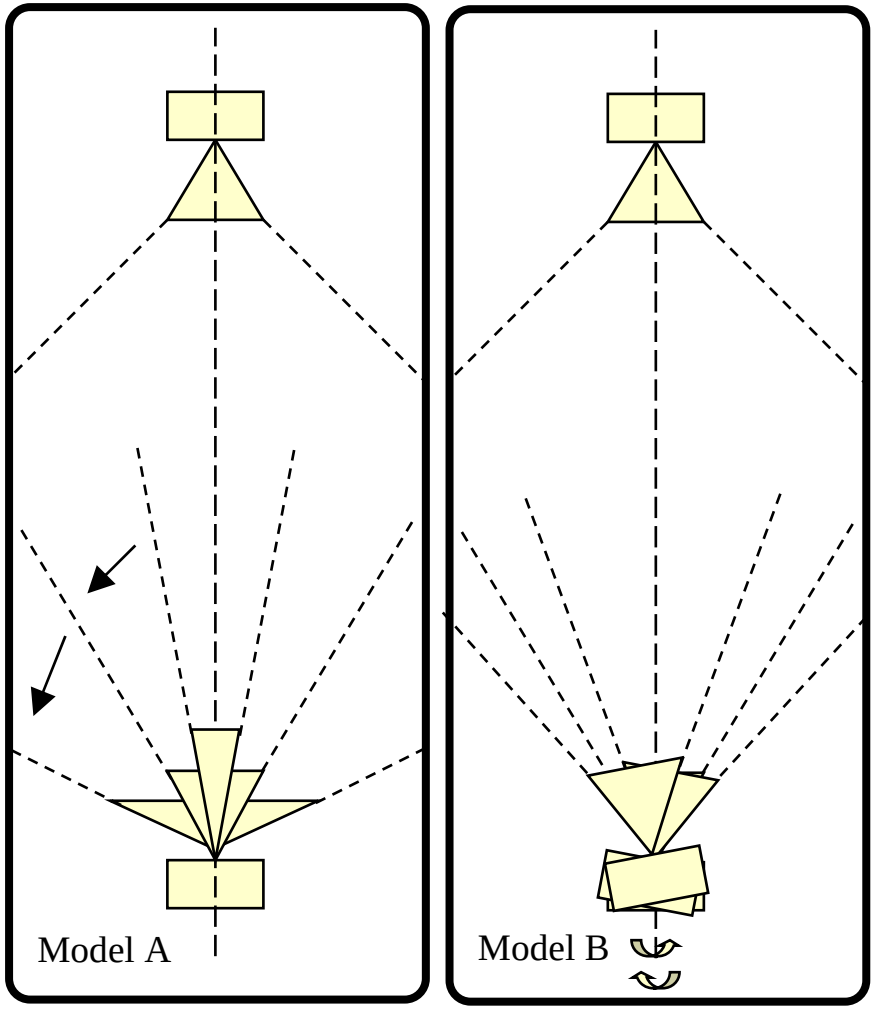
- To evaluate power consumption roughly, the impact of the resolution of AD/DA converters to the BER/PER performance must be shown
- Existence of AD/DA converters to realize the PHY proposals from contributors must be reported.

Items described in contributed document that shows PHY performance

- Show basic PHY parameter
  - Modulation scheme
  - Demodulation scheme
  - Coding
  - Filter configuration (TX and RX)
  - Total bandwidth
  - Transmission speed
  - Interleave (if use)
  - Frame configuration
  - Used Channel model
- Show proposed link budget
- Show proposed frame structure
- Show the performance
  - CNR v.s. BER and PER
  - Packet synchronization performance
  - Interference to adjacent channel
  - Tolerance to interference from adjacent channel

Propose two simulation procedures to reduce simulation time

- Alignment between TX and RX antennas is the dominant issue to decide PHY simulation period.
  - If degree of freedom for the alignment is large, simulation time increases.
  - Is the consideration on the alignment needed to compare PHY proposals ?
- Two proposals
  - (Model A) TX antenna is fixed and the alignment between TX and RX is adjusted. By selecting width of antenna, PHY performance is evaluated.
  - (Model B) TX antenna is fixed initially, and the alignment between TX and RX is adjusted. By changing the center axis with a distribution (e.g. uniform, Gaussian), PHY performance is evaluated.



Conclusions

- Propose a scheme to evaluate PHY performance by computer simulation in TG3c
  - Link budget
  - Frame design
  - BER (and/or) PER performance
- Propose parameters to evaluate PHY performance
  - Impact of power amplifier
    - Not AM-AM model but AM-PM must be needed because the degradation by AM-PM characteristics is larger than that by AM-AM.
  - Impact of phase noise
    - Call for data or data sheet for the phase noise, and make model voluntary
  - Impact of AD/DA converters
    - To evaluate power consumption, the impact of the resolution of AD/DA converter to the BER/PER performance must be discussed
- Clarify items described in contributed document that shows PHY performance
- Propose two simulation procedures to reduce simulation time
  - Handling of angles of TX and RX antennas
    - Two methods are proposed