



**IEEE Recommended Practice for  
Information technology—  
Telecommunications and information  
exchange between systems—  
Local and metropolitan area networks—  
Specific requirements**

**Part 15.5: Mesh Topology Capability in  
Wireless Personal Area Networks (WPANs)**

---

**IEEE Computer Society**

Sponsored by the  
LAN/MAN Standards Committee

---

IEEE  
3 Park Avenue  
New York, NY 10016-5997, USA

8 May 2009

**IEEE Std 802.15.5™-2009**

Currently in preview, click buy full version

**IEEE Recommended Practice for  
Information technology—  
Telecommunications and information  
exchange between systems—  
Local and metropolitan area networks—  
Specific requirements**

**Part 15.5: Mesh Topology Capability in  
Wireless Personal Area Networks (WPANs)**

Sponsor

**LAN/MAN Standards Committee  
of the  
IEEE Computer Society**

Approved 19 March 2009

**IEEE-SA Standards Board**

**Abstract:** This IEEE recommended practice defines the architectural framework that enables WPAN devices to promote interoperable, stable, and scalable wireless mesh topologies and, if needed, to provide the amendment text to the current WPAN standards that is required to implement this recommended practice.

**Keywords:** address assignment, block addressing, broadcast, carrier sense multiple access/collision avoidance, high-rate WPAN mesh, HR-WPAN mesh, multicast, low-rate WPAN mesh, LR-WPAN mesh, mesh, mesh coordinator, server routing, wakeup interval, multiple hop, multi-hop, local link state, logical tree, portable, portability, power saving, reliable broadcast, sensor network, traceroute, unicast, wireless PAN, WPAN

---

The Institute of Electrical and Electronics Engineers, Inc.  
Park Avenue, New York, NY 10016-5997, USA

Copyright © 2009 by the Institute of Electrical and Electronics Engineers, Inc.  
All rights reserved. Published 8 May 2009. Printed in the United States of America.

IEEE and 802 are registered trademarks in the U.S. Patent & Trademark Office, owned by the Institute of Electrical and Electronics Engineers, Incorporated.

PDF: ISBN 978-0-7381-5917-1      STD95913  
Print: ISBN 978-0-7381-5918-8      STDPD95913

*No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.*

**IEEE Standards** documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE-SA) Standards Board. The IEEE develops its standards through a consensus development process, approved by the American National Standards Institute, which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of the Institute and serve without compensation. While the IEEE administers the process and establishes rules to promote fairness in the consensus development process, the IEEE does not independently evaluate, test, or verify the accuracy of any of the information or the soundness of any judgments contained in its standards.

Use of an IEEE Standard is wholly voluntary. The IEEE disclaims liability for any personal injury, property or other damage, of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, or reliance upon this, or any other IEEE Standard document.

The IEEE does not warrant or represent the accuracy or content of the material contained herein, and expressly disclaims any express or implied warranty, including any implied warranty of merchantability or fitness for a specific purpose, or that the use of the material contained herein is free from patent infringement. IEEE Standards documents are supplied **“AS IS.”**

The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE Standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard. Every IEEE Standard is subjected to review at least every five years for revision or reaffirmation. When a document is more than five years old and has not been reaffirmed, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE Standard.

In publishing and making this document available, the IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity. Nor is the IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing this, and any other IEEE Standards document, should rely upon his or her independent judgment in the exercise of reasonable care in any given circumstances or, as appropriate, seek the advice of a competent professional in determining the appropriateness of a given IEEE standard.

**Interpretations:** Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretations is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of concerned interests, it is important to ensure that any interpretation has also received the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to interpretation requests except in those cases where the matter has previously received formal consideration. A statement, written or oral, that is not prepared in accordance with the IEEE-SA Standards Board Operations Manual shall not be considered the official position of IEEE or any of its committees and shall not be considered to be, nor be relied upon as, a formal interpretation of the IEEE. At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position, explanation, or interpretation of the IEEE.

Comments for revision of IEEE Standards are welcome from any interested party, regardless of membership affiliation with IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Comments on standards and requests for interpretations should be submitted to the following address:

Secretary, IEEE-SA Standards Board  
445 Hoes Lane  
Piscataway, NJ 08854  
USA

Authorization to photocopy portions of any individual standard for internal or personal use is granted by The Institute of Electrical and Electronics Engineers, Inc., provided that the appropriate fee is paid to Copyright Clearance Center. To arrange for payment of licensing fee, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; +1 978 750 8400. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

## Introduction

This introduction is not part of IEEE Std 802.15.5-2009, IEEE Recommended Practice for Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements.

