Telecommunications and Information Exchange Between Systems

ISO/IEC JTC 1/SC 6

Document Number:	N14181
Date:	2010-01-13
Replaces:	
Document Type:	Liaison organization contribution
Document Title:	Ecma-392 Wireless Communications using Television White Spaces (TVWS)
Document Source:	Ecma International
Project Number:	
Document Status:	For consideration at the SC 6 meeting in Barcelona.
Action ID:	FYI
Due Date:	
No. of Pages:	33

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Ecma-392 standard: Overview, and related regulatory and industry status

Kiran Challapali

Presentation outline

Ecma-392: Wireless Communications using Television White Spaces (TVWS)

- *Scope, applications supported*
- *Regulatory status worldwide*
  - **Ecma-392 approach to worldwide applicability**
- *A brief overview of the Ecma-392 standard*
  - **Related work**

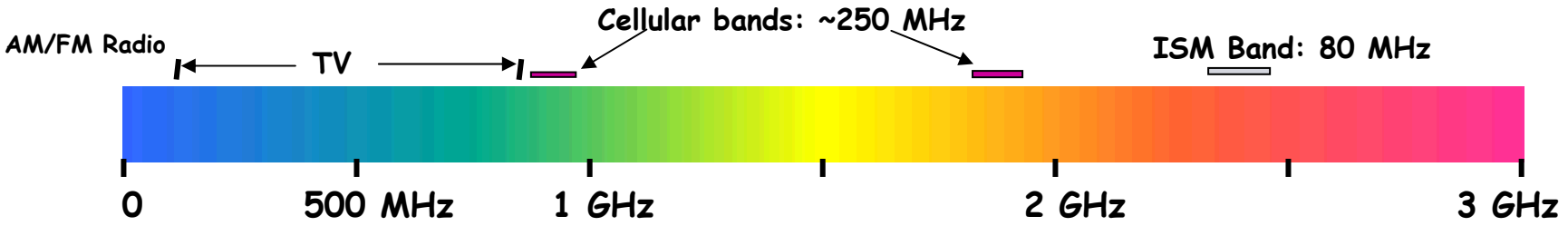
Demo: A demonstration of prototype television white spaces system

- *Showing streaming of high-definition video, an example*

Television White Spaces (TVWS)

Television white spaces are parts of the broadcast television spectrum in which regulatory rules allow (or will allow) unlicensed radio transmitters to operate at locations where that spectrum is not being used by licensed services.

This is typically below 700 MHz.



Ecma-392 – Salient features

Scope: Wireless communications using TVWS

- *Physical Layer (RF and Baseband);*
- *MAC layer (Media Access Control);*
- *Protocol and mechanisms for coexistence.*

The Ecma Standard aims to serve a broad range of applications, including multi-media distribution and internet access

- *Personal/portable device types operating in TV white spaces*
- *Robust support for real-time traffic*
- *Efficient design, even for long-range applications*

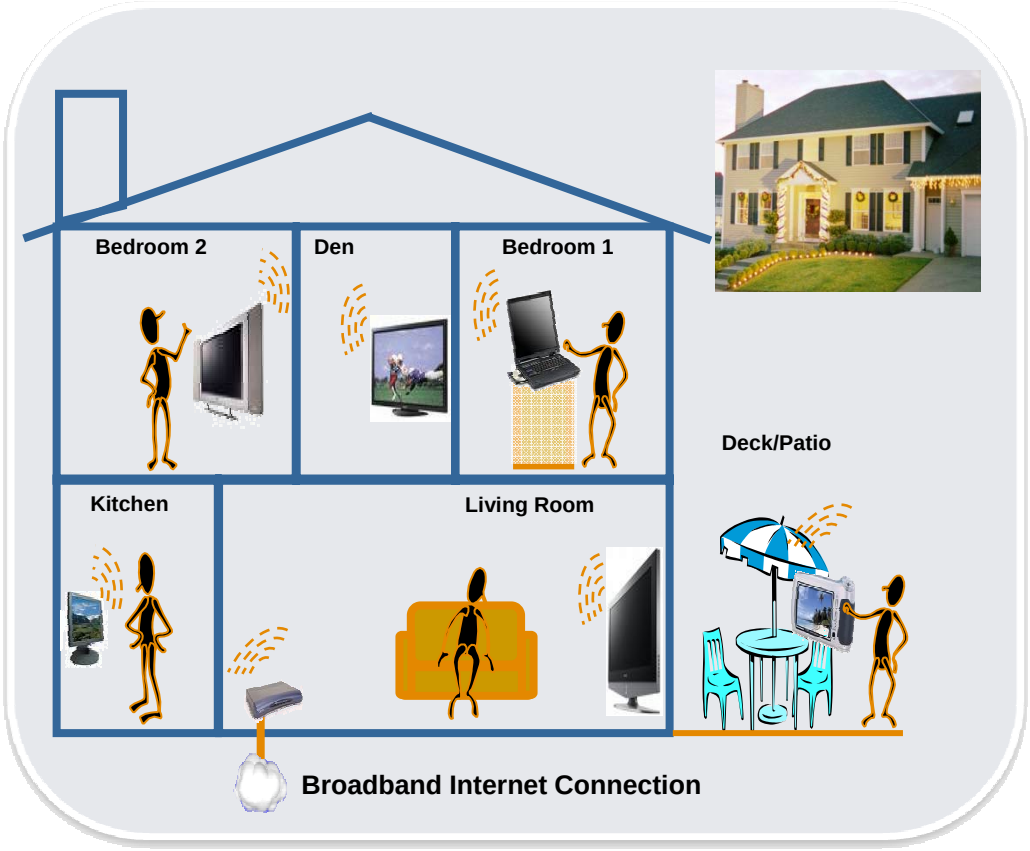
Adaption to worldwide regulatory requirements

- *This standard takes a toolbox approach*

Whole home video application

Television white spaces will enable wireless distribution of high-quality high-definition television for whole home, vastly improving the DTV experience.

