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

Submission Title: [**IEEE802.15.3c Progress and Achievement**]

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Re: []

Abstract: [**IEEE802.15.3c Progress and Achievement**]

Purpose: [Discussion]

IEEE802.15.3c Progress and Achievement

July 13, 2008

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(Concerns/opinions presented in this document are what came out from members of TG3c but are not necessarily the official comments of TG3c due to time limitation)

Contents

1. 802.15.3c PAR
2. Applications
3. Channel models
4. System requirements
5. TG3c's current status, future plan
6. TG3c's concern about VHT60 PAR and suggestions

TG3c: Progressing Towards RevCom Approval in September, 2009

TG3c's Letter Ballot (LB43) passed July 11, 2008 with 78.4% yes votes and with about 500 technical comments. TG3c has been working on comment resolution targeting re-circulation completion and getting into Sponsor Ballot in November, 2008

Major events in TG3c:

- Sep., 2009: RevCom approval (plan)

- **July, 2008: Letter Ballot passed with 77.8 % yes votes**
- May, 2008: Baseline document approved
- **November, 2007**: **Confirmation vote passed with 87 %** yes votes (first try)
- **January, 2007**: **CFP issued**
- Nov., 2007

  : Completed usage model definition, corresponding channel model analysis & creation, and system requirements
- **Mar.,2005: TG3c was formed**

802.15.3c PAR

1. **Scope**

   This project will define a 25 to 100 GHz (millimeter wave) alternative PHY clause for a higher data rate amendment to Standard 802.15.3-2003. This frequency range allows for the USA and Japanese unlicensed allocations and expected unlicensed allocations in other countries. Data rates will be at least 1 Gbps under normal operating conditions with a typical range no less than 10 meters

2. **Purpose**

   To standardize an alternative PHY that can achieve higher data rate transmission, higher spectral re-use via optional directional antennas, and superior coexistence than existing 802.15.3 wireless systems. Multiple data rates will be offered. Data rates of at least 1Gbps (see item 21), will satisfy an evolutionary set of consumer multi-media industry needs for WPAN communications.

Applications / Usage models

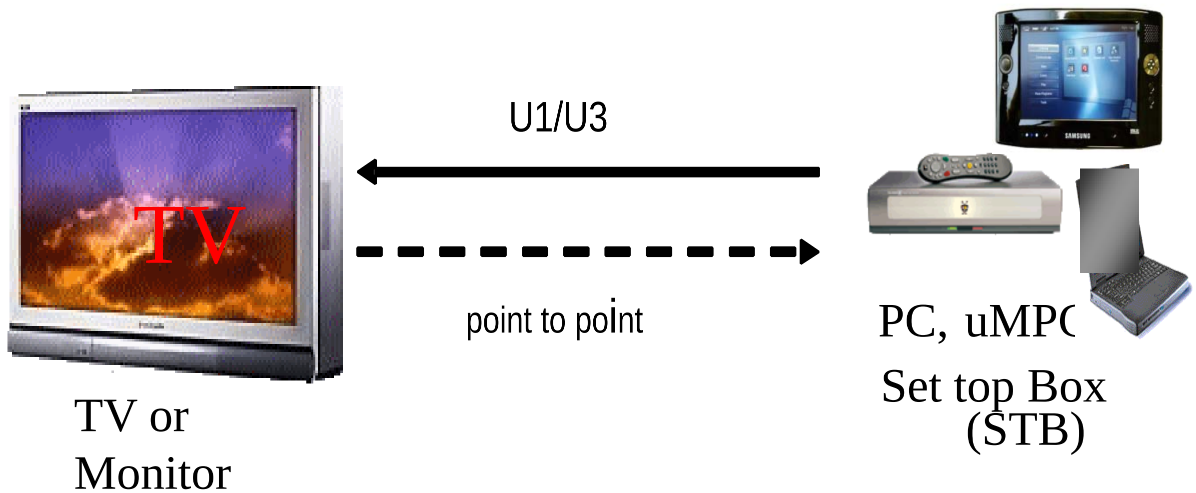
1. **Current selected usage models are composed of video streaming, data transfer and information down/up loading in LOS / NLOS environments**
2. **Channel models have been adopted for these usage models and composed of both LOS (Line of sight) and NLOS (Non line of sight) environments for video streaming and LOS for information down/up loading**
3. **The systems are WPANs (Wireless PANs) to transmit 1 Gbps (or higher) mandatory at PHY-SAP (Service access point)**
   - **Looking for 5 to 6 Gbps video / data transmission**

Usage Model (1/7)

1. Discussed and narrowed down to five (5) major usage models. They are categorized as mandatory usage models (UM1 and UM5) and optional usage models (UM2, 3, and 4)
2. **UM1** targets uncompressed high speed video streaming at 1.78 Gbps or 3.56 Gbps (MAC-SAP rates) over 5 to 10 m transmission ranges in LOS (Line of sight) and / or NLOS (Non line of sight) conditions in Residential channel environments. The target error rate is 10-9 TMDS CER (Character error rate, 24 bit per character) which will be evaluated by 10-6 BER (Bit error rate) in PHY simulation.
3. **UM5** targets "Kiosk file down loading" type file transfer applications at 1.5 or 2.25 Gbps (MAC-SAP rates) over 1 m transmission range in LOS condition in Office channel environments. The target PER (Packet error rate) is 8 % with a packet size of 2 K bytes. This application was proposed by COMPA to solve "directivity issue" practically by pointing the "Kiosk server" like a remote controller pointing a TV set. This can be used for PC peripherals as well and has been getting a lot of interests. The five usage models with images of use cases with some descriptions are given below.

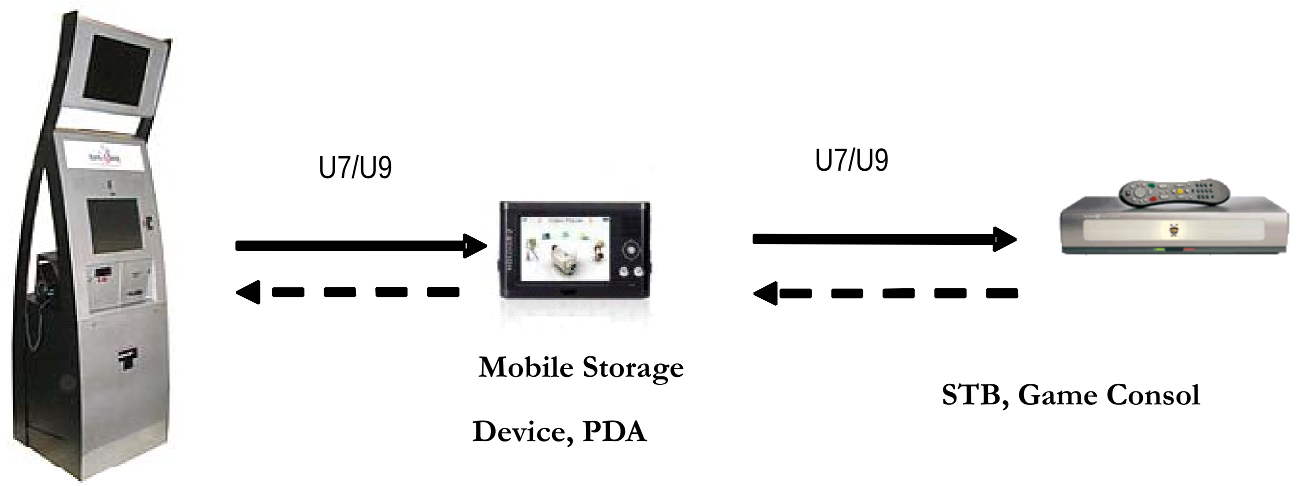
UM1 Uncompressed Video Streaming (2/7)