This recommended practice provides the architectural framework enabling WPAN devices to promote interoperable, stable, and scalable wireless mesh topologies. This recommended practice is composed of two parts: low-rate WPAN mesh and high-rate WPAN mesh networks. The low-rate mesh is built on IEEE 802.15.4 MAC, while high rate mesh utilizes IEEE 802.15.3/3b MAC. Common features of both meshes include network initialization, addressing, and multihop unicasting. In addition, low-rate mesh supports multicasting, reliable broadcasting, portability support, trace route and energy saving function, and high-rate mesh supports multihop time-guaranteed service.

## Notice to users

## Laws and regulations

Users of these documents should consult all applicable laws and regulations. Compliance with the provisions of this standard does not imply compliance to any applicable regulatory requirements. Implementers of the standard are responsible for observing or referring to the applicable regulatory requirements. IEEE does not, by the publication of its standards, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

## Copyrights

This document is copyrighted by the IEEE. It is made available for a wide variety of both public and private uses. These include both use by reference, in laws and regulations, and use in private self-regulation, standardization, and the promotion of engineering practices and methods. By making this document available for use and adoption by public authorities and private users, the IEEE does not waive any rights in copyright to this document.

## Updating of IEEE documents

Users of IEEE standards should be aware that these documents may be superseded at any time by the issuance of new editions or may be amended from time to time through the issuance of amendments, corrigenda, or errata. An official IEEE document at any point in time consists of the current edition of the document together with any amendments, corrigenda, or errata then in effect. In order to determine whether a given document is the current edition and whether it has been amended through the issuance of amendments, corrigenda, or errata, visit the IEEE Standards Association web site at <http://ieeexplore.ieee.org/xpl/standards.jsp>, or contact the IEEE at the address listed previously.

For more information about the IEEE Standards Association or the IEEE standards development process, visit the IEEE-SA web site at <http://standards.ieee.org>.

## Errata

Errata, if any, for this and all other standards can be accessed at the following URL: <http://standards.ieee.org/reading/ieee/updates/errata/index.html>. Users are encouraged to check this URL for errata periodically.

## Interpretations

Current interpretations can be accessed at the following URL: <http://standards.ieee.org/reading/ieee/interp/index.html>.

## Patents

Attention is called to the possibility that implementation of this recommended practice may require use of subject matter covered by patent rights. By publication of this recommended practice, no position is taken with respect to the existence or validity of any patent rights in connection therewith. The IEEE is not responsible for identifying Essential Patent Claims for which a license may be required, for conducting inquiries into the legal validity or scope of Patents Claims or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance, if any, or in any licensing agreements are reasonable or non-discriminatory. Users of this recommended practice are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility. Further information may be obtained from the IEEE Standards Association.

## Participants

At the time this recommended practice was completed, the IEEE P802.15 Working Group had the following officers:

**Dr. Robert L. Heile**, *Working Group Chair*  
**Richard Alvin**, *Working Group Vice Chair*  
**Patrick Kinney**, *Working Group Vice Chair & Secretary*  
**Dr. James P.K. Gilb**, *Working Group Technical Editor*  
**Dr. John Barr**, *Working Group Treasurer*

At the time this recommended practice was completed, the IEEE P802.15 Working Group had the following officers:

**Dr. Myung Jong Lee**, *Task Group 5 Chair*  
**Dr. Ho-in Jeon**, *Task Group 5 Vice Chair*  
**Dr. Tae Rim Park**, *Task Group 5 Secretary*  
**Dr. Chunhui (Allan) Zhu**, *Task Group 5 Low-Rate Editor*  
**Dr. Sang Sung Choi**, *Task Group 5 High-Rate Editor*