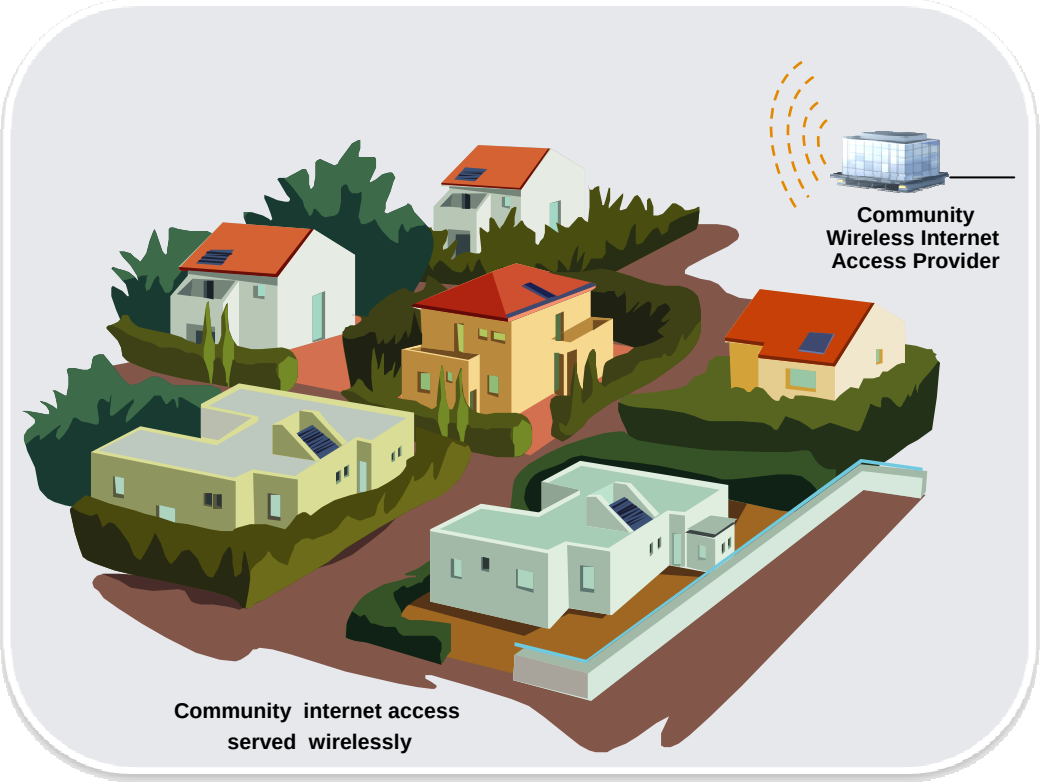
The new standard will provide reliable and robust coverage anywhere in a home, while consuming much lower power.



Community internet access application

Television white spaces will provide more widely available and cost effective access to the internet in underserved markets.

The superior propagation characteristics provide much greater coverage range than existing unlicensed technologies.



Television White Spaces regulatory scenario

The major agencies and bodies involved in developing rules for the unlicensed use of TV WS are the FCC in the US, Office of Communications (Ofcom) in the UK and the Electronic Communications Committee (ECC) of CEPT in Europe.

US FCC released the final rules for 'Unlicensed Operation in the TV Broadcast Bands' on February 17, 2009.

UK Ofcom has made significant progress in developing regulations for the TV white spaces with a first consultation released on February 16, 2009, and a further statement in July 2009.

The ECC created the SE43 group which is tasked with defining the technical and operational requirements of operating in the TV white spaces.

Television White Spaces regulatory scenario (detailed)

US FCC

- *Final Rules: both geolocation/databases and sensing are mandatory.*
- *Multiple "Petitions for Reconsideration" filed.*
- *Public Notice inviting White Space database proposals released on Dec. 18, 2009. Proposals due on Jan 4, 2010, proceeding closes Feb. 18, 2010.*

UK Ofcom

- *Released first consultation in February 2009, with proposed thresholds of -116 dBm for DVB-T and -126 dBm for wireless microphones.*
  - **Separate geolocation / database and sensing only devices.**
- *Statement in July 2009 lowered DVB-T sensing threshold to -120 dBm.*

Europe CEPT SE-43

- *Activity started mid-late 2009, with first reports on sensing and geolocation/ database due in May 2010.*

Ecma-392 Overview: Physical Layer

Physical Layer design features

- *OFDM based system*
- *Channelization of 6, 7 and 8 MHz supported*
- *Multiple PHY data rates to support different applications and QoS requirements.*
- *Multiple cyclic prefixes for different channel conditions*
- *Supports full HD streaming using one TV channel*
- *Normal and burst modes to support different application types*
- *Low preamble overhead*
- *Hopping pilot pattern*
- *Enhanced retransmission scheme*
- *Multiple Antennae support*

Ecma-392 Overview: MAC Layer

Medium Access Control (MAC) Layer design features

- *MAC architecture: one unified superframe structure*
- *MAC architecture: operation modes are master, slave, peer*
- *Channel access: both reservation and contention based access*
- *QoS: Highly optimized QoS and efficient support for HDTV*
- *Incumbent protection: DFS and TPC based on geo-location/database and sensing*
- *Self-coexistence: between neighboring networks*
- *Self-coexistence: Use beacon exchange for coordination*
- *Security: supported*

Relation of Ecma-392 with spectrum regulation

Spectrum regulations require (or will require) the protection of incumbent users in order to operate in TV WS. These incumbent protection regulations may vary from one region to another.

Ecma-392 takes a toolbox approach and specifies a number of incumbent protection mechanisms

- *including DFS, TPC, and spectrum sensing, that may be adapted based on the regulatory requirements of a particular region.*
- *Geo-location/database access is out of the scope of this standard but the standard facilitates the use of information so obtained (e.g. available channel list) by the devices to protect incumbents.*

Related work: CogNeA

CogNeA: Cognitive Networking Alliance

- *The Alliance was announced on December 16th 2008*

Members:

- *ETRI (p), HP (p), Philips (p), Samsung Electro-Mechanics (p), British Telecom (p), Cambridge Consultants (c), Maxlinear (c) Georgia Electronic Design Center (GEDC) at Georgia Institute of Technology (c) and Motorola (c).*

The Alliance completed

- *Marketing and Technical Requirements Documents (before announcement)*
- *Technical Specification (v0.8)*

The technical specification (v0.8) was transferred to Ecma International in March 2009 for further development

CogNeA will continue to build the ecosystem for TVWS applications.

