

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

Submission Title: [Current TG3c Modulation and Coding Schemes and Performance Examples]

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Abstract: [Current TG3c Modulation and Coding Schemes and Performance Examples]

Purpose: [Current TG3c Modulation and Coding Schemes and Performance Examples.]

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Summary

- This document presents current TG3c modulation and coding schemes of Single Carrier, HIS and AV PHYs and some improvement plan examples.
- TG3c has been working on the following to respond to the comments received through the Letter Ballot process:
 - i. Number of MCS (Modulation and Coding Schemes) reduction by consolidating similar performance MCSs and for chip manufacturers' easy implementation,
 - ii. Performance improvement in various environments,
 - iii. Design parameter alignment among PHYs.
- Presentations on the topics related to MCS reduction, performance and design parameter alignment will be given at future meetings between TG3c and VHT

Current SC PHY MCS list (1/2)

MCS class	MCS id	PHY-SAP (Mbps)	Modulation Scheme	Spreading factor (L_{SP})	FEC type
Class 1	LR1	50.6 (Common Mode)	$\pi/2$ -BPSK /Pre-coded GMSK /Pre-coded MSK	32	RS(255,239)
		379.6		4	
		759.2		2	
		1518.4 (Mandatory)		1	
	LR2	607.5		2	LDPC(672,504)
		1215		1	
	LR3	405		2	LDPC(672,336)
		810		1	

Current SC PHY MCS list (2/2)

MCS class	MCS id	PHY-SAP (Mbps)	Modulation Scheme	Spreading factor (L_{SP})	FEC type
Class 2	MR1	1620	$\pi/2$ -QPSK	1	LPDC(672,336)
	MR2	2430			LDPC(672,504)
	MR3	2835			LDPC(672,588)
	MR4	3024			LDPC(1440,1344)
Class 3	HR1	4555.1	$\pi/2$ -star 8QAM	1	RS(255,239)
	HR2	6073.4	$\pi/2$ -16QAM		RS(255,239)
Class 4	OOK	759.2	OOK	2	RS(255,239)
		1518.4	OOK	1	RS(255,239)
	DAMI	3036	DAMI	1	RS(255,239)

Current HSI PHY MCS list

MCS id	PHY-SAP (Mbps)	Modulation Scheme	Spreading factor (L_{SP})	Outer FEC	Inner FEC	
					msb	lsb
0	59	QPSK	24	RS(252,236)	LDPC(672,336)	
1	708		2		LDPC(672,336)	
2	1416		1		LDPC(672,336)	
3	2124		1		LDPC(672,504)	
4	2478		1		LDPC(672,588)	
5	2832	16-QAM	1		LDPC(672,336)	
6	4248		1		LDPC(672,504)	
7	4965		1		LDPC(672,588)	
8	6372	64-QAM	1	LDPC(672,504)		
9	1512	QPSK	1	-	LDPC(672,336)	
10	2664				LDPC(672,588)	
11	4536	16-QAM			LDPC(672,504)	
12 (UEP)	1770	QPSK	1	RS(252,236)	LDPC(672,336)	LDPC(672,504)
13 (UEP)	2301				LDPC(672,504)	LDPC(672,588)
14 (UEP)	3540	16-QAM			LDPC(672,336)	LDPC(672,504)
15 (UEP)	4602				LDPC(672,504)	LDPC(672,588)

Current AV PHY HRP and LRP MCS list

MCS id	PHY-SAP (Mbps)	Modulation Scheme	Coding Mode	Outer FEC	Inner FEC	
					msb	lsb
0	952	QPSK	EEP	RS(224,216)	CC(R=1/3, K=7)	
1	1904	QPSK			CC(R=2/3, K=7)	
2	3807	16-QAM			CC(R=2/3, K=7)	
3	1904	QPSK	UEP	RS(224,216)	CC(R=4/7, K=7)	CC(R=4/5, K=7)
4	3807	16-QAM			CC(R=4/7, K=7)	CC(R=4/5, K=7)
5	952	QPSK	MSB only	RS(224,216)	CC(R=1/3, K=7)	-
6	1904	QPSK			CC(R=2/3, K=7)	-

LRP MCS id	PHY-SAP (Mbps)	Modulation Scheme	FEC	Repetition
0	2.5	BPSK	CC(R=1/3, K=7)	8
1	3.8		CC(R=1/2, K=7)	8
2	5.1		CC(R=2/3, K=7)	8
3	10.2		CC(R=2/3, K=7)	4

Number of MCS (Modulation and Coding Schemes) Reduction

Working on:

1. MCS consolidation: Performance segregation required
 - P_e , Power consumption, hardware simplicity
2. Chip manufacturers' request: clear and simple set of MCS for chip implementation
3. MCS necessity: Need someone to implement

