**IEEE P802.15**

**Wireless Personal Area Networks**

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| Project | IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs) | |
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| Re: | [TG10 TGD] | |
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# Overview

Devices that implement IEEE Std 802.15.4 are widely deployed and support a variety of applications. The new PHYs and features added in the IEEE 802.15.4g and 802.15.4e amendments (the Smart Utility Network) enable support for smart metering applications operating over longer distances in a Neighborhood Area Network. The use of mesh network topologies is an essential characteristic of these applications, which enables range extension and reliability improvements.

Mesh networks are a class of network topologies where individual nodes have multiple neighbors within communication range. Packets traverse the mesh in multiple hops between nodes. Packets can be forwarded through the mesh along a number of possible paths. Nodes make dynamic decisions of which neighbor to forward a packet to, based on knowledge of the current set of available paths, and metrics related to congestion and signal quality.

Mesh networks may implement packet routing at layer 3 (IP routing), or at layer 2. One approach to layer 3 routing is specified in the RFC 6550 family (IPv6 Routing Protocol for Low-Power and Lossy Networks - RPL). RPL addresses some issues with IP routing over wireless networks such as 802.15.4, but there are still reasons that routing at layer 2 may be preferable. Routing at layer 3 tightly couples the network’s overall IP architecture to the routing, which has implications in IP hop counts, multicasting, fragmentation, and overall efficiency. Routing at Layer 2 enables a mesh network to look more like a single network segment to IP and higher layers.

In many ways, a layer 2 mesh looks like an 802.1 bridge (or a collection of bridges). However, the intended use cases for the 802.15.10 Layer 2 Routing amendment diverge from the design assumptions of 802.1 bridging.

One example is the design philosophy of low-energy, constrained resource network devices that are generally seen in the 802.15.4 family. Low power is implemented in these ways: 1) Low data rates resulting from relatively simple radio physical layers. 2) MAC layer design to optimize for very low duty cycle operation and extended sleep time.

The combination of these two principles with a multi-hop topology can result in significant delays in forwarding a frame through multiple nodes in a network. Data rates in 802.15.4 range from less than 1 Kbps to over 27 Mbps. In some 802.15.4 PHYs, packet lengths up to 2047 octets are supported, along with data rates in the low kbps range. Transmitting a maximal length packet at the minimum rate would require over 1 S. Even when more practical packet lengths and data rates are considered, the additional delays for synchronizing sleep cycles and multiple hops could easily result in end-to-end delays exceeding several seconds.

This upper bound on packet delivery through the bridged network exceeds the design expectations of 802.1, which call for end-to-end reply within 2 S.

The possibility of delays exceeding 2 S will need to be considered as existing bridging mechanisms specified in 802.1 are considered for application in 802.15.10.

Due to the limited bandwidth of 802.15 networks, the use of broadcast and multicast for establishment and maintenance of bridging operation should be carefully considered, and minimized when possible.

# Definitions

# Abbreviations and acronyms

# General requirements

## Summary of PAR

### Scope

### Purpose

## High level requirements

## Application requirements matrix

## Defined Behaviors Should Support the Following in 802.15.4

# Functional requirements

## Mesh Topology Discovery

## Mesh Routing Protocol

## Extensible Mesh Routing Architecture

## Mesh Broadcast Data Delivery

## Mesh Unicast Data Delivery

## Mesh Network Size

## Mesh Security

## Routing Metrics

### Radio-Aware

### Device-Aware

### Network-Aware

### Bridge-Aware

## Discovery and Association with a L2R network

## Changes to the MAC and PHY

# Performance requirements

## Required memory resource

## Calculation cost

## Energy consumption

## Control traffic overhead

## Route acquisition time

## Recovery time of link failure

## Scalability to network size

## End to End packet loss rate

## End to End data throughput and delay

## Life time of battery operated network

# Regulatory Considerations/Aspects

# Evaluation methodology