Other industry efforts and their impact

IEEE 802.11

- *PAR approved in Dec 2009 to start a TVWS Task Group, 802.11af*
- *Scope: modifications to 802.11 PHY and MAC, to meet the regulatory requirements for channel access and coexistence in the TV White Space*

IEEE 802.19

- *PAR approved in Dec 2009 to start a TVWS Task Group, 802.19.1*
- *Scope: The standard specifies mechanisms for coexistence among dissimilar or independently operated TV Band Device (TVBD) networks and dissimilar TV Band Devices.*

Initial Sponsor Ballot: 2012-12 and RevCom: 2013-12 for both

Other industry efforts and their impact contd'

IEEE P1900.4a

- *PAR approved in Mar 2009*
- *Scope: This standard amends the IEEE 1900.4 standard to enable mobile wireless access service in white space frequency bands without any limitation on used radio interface (physical and media access control layers, carrier frequency, etc) by defining additional components of the IEEE 1900.4 system*
- *Project 2011-02 for Initial Sponsor Ballot and 2011-09 for RevCom*

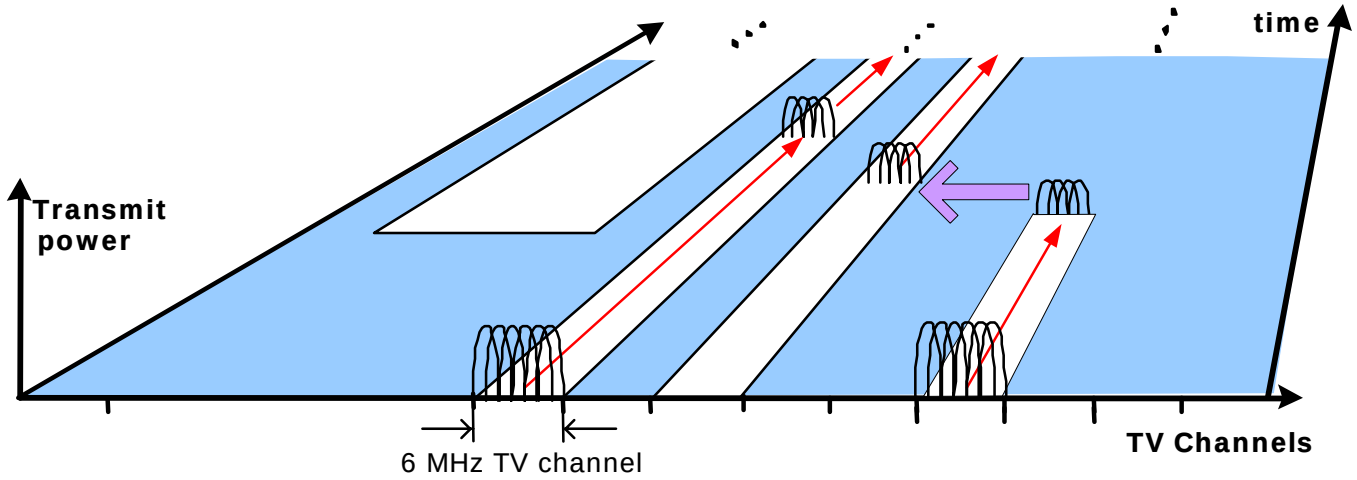
White Space Database Group

- *Group started in Feb 2009 by Google as an effort to standardize databases.*
- *Nine companies submitted proposals to the FCC on Jan. 4 for consideration to be database administrators, including Google.*

Potential value of white spaces

The potential value of white spaces has been variously estimated, generally seen as high.

Please see recent report commissioned by Microsoft



Television White Spaces prototype

DEMONSTRATION

Details of the Ecma-392 Physical and Medium Access Control specification.

BACKUP SLIDES

Please also see paper from more details:

"First Cognitive Radio Networking Standard for Personal/Portable Devices in TV White Spaces," *Accepted for publication in DySPAN 2010.*

Ecma-392: PHY design parameters

OFDM parameters for 6 MHz TVWS channel

- *Similar parameters defined for 7 and 8 MHz channels*

Parameter	Value
Subcarrier spacing, DF (KHz)	53.571
FFT period, T_{FFT} (ms)	18.667
Total number of subcarriers, N_{FFT}	128
Number of guard subcarriers, N_G (L, DC, R)	26 (13, 1, 12)
Number of used subcarriers, $N_T = N_D + N_P$	102
Number of data subcarriers, N_D	98
Number of pilot subcarriers, N_P	4
Signal bandwidth (MHz)	5.518

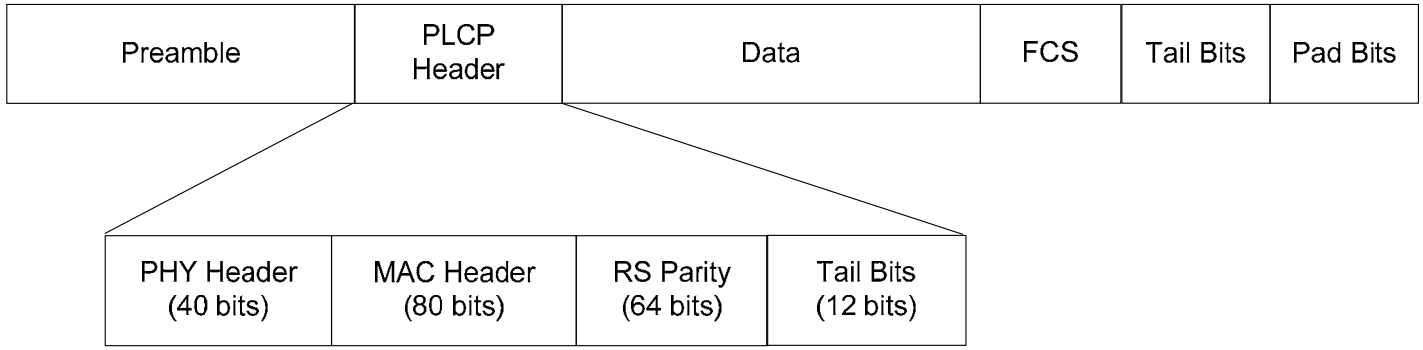
Ecma-392: PHY design contd'