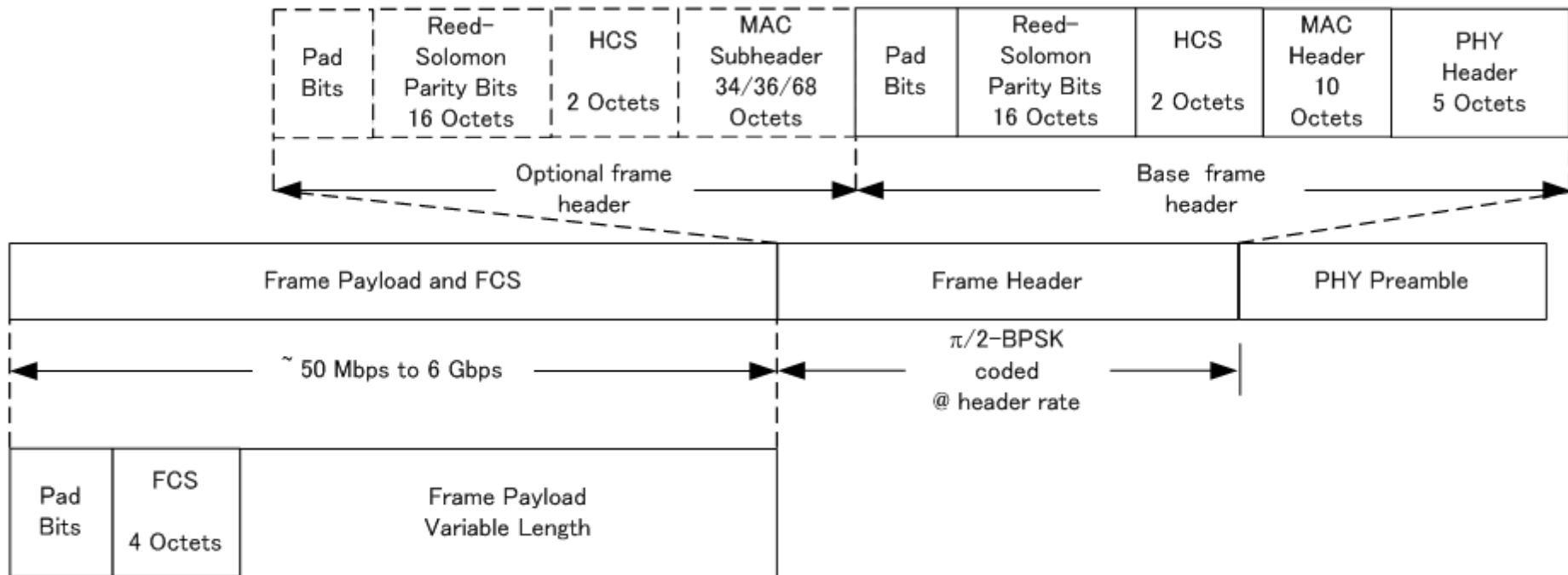
Performance improvement in various environments

1. Validation going on with the latest design parameters
2. PA, Header, Payload performance in various transmission environments
3. Transmission environments / channel models: need to be more applications specific: TG3c's system performance simulations for CFP used: CM 5.1 (Kiosk model, LOS), CM2.3 (Residential, NLOS), Residential LOS, AWGN
4. Transmission range
 - i. Common mode: 10 m in "NLOS" environments (two NLOS model discussed at TG3c – CM2.3 (eliminated LOS component in LOS channel model), NLOS channel transmitting from one room to the other passing through door/wall
 - ii. Kiosk /Synch and Go mode: 1 to 2 m in LOS
 - iii. PC peripheral: up to 3 m in LOS and NLOS
 - iv. Other applications: ?
5. Transmission rate: application specific
6. PA, Header, Payload performance: investigated at specific transmission rates as well

