**IEEE P802.15**

**Wireless Personal Area Networks**

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| Abstract | [TG4r - technical guidance for PHY proposals.] |
| Purpose | [Working document for the PAR to the P802.15 Working Group.] |
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**Abbreviations**

The following abbreviations are used in this document.

ATSC Advanced Television Systems Committee

CEPT European Conference of Postal and Telecommunications Administrations

CRTC Canadian Radio-Television and Telecommunications Commission

dB Decibels

DVB-T Digital Video Broadcasting — Terrestrial

ECC Electronic Communications Committee in Europe

EIRP Equivalent Isotropically Radiated Power

ERC European Radiocommunications Committee in Europe

ERP Effective Radiated Power

FCC Us Federal Communications Commission

FD Fixed Device

GDB Geo-Location Database

GSM Global System for Mobile Communications, originally Groupe Spécial Mobile

GHz Gigahertz (1 GHz = 109 Hertz or a frequency of one billion cycles per second)

IDA Info-Communications Development Authority in Singapore

ITU International Telecommunication Union

LOS Line-Of-Sight

M2M Machine To Machine

MAC Media Access Control Layer

MHz Megahertz (1 MHz = 106 Hertz or a frequency of one million cycles per second)

NLOS Non-Line-Of-Sight

NTSC National Television System Committee

PAR Project Authorization Request

PDP Power Delay Profile

PHY Physical Layer

PICS Protocol Implementation Conformance Statement

PPD Personal/Portable Device

TG4m Ieee802 Working Group 15 Task Group m

TGD Technical Guidance Document

TVBD TV Band Device

TVWS TV White Space

UHF Ultra High Frequency

VHF Very High Frequency

WPAN Wireless Personal Area Network

WPAN-WS Wireless Personal Area Network – White Space

WSD White Spaces Device

TG4r Technical Guidance Document (TGD)

# Introduction

## Purpose

This document provides technical guidance by summarizing parametrically the key PHY characteristics and any necessary MAC changes identified in consideration of WPAN application and regulatory requirements. The technical summary on PHY and MAC parameters are intended to provide guidelines to the proposals for Task Group 802.15.4r. It should be noted that the main objective of this document is to provide technical recommendations for designing and evaluating potential proposals, and should not be understood as mandatory requirements for the system design.

The intent of the task group is to use a flexible and efficient process that provides sufficient descriptions of the technical requirements to enable relevant responses, with efficiency of effort while meeting the critical need for a timely standard. The TG4r task group will use this document to help qualify MAC and PHY protocol related proposals.

The responsibility of the TG4r is to produce a quality and timely standard specification. To achieve this goal, TG4r will consider the technical recommendations in this document to assist the preparation and evaluation of technical proposals.

## Methodology

The methodology provides recommendations to defining a minimal set of features, characteristics, performance and constraints to be considered. This document provides:

* A functional view of the PHY characteristics, in the form of specific parameters which define externally verifiable performance and interoperability characteristics; and
* Application/performance description~~s~~ that characterizes the types of WPAN applications and the derived performance characteristics.

In preparing proposals, this can be used as a framework to produce a concise summary of the characteristics of each given proposal, and will allow the group to see the similarities and differences in submitted proposals.

# Requirements Discussion

## Summary of PAR

### Title:

IEEE Standard for Local and Metropolitan Area Networks Part 15.4: Low Rate Wireless Personal Area Networks (LR-WPANs) Amendment: Distance Measurement Techniques

### Scope:

This amendment integrates wireless ranging techniques and technologies, including those existing within IEEE 802.15.4 and new to IEEE 802.15.4, into a consistent, standardized method addressing the needs of a wide range of applications and PHYs and enabling the interoperability of devices by different vendors using this method. Additionally, the amendment defines necessary MAC and PHY extensions which enable common radio based distance measurements.

### Need for the Project:

The IEEE 802.15.4 standard addresses many markets where there is a substantial need for both communications and determination of distances between two devices, i.e. ranging. The following is a representative set of application examples: covering a variety of accuracies, from centimeters to many 10s of meters:

* a retailer needs to determine the proximity of a shopper to specific points/displays and then send the appropriate data
* a medical environment needs to determine the proximity of a staff person to a desired item and inform that staff as to specific data for that item
* lighting control networks need to determine the range between devices to facilitate binding for control, e.g. a specific switch to a specific light fixture
* TV whitespace networks require location awareness via accurate ranging from multiple devices to determine available frequency bands
* Railroad services desire the ability for a locomotive to determine the distance to various devices for identification, etc.

Given that various regions and applications are served by numerous frequency bands following different regulatory rules, modulations, and data rates; complexity and confusion can only be avoided if ranging data is made available to higher layers in a consistent manner for location

determination mechanisms. Hence there is a need for a Real Time Locating System (RTLS) which works with the diverse PHYs of IEEE 802.15.4.

The PAR can be found on the IEEE802 web site: (<https://development.standards.ieee.org/P866200033/par>).