Data Rates, for 6 MHz, Cyclic Prefix = 1/16 (1.167 us)

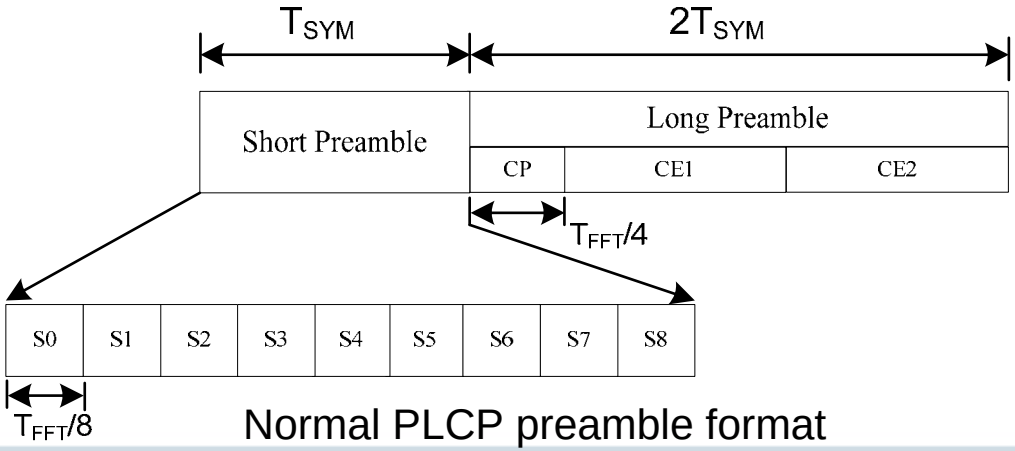
RATE R3 – R0	Modulation	Outer Coding	Inner Coding Rate	Data Rate (Mb/s)	Spectral Efficiency (bit/s/Hz)
0000 (0)	QPSK	(245,255,5)	1/2	4.75	0.79
0001 (1)	QPSK	(245,255,5)	2/3	6.33	1.05
0010 (2)	16-QAM	(245,255,5)	1/2	9.49	1.58
0011 (3)	16-QAM	(245,255,5)	7/12	11.08	1.85
0100 (4)	16-QAM	(245,255,5)	2/3	12.66	2.11
0101 (5)	64-QAM	(245,255,5)	1/2	14.24	2.37
0110 (6)	64-QAM	(245,255,5)	7/12	16.62	2.77
0111 (7)	64-QAM	(245,255,5)	2/3	18.99	3.16
1000 (8)	64-QAM	(245,255,5)	3/4	21.36	3.56
1001 (9)	64-QAM	(245,255,5)	5/6	23.74	3.96
1010 – 1111 (10 – 15) Reserved					

Ecma-392: PHY design contd'

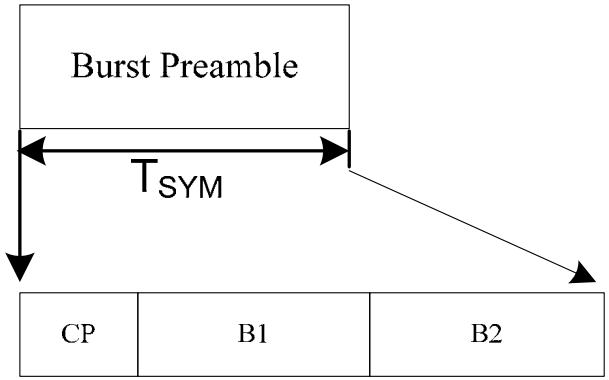
PPDU frame structure



PLCP preamble: designed to support burst transmission



Normal PLCP preamble format

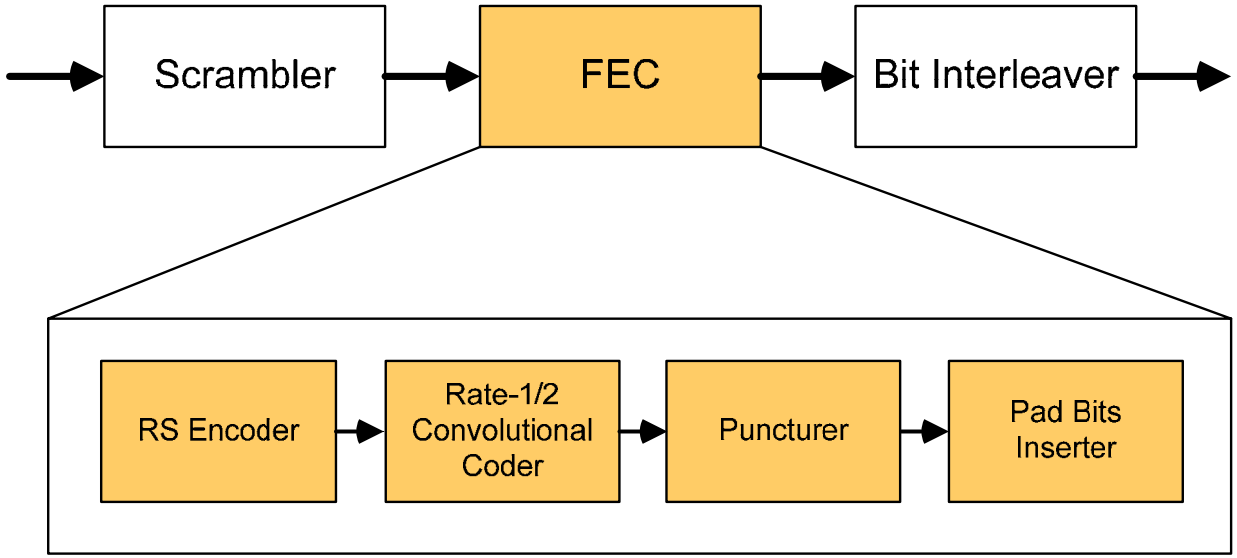


Burst PLCP preamble

Ecma-392: PHY design contd'