Design parameter alignment among PHYs

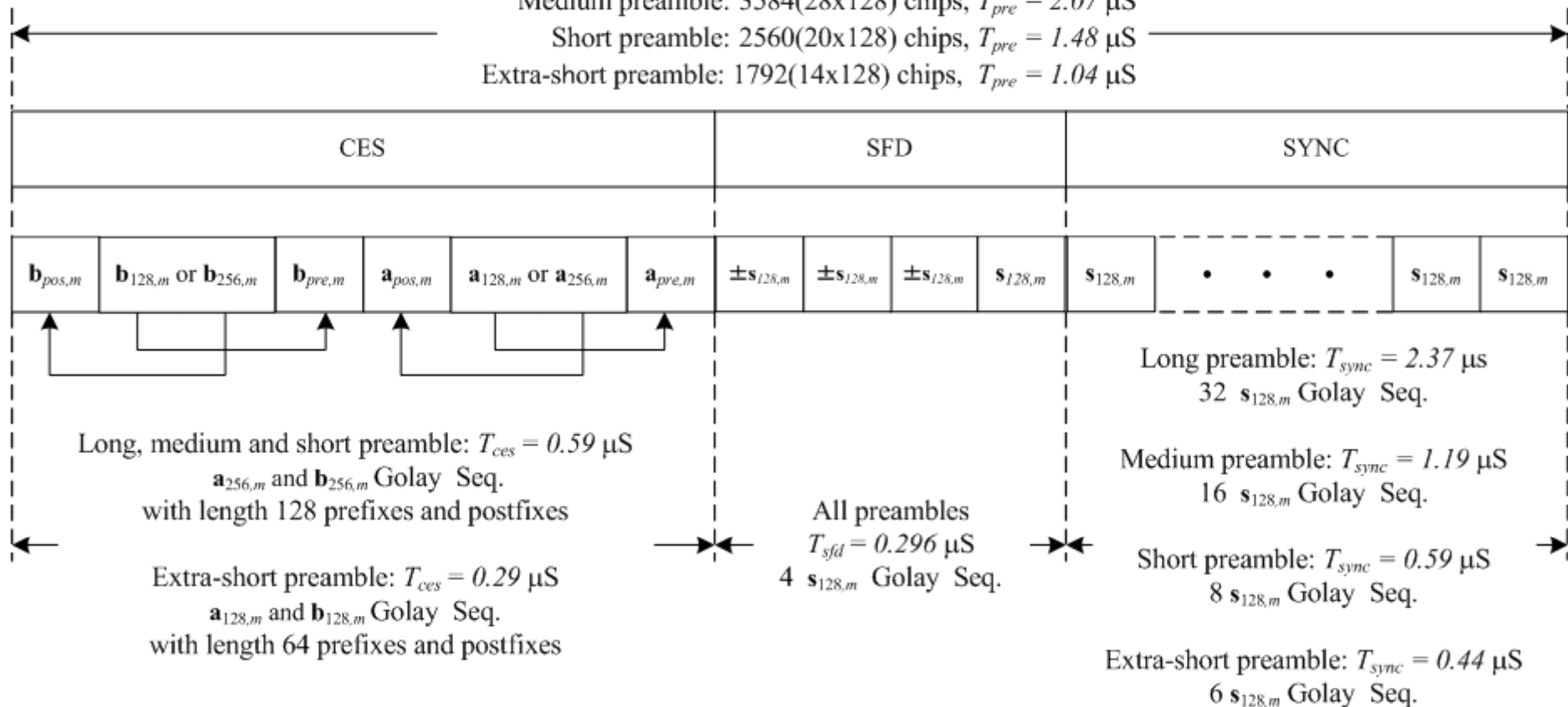
1. MAC for all PHYs
2. Common mode for all PNC capable devices regardless PHYs
3. Single Carrier and HSI OFDM have been aligning design parameters a lot including:
 - i. Preamble, Header, FEC (if HSI OFDM deploys RS (252, 236) for outer code, SC will consider to change RS (255, 239) to RS (252, 236), and so on)
4. Updated design parameters will be presented in Hawaii meeting

Current SC PHY Frame Format



Preamble Design

Long preamble: 5632(44x128) chips, $T_{pre} = 3.26 \mu\text{S}$
 Medium preamble: 3584(28x128) chips, $T_{pre} = 2.07 \mu\text{S}$
 Short preamble: 2560(20x128) chips, $T_{pre} = 1.48 \mu\text{S}$
 Extra-short preamble: 1792(14x128) chips, $T_{pre} = 1.04 \mu\text{S}$



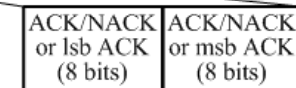
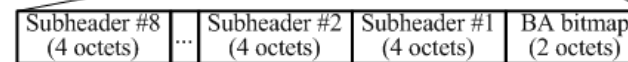
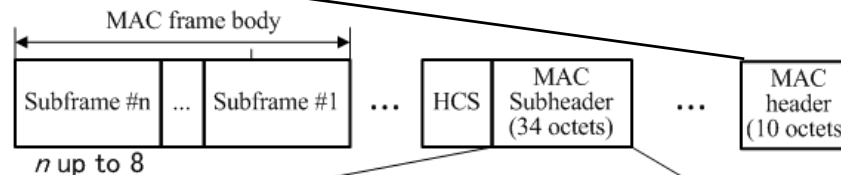
Header Designs

PHY Header

bits: 36-39	34-35	33	32	30-31	10-29	5-9	4	0-3
Reserved	PW length ID	Low latency mode	BF ID	Preamble type	Frame length	MCS	AGG	Scrambler seed ID