UM1 Uncompressed Video **Streaming**



Environment	Throughput MAC SAP	BER/ PiER	Distance	Note
NLOS, LOS Residential (STB-TV)	1.78 Gbps 1.49, W/O Blk Stream, Up to 1080i, 24, 60	10^{-6} BER for PHY Simulations	5	No data retransmission required Unidirectional data transmission noted by solid line Target of TMDS CER for HDMI: 10-9 Pixel is RGB, 24 bits
LOS, NLOS Residential (STB – TV)	3.56 Gbps 2.98Gbps, W/O Blk Stream, Up to 1080p, 24, 60	10^{-6} BER for PHY Simulations	10	

UM5 Kiosk File Downloading (3/7)

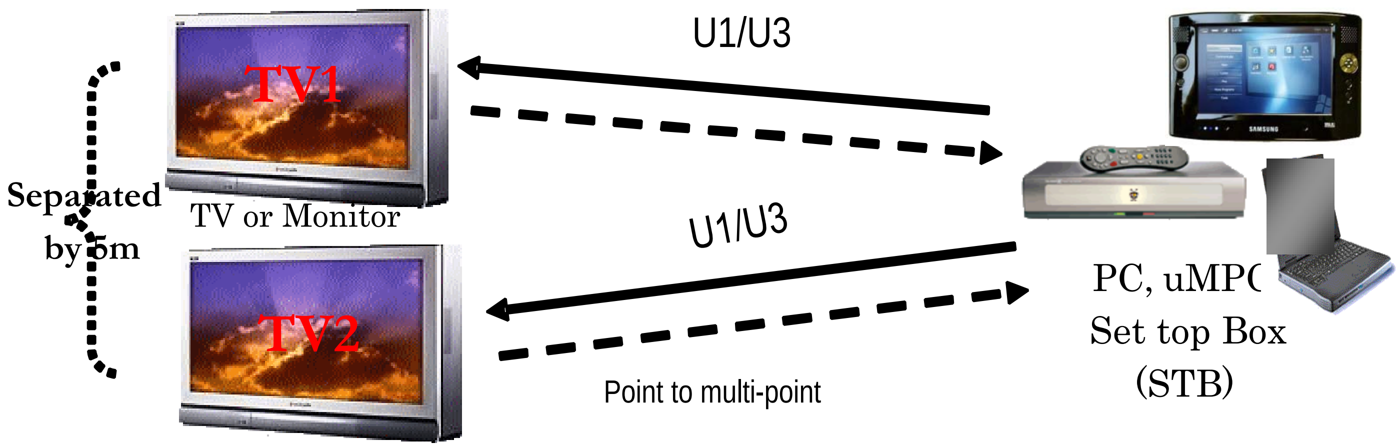


Movie and Game Kiosk

Environment	Throughput (MAC SAP)	BER/PER	Distance	Note
LOS office (Server-PDA or PDA-STB)	1.50 Gbps burst (Server-PDA or PDA-STB)	8% PER before retransmission 2K Byte	1 m	Asymmetric download/Upload
LOS -office (Server-PDA or PDA-STB)	2.25 Gbps burst (Server-PDA or PDA-STB)	8% PER before retransmission 2K Byte	1 m	Low data rate reverse link

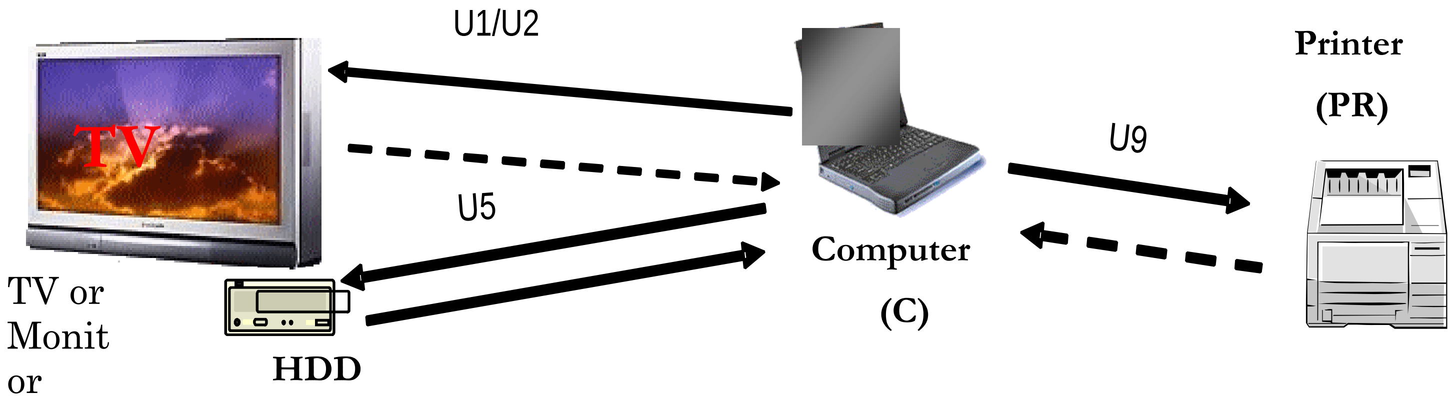
Yozo Shoji et al., “Re-summarization of merged Usage Model Definitions parameters”, IEEE 802. 15-06-0379-02-003c, September 2006

UM2 Multi Uncompressed Video Streaming (4/7)



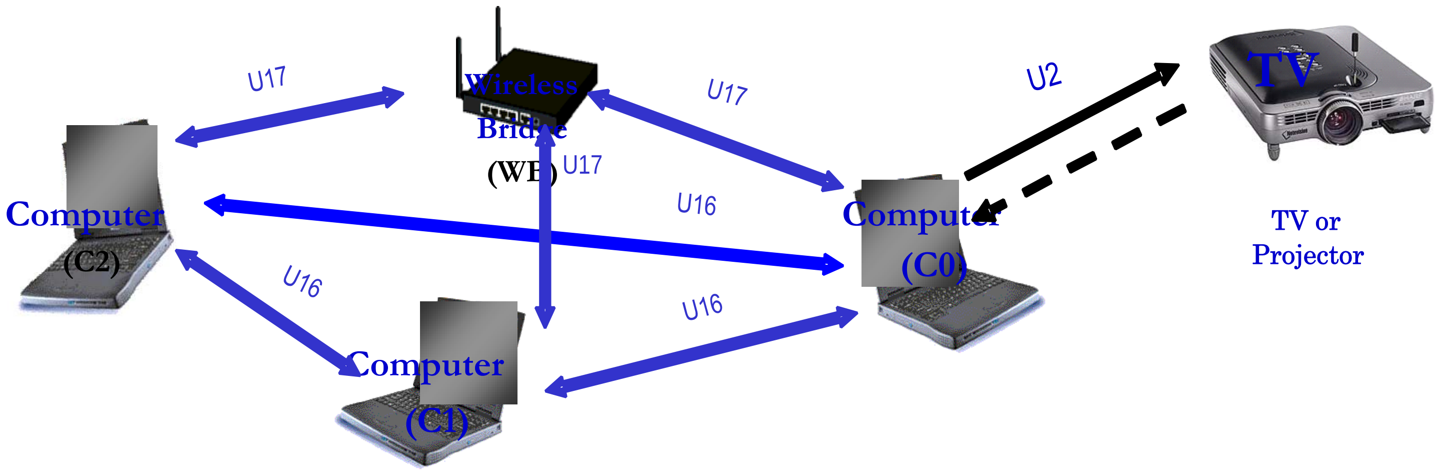
Environment	Throughput (MAC SAP)	BER/ PiER	Distance	Note
Residential TV1:LOS TV2:NLOS	TV1: 1.75 Gbps 1.49, w/o blk Stream 1080i, 24, 60 TV2: 0.62 Gbps 0.497, w/o blk Stream 720x480p, 24,60	10^{-6} BER for PHY Simulations	STB – TV1 & STB – TV2 : 5 m TV1 – TV2 : 5 m	No data retransmission required Unidirectional data transmission noted by solid line for U1 Low bitrate reverse link TV1-TV2 are not co-located, separation 5 m Different video content transmitted on each link Target of 10^{-9} TMDS CER for HDMI Pixel is RGB, 24 bits