Forward Error Correction (FEC)

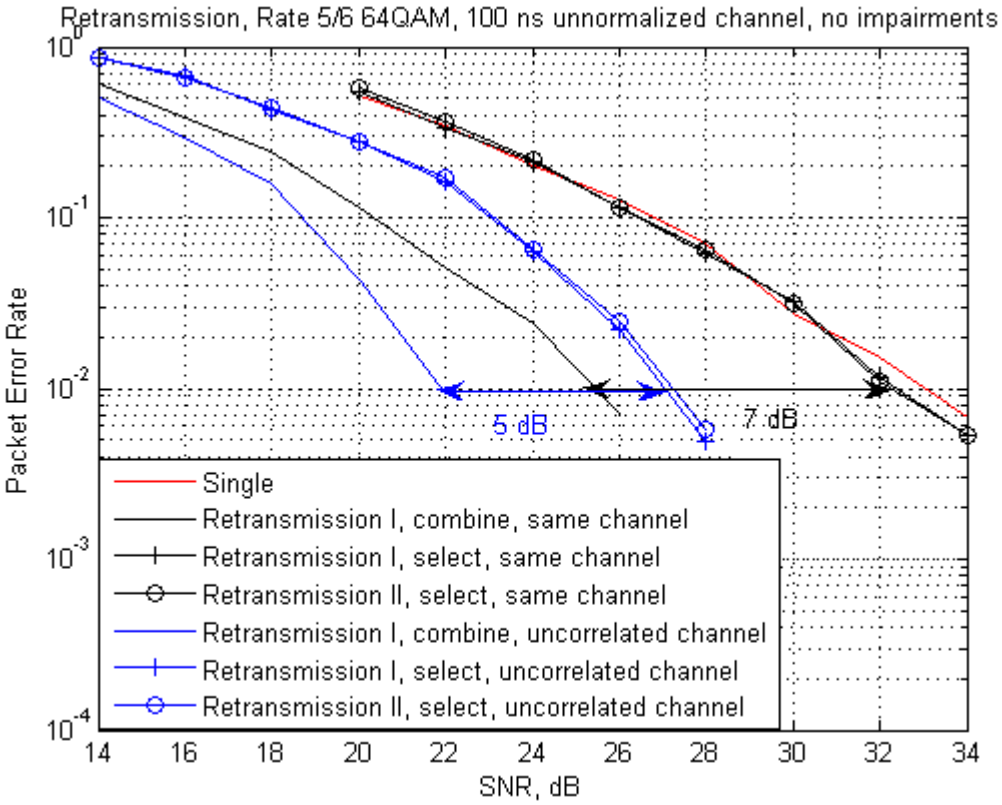
- *Reed-Solomon outer coding: (N = 255, K = 245, T = 5) using GF(256)*
- *Convolutional inner coding*



Ecma-392: PHY design contd'

Enhanced Retransmission

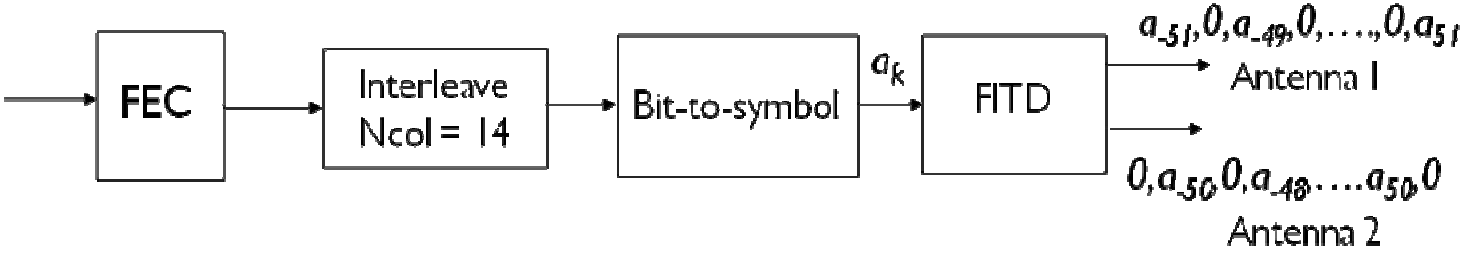
- *If a packet needs to be retransmitted, a different interleaver is used on the retransmission (Ncol = 7 instead of 14).*
- *Receiver can implement simple soft combining of the 2 transmissions for improved performance.*



Ecma-392: PHY design contd'

Multiple Antennae support (optional)

- *Devices may support three different types of multiple antenna schemes:*
  - **Frequency Interleaved Transmit Diversity (FITD) (2x2 or 2x1)**
  - **Alamouti Space Time Block Coding (STBC) (2x2 or 2x1)**
  - **Spatial Multiplexing (SM) (2x2)**
- *FITD optional at the transmitter but mandatory at all receivers to maintain robustness of the header and beacon and compatibility between devices with different capabilities*