MAC Header

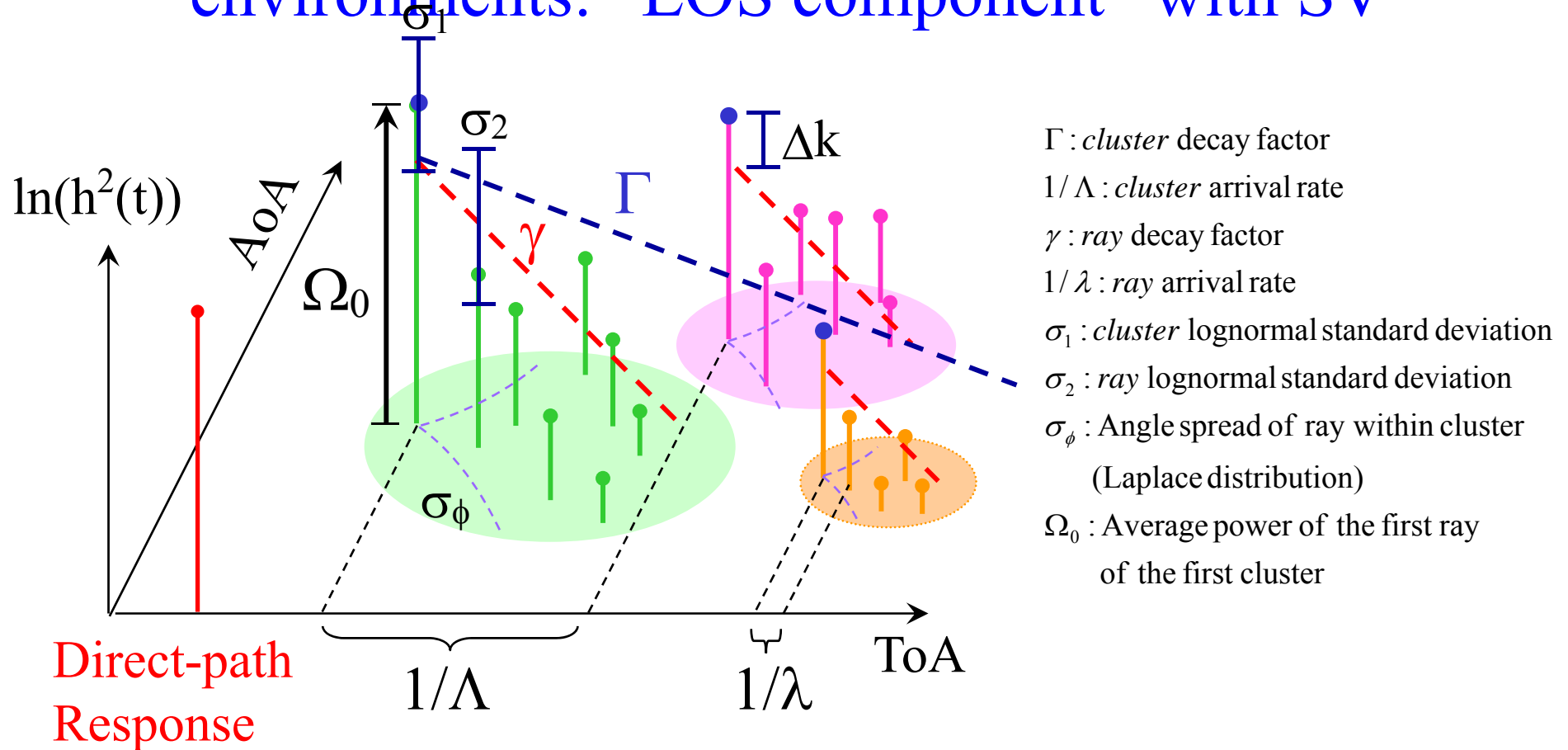
Octets	1	3	1	1	2	2
	Stream index	Fragmentation control	SrcID	DestID	PNID	Frame control



MAC Subheader For Standard Aggregation

Reserved (5 bits)	Last fragmentation (1 bit)	MSDU offset (3 bit)	Skewed Constellation mode (1bit)	Subframe information (2 bits)	Subframe length (11 bits)	Resolution indication (1 bit)	Retry bit (1 bit)	Retransmission (1 bit)	FCS information (1 bit)	MCS information (5 bits)
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TSV channel model for LOS and NLOS environments: “LOS component” with SV



Small Rician factor Δk and Ω_0 are necessary for TSV model

Created 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**

System Performance Evaluation : **Four (4) Different Environments**

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

System Simulation - RFP

- **Bit rate – PAR requirement: 1 Gbps or higher**

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