UM3 Office Desk Top (5/7)



Environment	Throughput (MAC SAP)	BER/PER	Distance	Note
NLOS, Desktop (C-TV) LOS, Desktop (C-HDD) NLOS, Office (C-PR)	**3.56 Gbps, 2.98 Gbps w/o blk** Stream, 1080p, 24, 60 And/or 1.75 Gbps, 1.49 Gbps w/o blk Stream, 1080i, 24, 60	10^{-6} BER for PHY Simulation	1 m	No data retransmission required for TV Unidirectional data transmission noted by solid line for U1 & U9 Lowbitrate reverse link for unidirectional link TV, HDD, PR are not co-located, separation by 120 deg. Target of 10^{-9} TMDS CER for HDMI Pixel is RGB, 24 bits One simulation for this Usage Model
	0.25 Gbps, average, async Each direction for HDD	8% PER before retransmission 2K Byte	1 m	
	0.5 Gbps average async	8% PER before retransmission 2K Byte	5 m	

UM4 Conference Ad Hoc (6/7)



Environment	Throughput (MAC SAP)	BER/PER	Distance	Note
LOS, office (C0 – TV) LOS, Desktop (C0 – C1 – C2)	**1.75 Gbps, 1.49 Gbps w/o blk** Stream, 1080i, 24, 60	10^{-6} **BER for PHY** Simulations	5 m	No data retransmission required for TV1 Unidirectional data transmission noted by solid line for U1 Low bit rate reverse link for unidirectional link device are not co-located Target of 10^{-9} TMDS CER for HDMI Pixel is RGB, 24 bits
	0.0416 Gbps, average Async, Each direction	8% PER before retransmission 2K Byte	1 m	
LOS, office (C0, C1, C2) - WB	0.125 Gbps, average Each direction for WB	8% PER before retransmission 2K Byte	3 m	

Usage Model (7/7)

- The two usage models, **UM1** and **UM5** have been selected **as mandatory for PHY simulations** for their relatively simple applications to cope with antenna directivity and large path loss. They are **point to point communications** and antenna directivity may be relatively easier and can be handled manually although **UM1 system requirement mandates automatic device discovery**

Channel Model

One of the areas COMPA contributed a lot

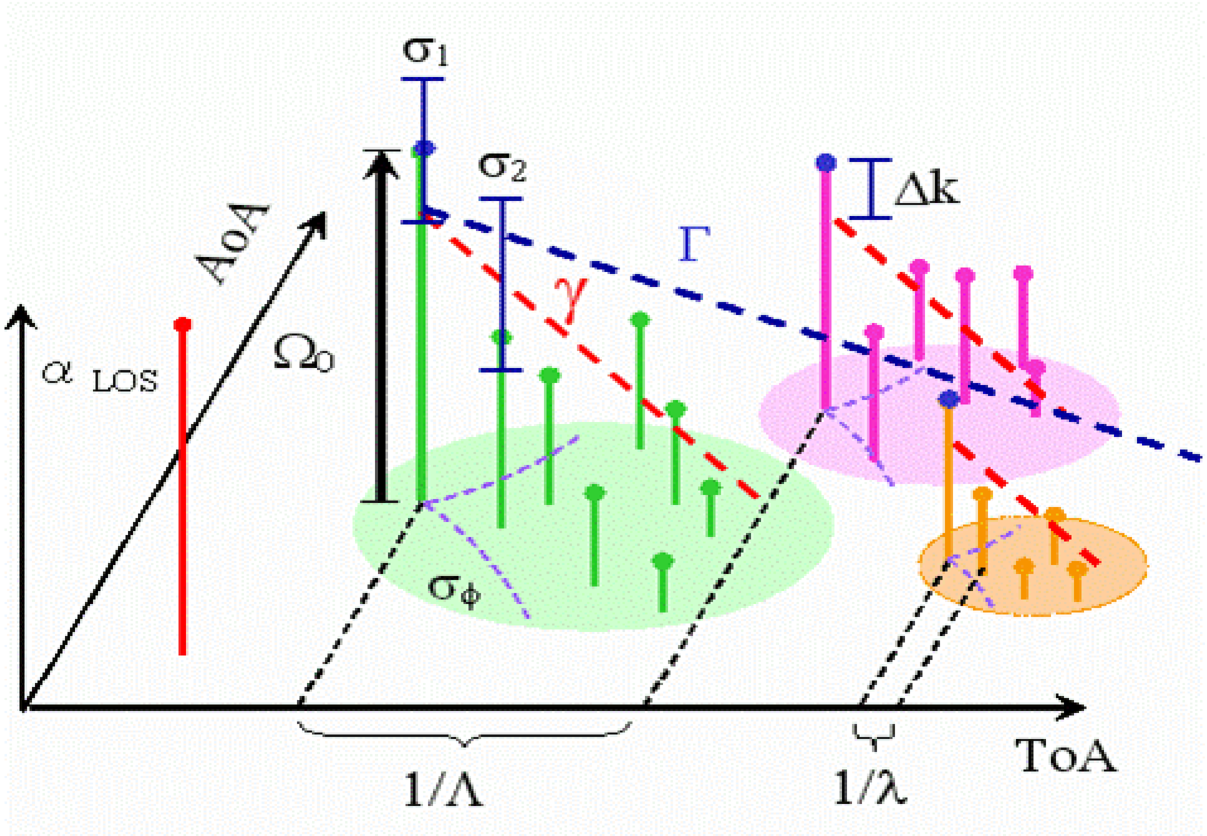
- A number of channel models were studied and proposed aligned with various applications scenarios, then they have been narrowed down to **8 (eight) channel models**
- The proposed channel models are categorized into two by having **LOS component or not**
- COMPA developed **Matlab codes** for various channels as they can be used by non-Matlab professionals for system simulations

References:

1. H. Sawada *et al*., "LOS office channel model based on TSV model," IEEE 802.15-06-0377-02-00-3c, Melbourne, Australia, Sept 2006.
2. H. Sawada *et al*., "LOS residential channel model based on TSV model", IEEE 802. 15-06-0393-00-003c, September 2006
3. H. Sawada et al., "NLOS Residential Channel Model Based on TSV Model," IEEE 802.15.06-0454-00-003c, Dallas, USA, Oct. 2006.
4. K. Sato *et al*, "A new LOS kiosk channel model based on TSV model," IEEE 802.15.07-0607-01-003c, Orlando, USA, Mar. 2007.
5. H. Harada *et al*, "Channel Model Matlab Code Release," IEEE 802.15.07-0648-00-003c, Orlando, USA, March. 2007
6. H. Harada *et al*," CM MATLAB Release 1.1 Support Document," IEEE 802.15-07-0559-03-003c, Orlando, USA, March 2007.