Authur Astrin  
Taehan Bae  
Jay Bain  
Gal Basson  
Tuncer Baykas  
Phil Beecher  
Bruce Bosco  
Andre Bourdoux  
Pat Carson  
Philippe Chambelin  
Huor-Hsin Chang  
Chang-Soon Choi  
Carlos Cordeiro  
Alexey Davydov  
Hendricus De Ruijter  
Paul Dixon  
Kai Dombrowski  
John Dorsey  
Bas Driesen  
Amal Ekbal  
Yossi Erlich  
Robert Fanfelle  
John Farserotu  
Reed Fisher  
Yoshitsugu Fujita  
Kiyoshi Fukui  
Shigeru Fukunaga  
Ryuhei Funada  
Uhland Goebel  
Paul Gorday  
Giriraj Goyal  
Eckhard Grass  
Mark Grodzinsky  
Vivek Gupta  
Robert Hall  
Christopher J. Hansen  
Shinsuke Hara  
Hiroshi Harada  
Seockdeock Hong  
Tian-Wei Huang  
Ichirou Ida  
Hideto Ikeda  
Tetsushi Ikegami  
Akio Iso  
Beomjin Jeon  
Young-Ae Jeon  
Seong-Soon Jeon  
Chol Su Kang  
Tae-Gyu Kang  
Yasunori Katayama  
Shuzo Kato

Yasutaka Kawamoto  
Stuart Kerry  
Jaehwa Kim  
Jae-Hyon Kim  
Jinkyong Kim  
Kihong Kim  
Kyeongpyo Kim  
Seong Kim  
Yongsun Kim  
Ryota Kimura  
Kursat Kimyacioglu  
Ryuji Kohno  
Fumihide Kojima  
Edwin Kwon  
Hyoungjin Kwon  
Ismail Lakkis  
John Lampe  
Zhou Lan  
Jae Lee  
Jeong Lee  
Myung Lee  
Seong-hee Lee  
Taehoon Lee  
Wooyong Lee  
Zhongding Lei  
Daniel Lewis  
Huan-Bang Li  
Liang Li  
Sheung Li  
Yong Liu  
Alexander Maltsev  
Abbie Mathew  
Taisuke Matsumoto  
Michael McInnis  
Michael McLaughlin  
Thomas Meyer  
Dino Miniutti  
Rajendra Moorti  
Jorge Myszne  
Yukimasa Nagai  
Ken Naganuma  
Chiu Ngo  
Paul Nikolich  
Yoshinori Nishiguchi  
Hiroyo Ogawa  
Jisung Oh  
Laurent Ouvry

Pascal Pagani  
Tae Rim Park  
Maulin Patel  
Stephane Pinel  
Frank Poegel  
Stephen Pope  
Clinton Powell  
Chang Woo Pyo  
Xiangping Qin  
Ivan Reede  
Richard Roberts  
Benjamin A. Rolfe  
Ali Sadri  
Katsuyoshi Sato  
Hirokazu Sawada  
Kamran Sayrafian  
Michael Schmidt  
Jean Schwepker  
Huai-Rong Shao  
Stephan Schmidhammer  
Shin-ku Shimada  
Takihito Shimakata  
Chang Sub Shin  
Michael Sim  
Harkirat Singh  
Carl Stevenson  
Paul Strauch  
Chin Sum  
Kazuaki Takahashi  
Kenichi Takizawa  
Arnaud Tonnerre  
Ichihiko Toyoda  
Jason Trachewsky  
Solomon Trainin  
Alberto Valdes Garcia  
Magnus Wiklund  
Gerald Wineinger  
Ludwig Winkel  
Eun Tae Won  
Jongeeun Won  
Pengfei Xia  
Kamya Yazdandoost  
James Yee  
Kaoru Yokoo  
Su Yong  
Zhan Yu  
Bin Zhen  
Chunhui Zhu

Major contributions for this recommended practice were received from the following individuals:

James Allen  
Jay Bain  
Phil Beecher  
John Boot  
Ishikawa Chiaki  
Sungrae Cho  
Sang Sung Choi  
Wonsuk Choi  
Chun-Ting Chou  
Francis daCosta  
Klaus Fosmark  
James P.K. Gilb  
Uhland Goebel  
Guido R. Hiertz

Ho-In Jeon  
Young-Ae Jeon  
Seong-Soon Joo  
Hakyung Jung  
Patrick Kinney  
Seongjae Kwon  
Inhwan Lee  
Myung Jong Lee  
Seong-hee Lee  
Yong Liu  
Sebastian Max  
Klaus Meyer  
Laihyuk Park

Sung-Woo Park  
Frank Poegel  
Hans-Jürgen Reuerman  
Seung Hyong Rhee  
Benjamin A. Rolfe  
Michael Schmidt  
Huai-Rong Shao  
Chang Sub Shin  
Michael Sim  
Marcus Wong  
June Yoon  
Rui Zhang  
Jianliang Zheng  
Chunhui Zhu

The following members of the individual balloting committee voted on this recommended practice. Balloters may have voted for approval, disapproval, or abstention.