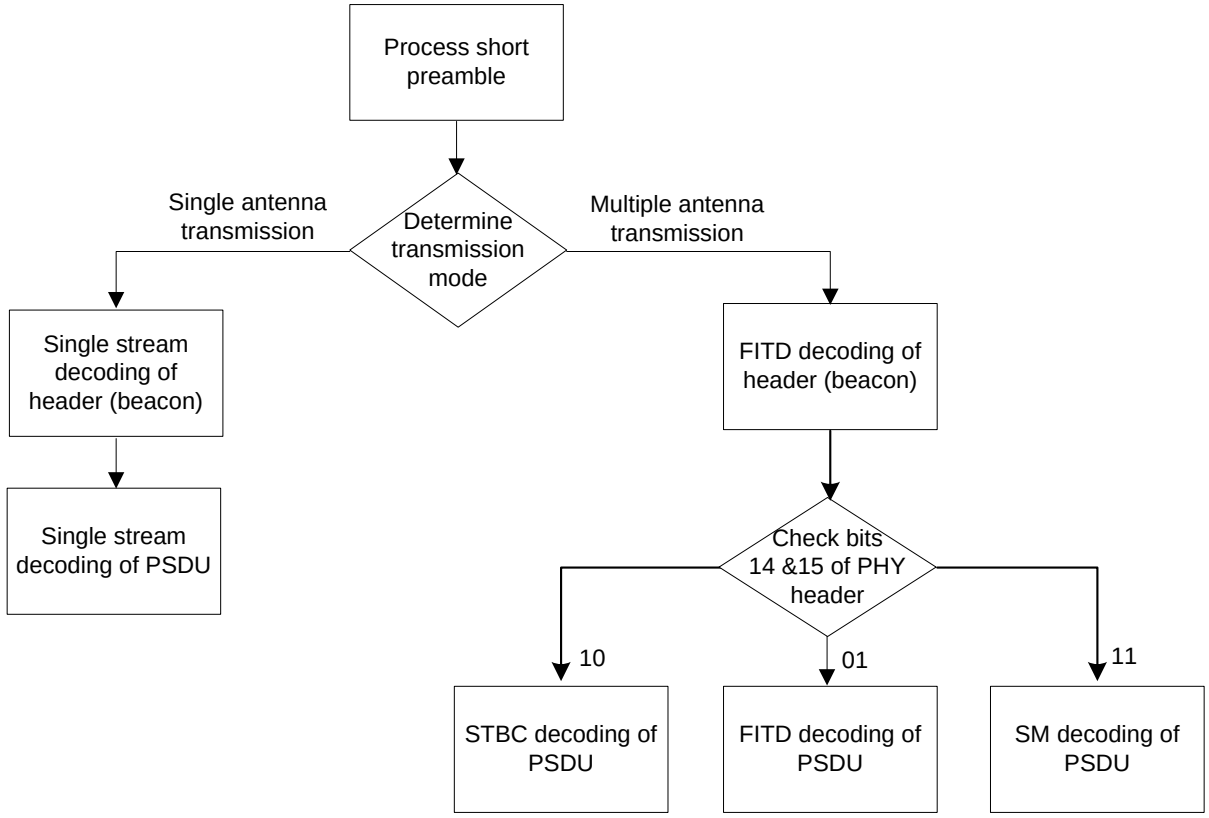


Block diagram of Frequency Interleaved Transmit Diversity (FITD) transmission scheme

Ecma-392: PHY design contd'

Multiple antennae PLCP header specification

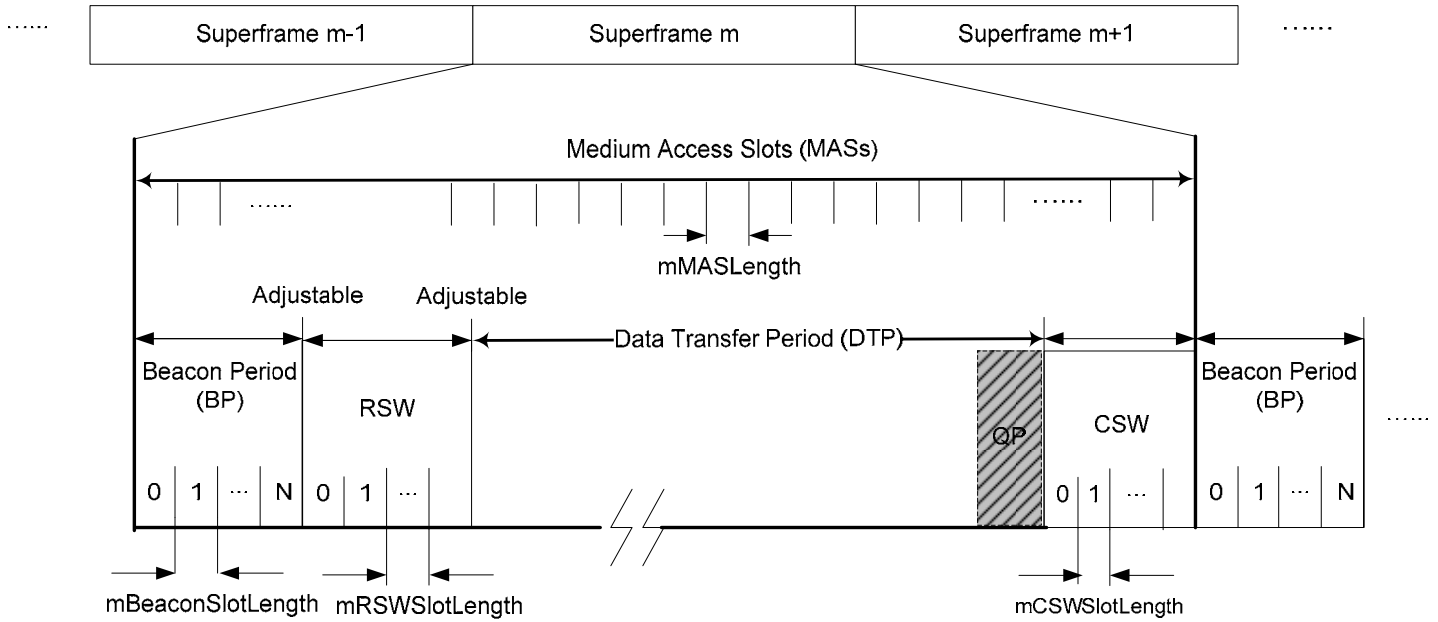
- *Preamble sequence indicates whether 2 antennae used at transmitter*
- *PLCP header transmitted using FITD if 2 antennae used*
- *PHY header indicates the mode (FITD, STBC or SM) for the data payload*