Typical TSV Channel Model

(LOS components and reflected waves: proposed by COMPA)



Channel models and Environments

Channel Model	Scenario	Environment	Descriptions
CM1	LOS	Residential	Typical home with multiple rooms and furnished with furniture, TV sets lounges, etc. The size is comparable to the small office room. The walls/floor are made of concrete or wood covered by wallpaper/carpet. There are also windows and wooden door in different rooms within the residential environment.
CM2	NLOS		
CM3	LOS	Office	Typical office setup furnished with multiple chairs, desks, computers and work stations. Bookshelves, cupboards and whiteboards are also interspersed within the environment. The walls are made by metal or concrete covered by plasterboard or carpet with windows and door on at least one side of the office. Cubical, laboratory, open and closed office can be treated as a generic office. Typically these offices are linked by long corridors.
CM4	NLOS		
CM5	LOS	Library	Typical small size library with multiple desks, chairs and metal bookshelves. Bookshelves are filled with books, magazines, etc. Some tables and chairs were interspersed between the bookshelves. At least one side of room has windows and/or door. The walls are made of concrete.
CM6	NLOS		
CM7	LOS	Desktop	Typical office desktop and computer clutter. Partitioning surrounded this environment
CM8	NLOS		

Available LOS / NLOS Channel Models and MATLAB Codes

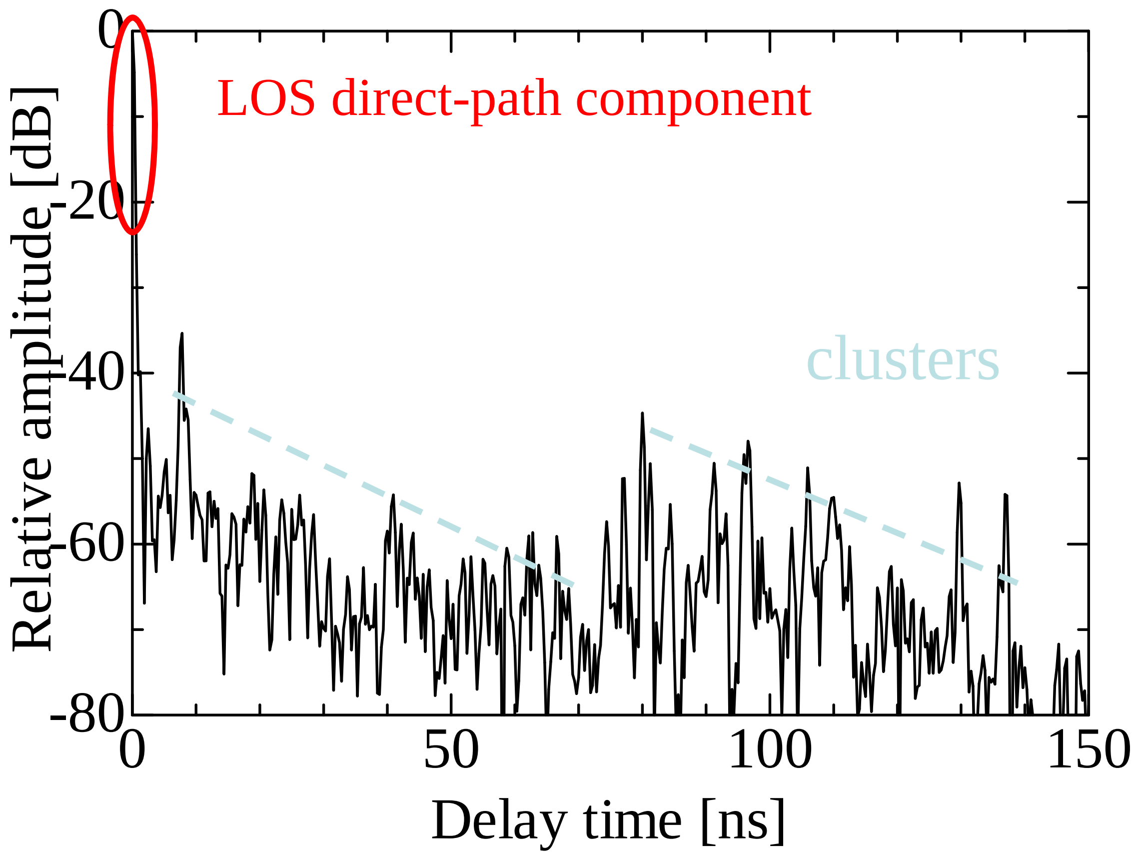
	LOS	NLOS
Office	Available (NICT)	Available (NICT)
Residential	Available (NICT)	Extracted (from NICT data)
Desktop	Available (NICT)	N/A
Library	Available (IMST/Intel)	N/A

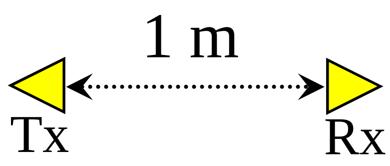
These parts are now available based on TSV-model