Richard Alfvén  
James Allen  
Danilo Antonelli  
Philip Beecher  
Lyle Bullock  
William Byrd  
James Carlo  
Sang Sung Choi  
Keith Chow  
Charles Cook  
Todor Cooklev  
Thomas Dineen  
Sourav Dutta  
Paul Eastman  
Richard Eckard  
Marc Emmelmann  
Avraham Freedman  
Devon Gayle  
James P.K. Gilb  
Randall Groves  
C. Guy  
Rainer Hoch  
John Hawkins  
Marco Hernandez  
Atsushi Ito

Beomjin Jeon  
Young-Ae Jeon  
Bobby Jose  
Kaku, Shinkyō  
Stuart J. Kerry  
Yongbum Kim  
Patrick Kinney  
Cees Klik  
Joseph Koo  
Myung Jong Lee  
Seong-hee Lee  
Jian-Ren Liao  
Arthur Light  
William Lumpkins  
Peter Martini  
Michael Mcinnis  
Wade Midkiff  
Avygdor Moise  
Hiroyuki Nakase  
Michael S. Newman  
Charles Ngethe  
John Notor  
Satoshi Obara  
Knut Odman  
Okundu Omeni  
Satoshi Oyama

Tae Rim Park  
Eldad Perahia  
Subburajan Ponnuswamy  
Clinton Powell  
Robert Robinson  
Benjamin Rolfe  
Shigenobu Sasaki  
Peter Saunderson  
Bartien Sayogo  
Chang Sub Shin  
Kapil Sood  
Amjad Soomro  
Thomas Starai  
Rene Struik  
Walter Struppler  
Mark Sturza  
Thomas Tullia  
Dmitri Varsanofiev  
Prabodh Varshney  
Stanley Wang  
Andreas Wolf  
Paul Work  
Oren Yuen  
Wenhao Zhu  
Juan Zuniga

When the IEEE-SA Standards Board approved this recommended practice on 19 March 2009, it had the following membership:

**Robert M. Grow**, *Chair*  
**Thomas Prevost**, *Vice Chair*  
**Steve M. Mills**, *Past Chair*  
**Judith Gorman**, *Secretary*

John Barr  
Karen Bartleson  
Victor Berman  
Ted Burse  
Dick DeBlasio  
Andy Drozd  
Mark Epstein

Alexander Gelman  
Jim Hughes  
Richard Hulett  
Young Kyun Kim  
Joseph L. Koepfinger\*  
John Kulick  
David J. Law

Ted Olsen  
Glenn Parsons  
Ron Petersen  
Narayanan Ramachandran  
Jon Walter Rosdahl  
Sam Sciacca  
Howard Wolfman

\*Member Emeritus

Also included are the following nonvoting IEEE-SA Standards Board liaisons:

Satish K. Aggarwal, *NRC Representative*  
Michael Janezic, *NIST Representative*

Michelle D. Turner  
*IEEE Standards Program Manager, Document Development*

Michael D. Kipness  
*IEEE Standards Program Manager, Technical Program Development*

## Contents

1. Overview .....	1
1.1 Scope .....	1
1.2 Purpose .....	2
2. Normative references.....	2
3. Definitions .....	2
4. Acronyms .....	4
5. Low-rate WPAN mesh .....	7
5.1 General description.....	7
5.2 Mesh service description .....	9
5.2.1 Mesh data service.....	9
5.2.2 Mesh management service.....	15
5.3 Frame formats.....	41
5.3.1 General mesh service frame format .....	41
5.3.2 Format of individual frame types.....	44
5.3.3 Mesh sublayer information in MAC beacon payload .....	62
5.4 Mesh sublayer constants, mesh information base and status values.....	64
5.4.1 Mesh sublayer constants .....	64
5.4.2 Mesh information base.....	64
5.4.3 Mesh status values .....	69
5.5 Mesh function description .....	70
5.5.1 Starting a mesh network.....	70
5.5.2 Joining a mesh network.....	71
5.5.3 Address assignment .....	72
5.5.4 Mesh topology discovery and formation.....	74
5.5.5 Mesh path selection and data forwarding.....	77
5.5.6 Mesh path maintenance.....	79
5.5.7 Leaving a mesh network .....	80
5.5.8 Mesh path selection and forwarding for multicast.....	82
5.5.9 Reliable broadcast.....	93
5.5.10 Energy Saving in Battery-Powered Networks.....	95
5.5.11 Portability support.....	109
5.5.12 Traceroute .....	111
6. High-rate WPAN mesh.....	114
6.1 General description.....	114
6.2 MHME SAP interface.....	115
6.2.1 Generic management primitives .....	115
6.2.2 Resetting the mesh sublayer/MHME .....	117
6.2.3 Scanning for mesh networks .....	118
6.2.4 Starting a mesh-enabled piconet .....	122
6.2.5 Stopping a mesh network.....	124
6.2.6 Associating with a mesh network .....	125
6.2.7 Disassociation from a mesh network .....	127
6.2.8 TREEID assignment .....	129
6.3 Mesh SAP interface .....	130
6.3.1 MESH-ASYNC-DATA.request.....	133
6.3.2 MESH-ASYNC-DATA.confirm.....	133