Ecma-392: MAC design

Superframe Structure

- *Beacon Period (BP), Data Transfer Period (DTP), Contention Signaling Window (CSW)*
- *Reservation based Signaling Window (RSW) for master-slave operation, optional for peer-to-peer*
- *Master device and Peer device participates in beaconing*



Ecma-392: MAC design contd'

Reservation based Channel Access during DTP

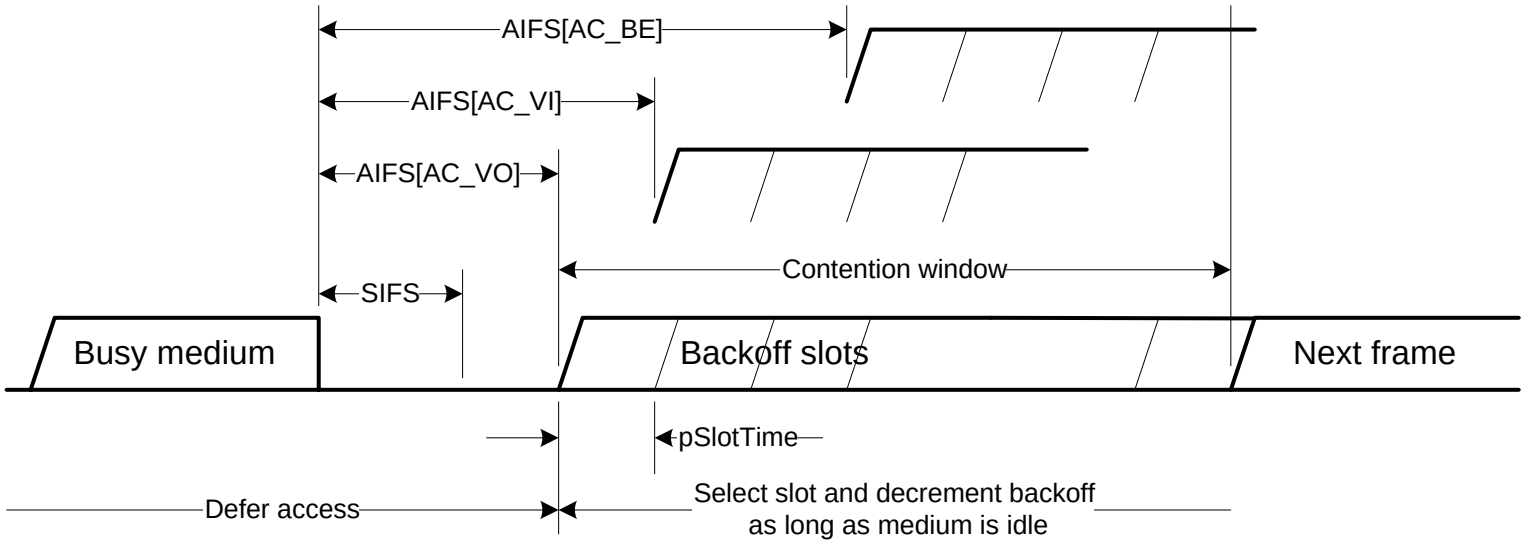
- *Beaconing device negotiates and maintains reservation through beacon*
- *Nonbeaconing slave device uses RSW for reservation*
- *Five reservation types:*

Reservation Type	Description
Alien BP	Prevents transmission during MASs occupied by an alien BP.
Hard	Provides exclusive access to the medium for the reservation owner and target; unused time should be released for PCA
Soft	Permits PCA, but the reservation owner has preferential access.
Private	Provides exclusive access to the medium for the reservation owner and target. Channel access methods and frame exchange sequences are out of scope of this specification; unused time should be released for PCA
PCA	Reserves time for PCA. No device has preferential access.

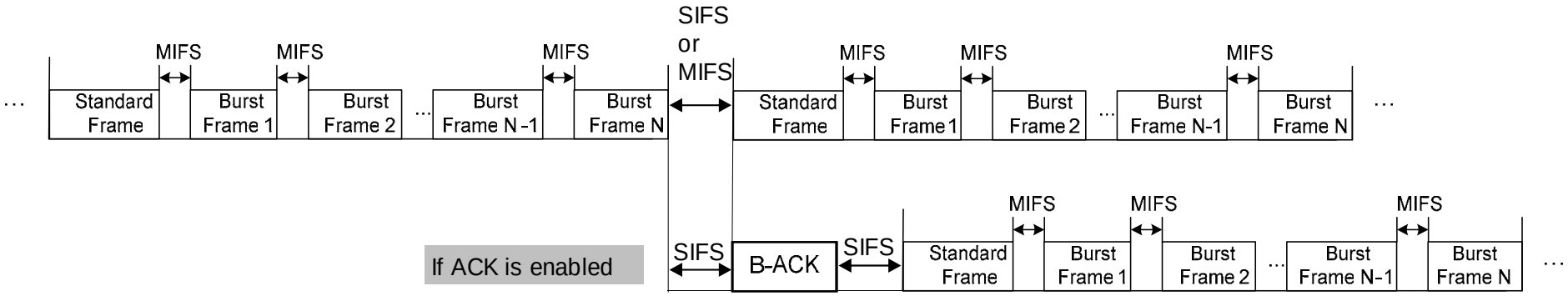
Ecma-392: MAC design contd'

Contention based Channel Access during DTP

- *All MASs unreserved or reserved for PCA can access via prioritized CSMA*
- *Four Access Categories (AC): Voice (VI), Video (VO), Best effort (BE), Background (BK)*



Aggregation, Burst transmission and Block-acknowledgement (B-ACK)