## High Level Requirements Overview

* Key Characteristics
	+ Resolution (distance,dBm, angle,time), Position Accuracy, Acquisition Time
	+ Acquisition Speed – update rate, measurement time
	+ Range,
	+ Support for mobility, maximum velocity
	+ …
	+ Dimensions (x,y,z,t)
	+ Position (absolute and relative): P(x,y,z,t) = V\*t+P0
	+ Environment (indoor, outdoor), speed variances
	+ Intended frequency bands
* Leverage a combination of radio signal parameters:
	+ Signal Strength (RSSI),
	+ Phase and Phase Difference,
	+ Time,
	+ ...
* Classes of Devices
	+ Fixed and mobile
	+ Stationary and Non-Stationary
* Type of operation
	+ Device to device
	+ Device to network of devices
	+ Active radar
	+ Passive radar
* level results reporting
	+ Specifics of the Measurement :– turn-around-time, phase difference
	+ Derived Parameters: Distance
	+ Higher level equals measurement technique independent
	+ Ranging down to lower level (measurement technique dependant – raw data)
* Positioning
	+ Triangleation
	+ Trilateration
* Collateral Support (Applications)
	+ Add. Sensors (accelerometer, air pressure, orientation, gyrometer, magnetometers, other sensors)
	+ Access Geolocation Database
* Use available frequency bands (narrow band, wide band approaches, multi-band approach) in compliance with local regulatory requirements)
* Various different distributions of complexity to achieve low power (tradeoffs between infrastructure devices and mobile objects; unidirectional, bi-directional, blink and network time)

From the PAR and general procedural rules, key overall goals and requirements of this project can be summaried as follows:

* [Look at TG 4m]
* The amendment complies with the P802.15.4r PAR and 5 Criteria.
* The amendment will include a PICS proforma.
* The amendment should provide technical mechanisms to enable direct device-to-device communications in both star and peer-to-peer networks.

### Application Requirements Matrix

|  |  |  |
| --- | --- | --- |
| **Application** | **Key Parameters** | **Reference** |
|  | Resolution | Acq.Speed | Range | Dimensions | Mobility | TBC |
| Lighting | <1m | 1/s | <50m | 1-4 (x,y,z,t) | None |  |
| TWS(min. Req. by regulatory | +/-50m min.  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| Applications using TVWS | DMT and TBC | TBC |
| Medical | TBC | TBC |
| Lighting |  |  |
| Smart Energy |  |  |
|  |  |  |

## Frequency Band Related Regulations

### Summary of Regulations

Incorporate TWS

Enable DMT as widely as possible

### Regulatory Requirements

There are several regulatory bodies including the Federal Communications Commission (FCC) in the U. S, Electronic Communications Committee (ECC) under the European Conference of Postal and Telecommunications Administrations (CEPT) in EU, Ofcom in the U. K., and Industry Canada in Canada. Based on the rules from the FCC (refer to FCC 10-174, Second Memorandum Opinion and Order, September 2010) and ECC (refer to ECC Report 159, January 2011), a set of regulatory requirements for white space communications is identified. Therefore whenever new rules are established or future changes of rules from any regulatory bodies are made, they should be considered for the proposals.

Requirements identified from FCC rules

A set of common regulatory requirements for white space communications from the rules of FCC are listed as follows:

Frequency bands:

* Devices shall be operatied in any of the regionally available frequency bands on a license-exempt basis.

Types of devices:

Transmit power:

Transmit power related requirements:

* All devices may incoporate transmit power control to limit their operating power to the minimum necessary for successful communication.

Geolocation requirements:

E.G. TVWS

* Fixed devices
* Mode II personal/portable devices
* Mode I personal/portable devices

Security:

***Requirements from ECC rules not identified in or different from the rules of FCC***

## Coexistence

The amendment should provide mechanisms to fulfil the requirements mandated in different regulatory domains, particularly in addressing the coexistence with users protected by the regulations.

Coexistence among systems within the same band should be addressed fulfilling the requirements of the coexistence assurance document.

The importance of successful coexistence between 802 wireless systems has been an increasingly important concern within (and between) 802 wireless working groups. Future 802.15.4 devices supporting DMT must successfully operate in proximity to other wireless devices. Coexistence may be viewed from two aspects - tolerance to other systems in the same space and impact on other systems in the same space, including transmitters which might intentionally share the band and unintentionally impact the band. These evaluations and recommendations may be included as a part of the coexistence assurance document.

Thoughts:

* The drafters should make a reasonable attempt to establish coexistence with the majority of currently deployed systems.
* The proposers shall provide information relative to coexistence with existing systems

## Interoperability

Proposals should discuss levels of interoperability. Support for previously deployed systems is encouraged but not required.

As guidance to the drafters of the standard, the standard should be written such that there may be behavior that will facilitate interoperability and coexistence with existing devices in the field.

Thoughts:

* Investigate need for clarification relative to interoperability for existing PHY’s assuring independent implementations to achieve results of a certain minimum quality.

## Complexity and Cost considerations

The PHY(s) supporting DMT following TG4r should be realizable by low complexity implementations to minimize cost and to enable mass adoption of the standard. The cost considerations are not only for low capital expenditure, but also low operational expenditure. One of this proposed amendment’s objectives includes low cost installation with minimal to no operator intervention.

Cost effective communication and simple modulation techniques are potential mechanisms that help meet the low complexity, low cost requirements.

## Channel Characteristics

To evaluate the proposed systems, channel models are needed which represent target environments given for applications considered for TG4r.

### Path Los Channel Models (for link budget calculation)

1. *Line-of-Sight (LOS) Propagation Model*

***b.*** *Non-Line-of-Sight (NLOS) Propagation Model*

### Channel Impulse Response Model (for PHY simulations)

1. For indoor scenarios

1. For Outdoor scenarios

# Definitions

The following provides definition of specific terms in the context of discussion with respect to TG4m applications and PHY proposals**.**

Available Channel:

Fixed device:

Geo-location capability:

# References