MAC

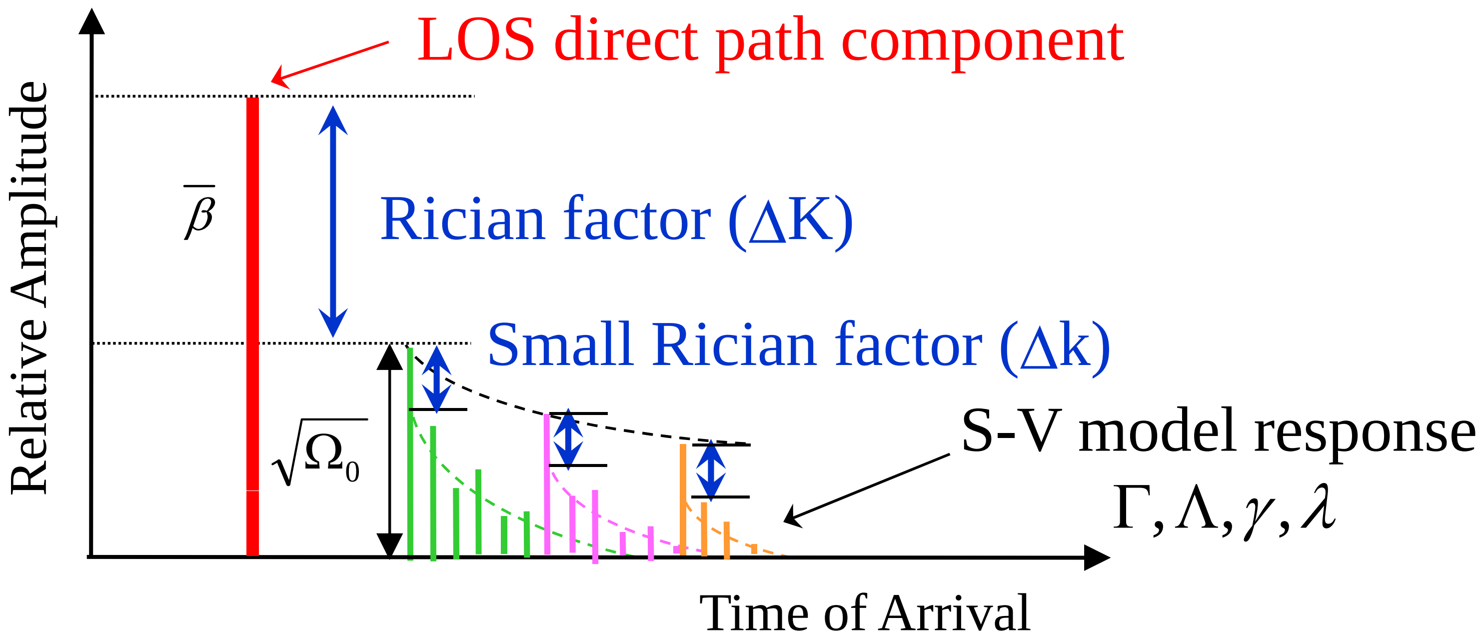
- PAR requirements: 15.3c MAC shall be based on 15.3 and 15.3b MAC and expanded if necessary. Obviously, functions related to **antenna directivity** such as DEV-DEV communications are necessary add-on items to be incorporated into 15.3b MAC
- The current decision by Committee for system evaluation, adopting UM1 and 5 as Mandatory has made inherently complicated MAC design and analysis for 15.3c much easier
- The Committee has agreed not to mandate MAC simulations for PHY performance simulations and system proposals but **analysis**
- **802.15.3c Major MAC Attributes to PHY Design**
  1. **Channel Probing**
  2. **Device to Device Communications**
  3. **Beam forming**
  4. **UEP (Unequal error protection)**
  5. **Others**

Example PDPs (Power delay profile) in measurement environment 1 (Beam width: Tx=30, Rx=30)





Impulse response



By setting $\Gamma_0 = 0$, TSV model can generate impulse response for LOS kiosk channel without any modification

TSV model for LOS kiosk environment

- For LOS desk top environment (06/297)

TSV model = Two-path component + S-V component

$$h(t)=\beta\,\delta(t)+\sum_{l=0}^{L-1}\sum_{m=0}^{M_l-1}\alpha_{l,m}\,\delta(t-T_l-\tau_{l,m})\,\delta(\varphi-\Psi_l-\psi_{l,m})$$

$$\beta=\left(\frac{\mu_D}{D}\right)\left|\sqrt{G_{t1}G_{r1}}+\sqrt{G_{t2}G_{r2}}\Gamma_0\exp\left[j\frac{2\pi}{\lambda_f}\frac{2h_1h_2}{D}\right]\right|$$

Statistical factors in both two-path and S-V

- For LOS kiosk environment

Reflection coefficient: $\Gamma_0 \cong 0$

Modified TSV model = Direct-path component + S-V component

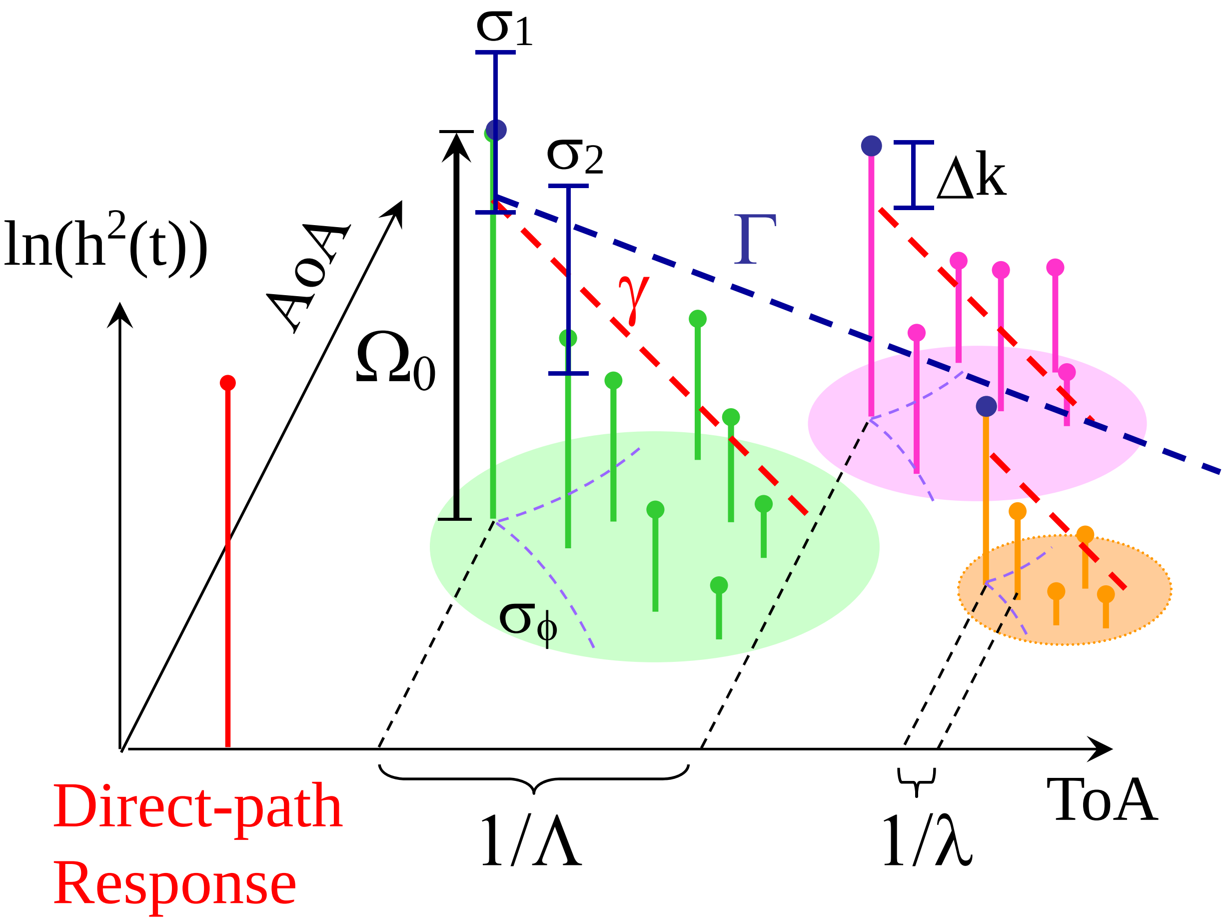
$$h(t)=\beta\,\delta(t)+\sum_{l=0}^{L-1}\sum_{m=0}^{M_l-1}\alpha_{l,m}\,\delta(t-T_l-\tau_{l,m})\,\delta(\varphi-\Psi_l-\psi_{l,m})$$

$$\beta\Big|_{\mu_D<<D}=\sqrt{G_{t1}G_{r1}}$$

Statistical factors in only S-V

Refer to Appendix A for each parameter

TSV model parameters to be extracted



Γ : *cluster* decay factor

$1/\Lambda$: *cluster* arrival rate

γ : *ray* decay factor

$1/\lambda$: *ray* arrival rate

σ_1 : *cluster* lognormal standard deviation

σ_2 : *ray* lognormal standard deviation

σ_ϕ : Angle spread of ray within cluster (Laplace distribution)