6.3.3 MESH-ASYNC-DATA.indication .....	133
6.3.4 MESH-ISOCH-DATA.request .....	134
6.3.5 MESH-ISOCH-DATA.confirm .....	134
6.3.6 MESH-ISOCH-DATA.indication .....	134
6.4 Mesh PIB .....	135
6.5 Frame formats .....	135
6.5.1 General mesh frame format .....	135
6.5.2 Format of individual frame types .....	137
6.5.3 Command types .....	138
6.6 Mesh service support .....	144
6.6.1 Starting a mesh network .....	144
6.6.2 Tree formation .....	146
6.6.3 TREEID assignment .....	148
6.6.4 Leaving a mesh network .....	151
6.6.5 Routing procedure .....	152
6.6.6 Routing Alternative .....	155
Annex A (informative) Amendment to MAC sublayer .....	158

# IEEE Recommended Practice for Information technology— Telecommunications and information exchange between systems— Local and metropolitan area networks— Specific requirements

## Part 15.5: Mesh Topology Capability in Wireless Personal Area Networks (WPANs)

*IMPORTANT NOTICE: This standard is not intended to ensure safety, security, health, or environmental protection in all circumstances. Implementers of the standard are responsible for determining appropriate safety, security, environmental, and health practices or regulatory requirements.*

*This IEEE document is made available for use subject to important notices and legal disclaimers. These notices and disclaimers appear in all publications containing this document and may be found under the heading “Important Notice” or “Important Notices and Disclaimers Concerning IEEE Documents.” They can also be obtained on request from IEEE or viewed at <http://standards.ieee.org/IPR/disclaimers.html>*

### 1. Overview

A Wireless Personal Area Network (WPAN) mesh is a network of WPANs with mesh topology. This document defines a recommended practice for WPAN meshes.

#### 1.1 Scope

The scope of this standard is to provide a recommended practice to provide the architectural framework enabling WPAN devices to promote interoperable, stable, and scaleable wireless mesh topologies and, if needed, to provide the amendment text to the current WPAN standards that is required to implement this recommended practice.

## 1.2 Purpose

The purpose of this project is to facilitate wireless mesh topologies optimized for IEEE 802.15 WPANs.

Mesh Topology provides the following features to WPANs:

- Extension of network coverage without increasing the transmit power or the receiver sensitivity
- Enhanced reliability via route redundancy
- Easier network configuration
- Better device battery life

## 2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEEE Std 802.15.3<sup>TM</sup>-2003, IEEE Standard for Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements Part 15.3: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for High Rate Wireless Personal Area Networks (WPANs).<sup>1,2</sup>

IEEE Std 802.15.3b<sup>TM</sup>-2005, IEEE Standard for Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements Part 15.3: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for High Rate Wireless Personal Area Networks (WPANs) Amendment 1: MAC Sublayer.

IEEE Std 802.15.4<sup>TM</sup>-2006, IEEE Standard for Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements Part 15.4: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low Rate Wireless Personal Area Networks (WPANs).

## 3. Definitions

For the purposes of this draft recommended practice, the following terms and definitions apply. *The Authoritative Dictionary of IEEE Standards Terms* should be referenced for terms not defined in this clause.

**3.1 active duration:** A time period defined in both synchronous and asynchronous energy saving modes in the mesh sublayer during which a mesh device accesses the common channel using carrier sense multiple access with collision avoidance mechanism.

---

<sup>1</sup> IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08854, USA (<http://standards.ieee.org/>).

<sup>2</sup> The IEEE standards or products referred to in this clause are trademarks of the Institute of Electrical and Electronics Engineers, Inc.