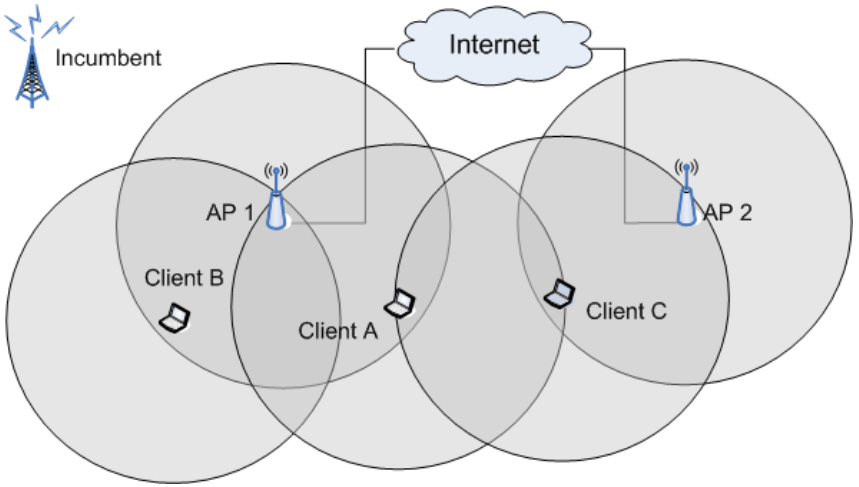


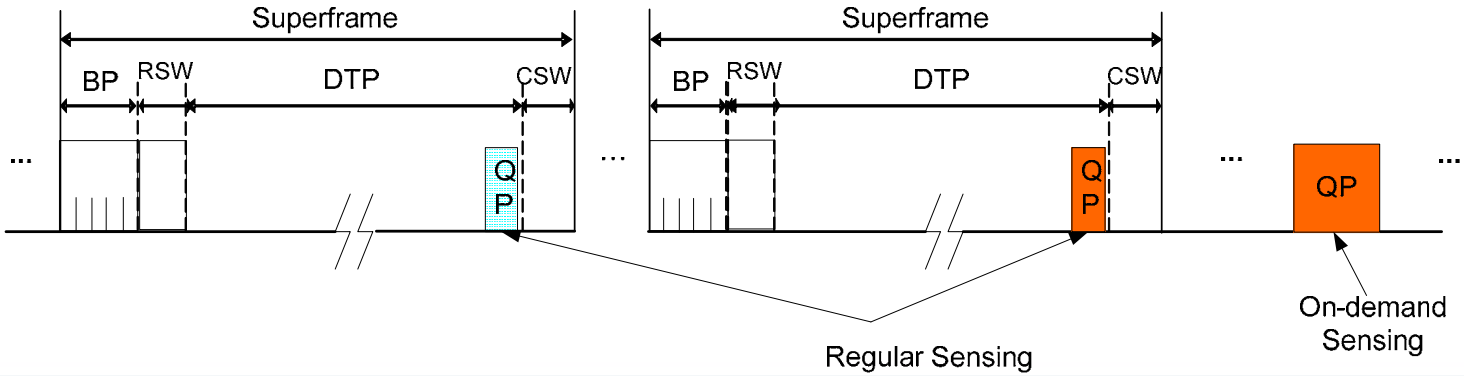
Note:
MIFS: minimum inter-frame space, used for burst transmissions
SIFS: shortest inter-frame space
Standard frame: frame with standard preamble
Burst frame: frame with burst preamble

Ecma-392: MAC design contd'

Incumbent protection

- *Establish extended Quiet Zone for reliable sensing*
- *Diagrams show quiet zones in superframe (below) and neighboring networks (right)*





Ecma-392: MAC design contd'

Incumbent protection

- *Dynamic Frequency Selection*
  - **With input from channel measurement and/or geo-location database**
  - **In a master-slave network, the master coordinates DFS. While in a peer-to-peer network, any peer device may initiate DFS with the new channel setup parameters pre-agreed.**

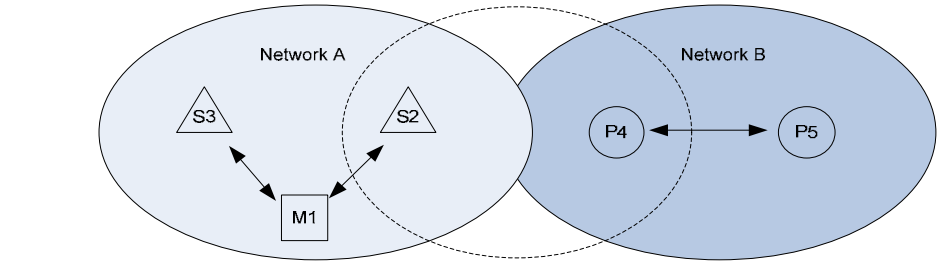
Transmission Power Control

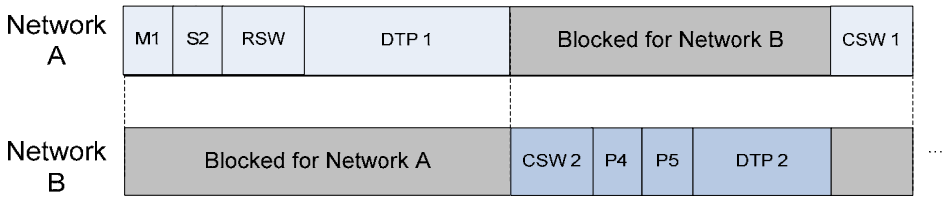
- *Transmission power limit reduced from 100mW down to 40mW when operating in adjacent channel*

Ecma-392: MAC design contd'

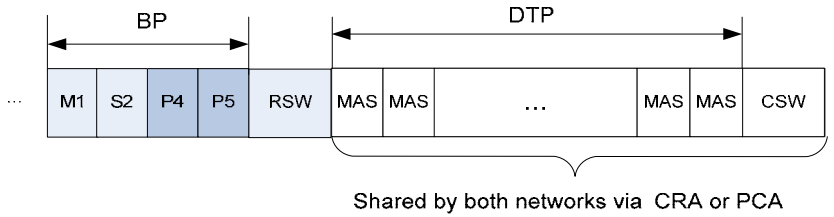
Self coexistence

- *Superframe merge*
- *Beaconing promotion (for slave device)*





Case 1: Non-merged Superframe



Case 2: Merged Superframe

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