Ω_0 : Average power of the first ray of the first cluster

Small Rican factor Δk and Ω_0 are necessary for TSV model

Available LOS / NLOS Channel Models and MATLAB Codes

	LOS	NLOS
Office	Available (NICT)	Available (NICT)
Residential	Available (NICT)	Extracted (from NICT data)
Desktop	Available (NICT)	N/A
Library	Available (IMST/Intel)	N/A

These parts are now available based on TSV-model

Four (4) Different Environments for System Performance Evaluation

- **AWGN** (Additive white Gaussian noise),
- **Office (LOS) for UM5**
- **Residential (LOS** and **NLOS(CM2.3)) for UM1**
- Including PA non-linearity,
- Phase **noise defined by TG3c**

System Simulation

- **Bit rate**

  At least one mandatory mode with a **PHY-SAP Payload Bit Rate** of **2Gbps or more is required for system simulation (only for System simulations but not for PAR)**. Also, at least one optional mode with a PHY-SAP Payload Bit Rate of **3Gbps or more is desired**.

- **Channelization**

  The PHY shall provide **a minimum of 3 channels**, each being able to support the data rates mentioned above. This requirement is based on the bandwidth available in the US, Canada, Japan and Korea regulatory domains. The proposers should demonstrate the number of channels that their proposal provides in other regulatory domains, where possible

- **Simulation cases**

  The **simulation cases** have been reduced to the very **basic four (4)** from 240. They are performance simulations in **AWGN** (Additive white Gaussian noise), **Office (LOS) for UM5** and **Residential (LOS** and **NLOS) for UM1** including PA non-linearity, and phase **noise defined by TG3c**

- **Transmission range**

  Under mandatory usage models and given channel models, transmission ranges will be one of the important parameters to be presented by proposers for system selection

Single Carrier MCS Example

MCS Class	MCS Identifier	PHY-SAP rate Mbs	Modulation Scheme	Spreading factor	FEC Type	FEC Rate
Class 1	LR1	**50.6**(CR)/379.6/ 759.2/**1518.4**(MLR)	π/2-BPSK/(G)MSK	32/4/2/1	RS(255,239)	0.937
	LR2	607.5/1215.0	π/2-BPSK/(G)MSK	2/1	LDPC(576,432)	0.750
	LR3	810.0	π/2-BPSK/(G)MSK	1	LDPC(576,288)	0.500
Class 2	MR1	1620.0	π/2-QPSK	1	LPDC(576,288)	0.500
	MR2	2430.0	π/2-QPSK	1	LPDC(576,432)	0.750
	MR3	2835.0	π/2-QPSK	1	LDPC(576,504)	0.875
	MR4	3024.0	π/2-QPSK	1	LDPC(1440,1344)	0.933
	MR5	3036.7	π/2-QPSK	1	RS(255,239)	0.937

MCS Class	MCS Identifier	PHY-SAP rate Mbs	Modulation Scheme	Spreading factor	FEC Type	FEC Rate
Class 3	HR1	4555.1	π/2–Star 8QAM	1	RS(255,239)	0.937
	HR2	6073.4	π/2-16QAM	1	RS(255,239)	0.937
Class 4	OOK1	1518.4/759.2	OOK	1/2	RS(255,239)	0.937
	DRB1	3036.7	Dual Rail Bipolar	1	RS(255,239)	0.937

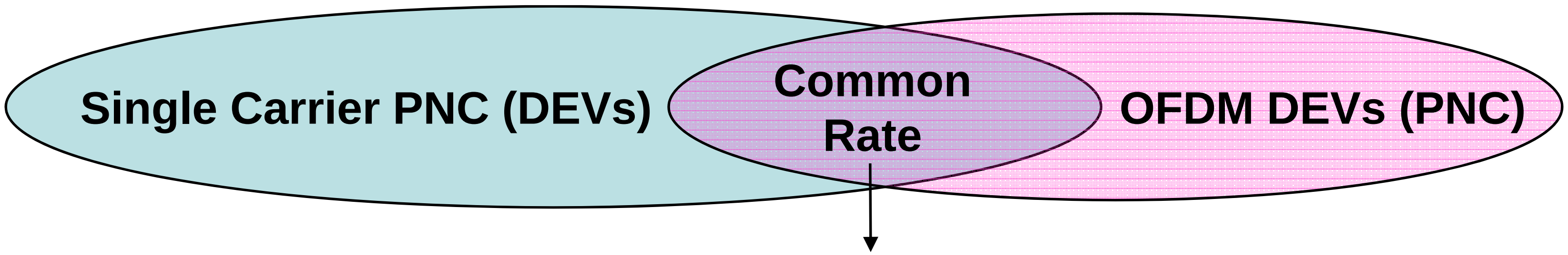
Adopted System Proposal by IEEE802.15.3c Task Group for Baseline Document(Confirmed in Jacksonville in May, 2008)

- Having Common mode for **all PNC capable devices (as mandatory)** as **Super PHY** for TG3C standard on top of Common channelization: 4 channels over 9 GHz – good DAA expected by the same chanelization
- Having three different PHY for specific applications to coexist **under Super PHY -** i. SC (Single Carrier), ii. HSI-OFDM iii. AV- OFDM

Common Rate

(Simple Single Carrier bridging different air interfaces)

- **Both SC and OFDM air interfaces** are **simultaneously** supported on top of common rate frame
- **Common rate: simple single carrier (π/2 BPSK with Reed Solomon as FEC)** for robust and longer transmission range
- **Common rate** is to **bridge an air interface to different air interfaces** best fitting to the applications
- **Common rate**is used for **beacon and association**
- **Market will decide best fit air interfaces**



Simple Single Carrier (π/2 BPSK with RS as FEC)

Common rate (50 Mbps) communication (3/6)

- **a base rate** single carrier (SC) transmission
- **mandatory** for all devices except non-PNC capable OFDM or non-PNC capable OOK devices
- **a bridge to realize coexistence and interoperability between SC and OFDM**, OOK and also functions
- **the most robust performance** in all transmission modes,
- a long transmission range **with “omni” * antennas in both LOS (AWGN) and NLOS channels without any equalization**
  - 10 m (TX and RX antenna gains are 4 dBi) in LOS (AWGN)
  - 10 m (TX and RX antenna gains are 4 dBi) in NLOS
- **used for beaconing and signaling** for association / disassociation, beam forming, and channel probing
- **employs p/2-BPSK** and **Reed Solomon (RS) (255, 239)** and **Golay code of 64 chips (equivalent spreading factor: 32)**,
- can be **easily implemented**
- extra protection designed for **preamble and header** of the Common mode to further increase its robustness for a “fallback mode”

Important Design 1

COMPA Channel Plan allows:

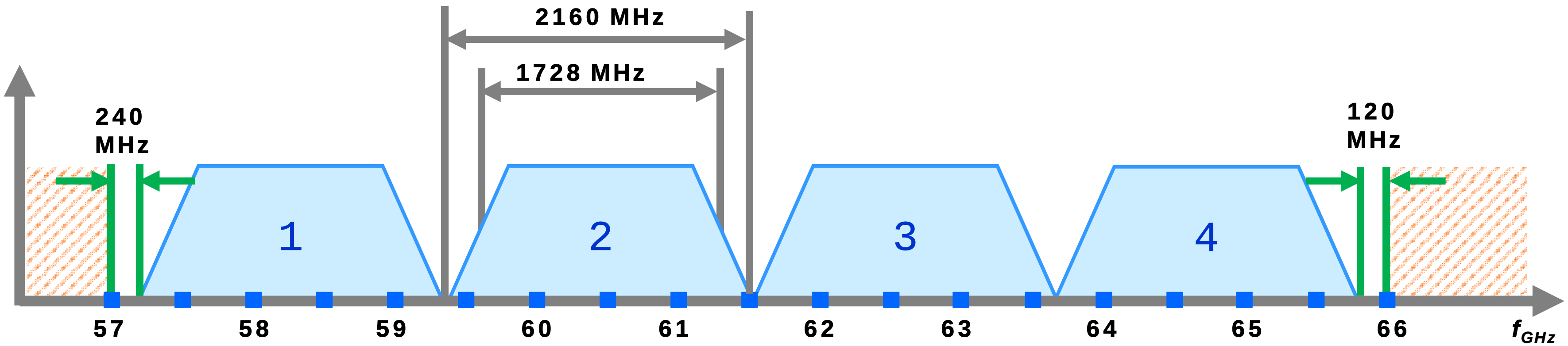
Generation of **Sampling clock** and

60 GHz center frequencies from
"**cell phone XTAL** (19.2, 24 MHz)" as well as
"**video terminal XTAL** (54 MHz)"

CoMPA channel plan built on
19.2 MHz, 24 MHz,
27 MHz, 30 MHz, 45 MHz 54 MHz,
60 MHz, 90 MHz, 108 MHz, and 120 MHz XTAL

TG3c Channel Plan

Channel Number	Low Freq. (GHz)	Center Freq. (GHz)	High Freq. (GHz)	Nyquist BW (MHz)	Roll-Off Factor
A1	57.240	58.320	59.400	1728	0.25
A2	59.400	60.480	61.560	1728	0.25
A3	61.560	62.640	63.720	1728	0.25
A4	63.720	64.800	65.880	1728	0.25



- Support Cell phone XTAL: **19.2 MHz** & 24 MHz & Other High frequency XTALs: 54MHz, 60MHz, 108MHz, …
- Balanced margins to 57/66 GHz & Good roll-off factor
- Supports Multiple PLL Architectures with the Cell phone XTAL
- Dual PLL: High frequency PLL that generates carrier frequencies
  Low frequency PLL that generates ADC/DAC & ASIC frequencies

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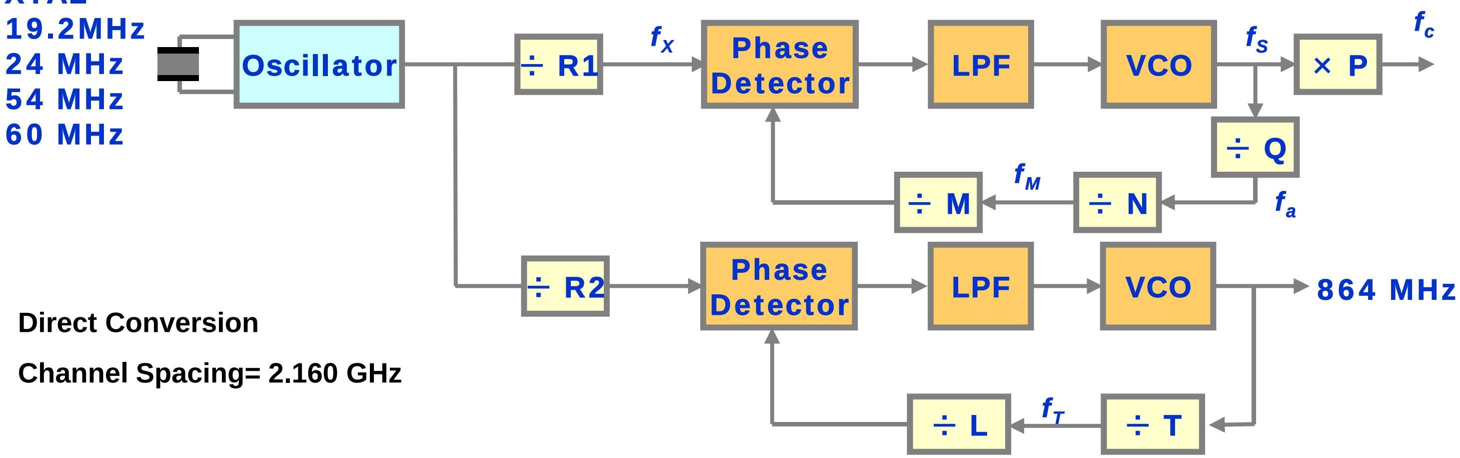
Example of clock generation and carrier generations based on Double PLL architecture



Direct Conversion

Channel Spacing= 2.160 GHz

XTAL	R1	f_X MHz	f_c (GHz)	P	f_s (MHz)	Q	f_a (MHz)	N	f_M (MHz)	M	R2	T	f_T(MHz)	L
19.2	4	4.8	58.320	2	29160	3^2x5	648	1	648	27	1	3	288	15
19.2	4	4.8	60.480	2	30240	3^2x5	672	1	672	28	1	3	288	15
19.2	4	4.8	62.640	2	31320	3^2x5	696	1	696	29	1	3	288	15
19.2	4	4.8	64.800	2	32400	3^2x5	720	1	720	30	1	3	288	15
24	1	24	58.320	2	29160	3x5	3645	3	1215	27	1	4	216	9
24	1	24	60.480	2	30240	3x5	3780	3	1260	28	1	4	216	9
24	1	24	62.640	2	31320	3x5	3915	3	1305	29	1	4	216	9
24	1	24	64.800	2	32400	3x5	4050	3	1350	30	1	4	216	9
54	1	54	58.320	2	29160	2^2x5	1458	1	1458	27	1	2^3	108	1
54	1	54	60.480	2	30240	2^2x5	1512	1	1512	28	1	2^3	108	1
54	1	54	62.640	2	31320	2^2x5	1566	1	1566	29	1	2^3	108	1
54	1	54	64.800	2	32400	2^2x5	1620	1	1620	30	1	2^3	108	1
60	1	60	58.320	2	29160	2^2x3^2	810	1	810	27	**5**	2^3	108	9
60	1	60	60.480	2	30240	2^2x3^2	840	1	840	28	**5**	2^3	108	9
60	1	60	62.640	2	31320	2^2x3^2	870	1	870	29	**5**	2^3	108	9
60	1	60	64.800	2	32400	2^2x3^2	900	1	900	30	**5**	2^3	108	9

Important Design 2 : Common Rate (1/2)
(Simple Single Carrier bridging different air interfaces)

- **Both SC and OFDM air interfaces** are **simultaneously** supported on top of common rate frame
- **Common rate: simple single carrier (π/2 BPSK with Reed Solomon as FEC)** for robust and longer transmission range
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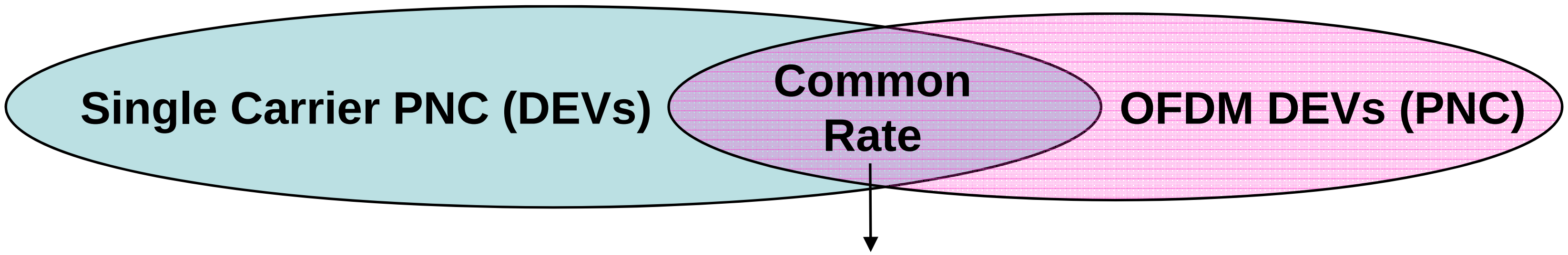

Simple Single Carrier (π/2 BPSK with RS as FEC)

Common rate (50 Mbps) communication (2/2)

SUPER PHY for all PNC capable devices: all piconets can talk each other

- **a base rate** single carrier (SC) transmission
- **mandatory** for all PNC capable devices for better interference avoidance
- **a bridge to realize coexistence and interoperability between SC and OFDM**, OOK and also functions
- **the most robust performance** in all transmission modes,
- a long transmission range **with "omni" * antennas in both LOS (AWGN) and NLOS channels without any equalization**
  - 10 m (TX and RX antenna gains are 4 dBi) in LOS (AWGN)
  - 10 m (TX and RX antenna gains are 4 dBi) in NLOS
- **used for beaconing and signaling** for association / disassociation, beam forming, and channel probing
- **employs p/2-BPSK** and **Reed Solomon (RS) (255, 239)** and **Golay code of 64 chips (equivalent spreading factor: 32)**,
- can be **easily implemented**
- extra protection designed for **preamble and header** of the Common mode to further increase its robustness for a "fallback mode"

Common Rate (single carrier) required for all SC devices, all PNC capable HSI - , AV - OFDM devices

Common rate can be expanded very easily to **1.5 Gbps transmission** by using the same modulation and demodulation with different spreading factors

- Can meet “PAR: 1 Gbps or higher transmission”

  -1.5 Gbps (PHY-SAP) in Single carrier mode
- Transmission range: 5 m in LOS environments without equalizer
- Based on Common rate transmission capability

TG3c Current Status: Progressing Towards RevCom Approval in September, 2009

TG3c's Letter Ballot (LB43) passed July 11, 2008 with 78.4 % approval ratio and with 487 technical comments and TG3c has been working on comment resolution targeting re-circulation completion and getting into Sponsor Ballot in November, 2008

Major events in TG3c:

1. **Letter Ballot passed** by first try with 78.4 % yes vote in July 2008
2. **Baseline document completed** and went into letter ballot: May/June 2008
3. **Confirmation vote passed** by first try with 87 % yes vote in **November, 2007**
4. **CFP issued in January, 2007**
5. **Completed usage model definition, corresponding channel models, and system requirements by spending about 2 years**
6. **TG3c was formed in March 2005**

TG3c’s Concerns about VHT60 PAR

1. **Uniqueness of PAR**

   i. Need to clarify applications and transmission range differences from what TG3c has been working on

2. **Co-existence**

   i. Channelization

   ii. Common rate to avoid interference

Comparison of PAR Scope

	802.15.3	VHT-SG
Type of PAR	Alternate PHY	Amendments to PHY and MAC
Frequency Range	25-100GHz	57 - 66 GHz
Data Rate	> 1 Gbps,	> 1 Gbps
Range	> 10 m	None stated
Intended MAC	802.15.3 MAC	802.11 MAC
Other	None stated	fast session transfer between PHYs

Differences:

- ❑Intended MAC
- ❑Requirement of fast session transfer between PHYs
- ❑maintaining the 802.11 user experience in VHTSG

Comparison of PAR Purposes

TG3c	**VHT**	**Difference**
High data rate	Higher throughput	No Phy difference
Consumer multimedia industry	local area networking	No Phy difference

Appendix 1 Scope in 802.15.3c and VHT PARs

1. **802.15.3c**

   This project will define a 25 to 100 GHz (millimeter wave) alternative PHY clause for a higher data rate amendment to Standard 802.15.3-2003. This frequency range allows for the USA and Japanese unlicensed allocations and expected unlicensed allocations in other countries. Data rates will be at least 1 Gbps under normal operating conditions with a typical range no less than 10 meters.

2. **VHT SG**

   The scope of this project is to define an amendment that shall define standardized modifications to both the 802.11 physical layers (PHY) and the 802.11 Medium Access Control Layer (MAC) to enable operation in the 60 GHz frequency band (typically 57-66 GHz) capable of very high throughput. The MAC and PHY specified in this amendment:

   – Enable a maximum throughput of at least 1 Gbps, as measured at the MAC data service access point (SAP)
   – Enable fast session transfer between PHYs
   – Maintain the 802.11 user experience
   – Address coexistence with other systems in the band

Appendix 2 Purpose in 802.15.3c and VHT PARs

1. **802.15.3c**

   To standardize an alternative PHY that can achieve higher data rate transmission, higher spectral re-use via optional directional antennas, and superior coexistence than existing 802.15.3 wireless systems. Multiple data rates will be offered. Data rates of at least 1Gbps (see item 21), will satisfy an evolutionary set of consumer multi-media industry needs for WPAN communications.

2. **VHT SG:** The purpose of the project is to improve the 802.11 user experience by providing significantly higher throughput for local area networking

Concerns and Suggestions for VHT60 (60) PAR

For the 2nd conference call between TG3c and VHT

July 7, 2008

From TG3c

(Concerns presented in this document are what came out from members of TG3c but not necessarily represent the official comments of TG3c due to time limitation)

I. For Better Co-existence

One of the concerns of TG3c on VHT60 PAR is the co-existence. Based on what achieved by TG3c so far, TG3c suggests for VHT60 PAR to have following statements in VHT60 PAR:

- Same channelization: 2160 MHz per channel x 4 over 9 GHz,
- Common mode for all PNC capable devices,
- Some etiquette rule which will allow to open a channel for new devices to be able to establish communications links by doing something such as backing off,
- Investigate applicability of the PHY developed by TG3c with the highest priority.

II. Uniqueness of PAR

In general, it is mandatory for new TG to have a UNIQUE PAR and suggests following 1 and 2:

- Need to compare existing PAR in the same frequency band (TG3c),
- What are differences/uniqueness: must be stated clearly,

The VHT PAR (11-08/223r5), part 17.5.3 says:
"VHT will be the only technology that can allow a corporate or home user to roam from high throughput (60 GHz) dense cells to wider area networks (e.g. 802.11a/b/g) in a seamless manner ---".

This "seamless" roaming feature may be the only perceived advantage that VHT has over 3C.

Although the current 3C MAC has “handover capability” but not roaming capability, it will be TG3c’s future work naturally like 802.21 working on WIMAX and 802.11.a/b/g handover

III. VHT60 PAR: may need further clarification

Examples

1. Maintain the 802.11 user experience
2. Applications differences from those of TG3c
3. Transmission range
4. Others