RPL Routing Pathology In a Network
With a Mix of Nodes Operating in
Storing and Non-Storing Modes

draft-ko-roll-mix-network-pathology

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Recap: Downwards Routing in RPL

- RPL supports two types of downwards routing

![Diagram of DODAG with Storing Mode and Non-Storing Mode](image)

**Abstract**

Ranging from computers, mobile phones, appliances, and miniature sensing platforms, with the help of global standards at different layers, all things are now being connected to the Internet. As such systems gain more and more interest, the interoperability among different implementations of the standards becomes an important issue. In this article, we focus on the interoperability performance of the recently proposed IETF RPL routing protocol. Our analysis of RPL has revealed circumstances that degrade the reliability of packet delivery in a low power wireless network when different standard-compliant implementations of RPL are mixed together in a network. With two standard compliant implementations of RPL, we experimentally present that the restrictions that RFC 6550 enforces for different downwards routing schemes can hurt the performance of the network. Furthermore, this article proposes and evaluates a light-weight modification to RPL that helps restore RPL's data delivery performance.

**Introduction**

Since the initial concept of deploying low-power wireless sensing systems, various protocols for wireless sensor networks have been proposed at different layers of the network stack. Like most engineering research efforts, WSN research had the goal of promoting well-working wireless techniques to impact our everyday lives. Research concepts such as 'smart dust' made it look like smart buildings, offices, and environments were in close reach. A decade has passed since this initial kickoff of sensor network research but the vision still seems elusive. One of the reasons for this gap between technology advances and real life applicability was the lack of suitable standards to agree on, therefore, naturally restraining the initialization of large scale deployments from the industry.

Realizing this, over the last few years, the research community and standardization committees, together, have gathered to design standards that address the unique challenges that WSNs introduce. Specifically, by connecting small-sized, low power embedded devices to the Internet, these efforts resulted in new concepts such as the vision of Internet of Things. At last, with the support of various standardization communities such as the IEEE, IETF, and Zigbee, IoT systems are equipped with protocols and application profiles that can initiate large scale deployments. However, given that these standards have been reluctant in adopting new research findings, some of the issues that they try to address are overly simplified, thus, leading to inefficiency in the system's performance. In this article, we focus on an issue that the recently proposed IETF RPL [RFC 6550] introduces.

RPL provides two sets of routing capabilities. Its most common use is collecting data from a low power and lossy network (LLN) using a destination oriented directed acyclic graph (DODAG), an implementation of distance vector routing. RPL also provides schemes for maintaining routes to individual nodes participating in the network. Defined as downwards routes, such routes help simplify network management and can also reveal new applications.

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![Diagram of DODAG with Storing Mode and Non-Storing Mode](image)
Using Both Types of Downwards Routing Options

• RPL networks are applied to systems with various hardware capabilities
  
  – Computational power-scarce nodes can only implement the *non-storing mode* downwards routing mode
  
  – Computational power-rich nodes can implement *storing mode* to increase the network efficiency
    • Shorter routing path
    • Less bandwidth usage due to the lack of SRHs
Routing Pathology

- Nodes with different MOP compared to the RPL DODAG root can only join the RPL network as a leaf node.

- This affects the downwards routing performance in a mixed RPL network as well as the efficiency of the collection path.

- Take the following dumbbell topology as an example...

If the non-storing mode node is forced as a leaf, both *downwards* AND *collection* performance is affected!!!
Benefits of Using Mixed Downwards Routing Mode-based Networks

• Intermediate nodes on the upwards path with route storing capabilities can exploit the efficiency of using storing mode
  – Non-storing mode nodes send the packet “up” the DODAG until a route storing mode node with knowledge of the target destination is met

• RPL’s collection performance can be improved by selecting from a larger pool of nodes
  – No need to neglect the selection of specific nodes as parent nodes just because they have a different MOP

• Solves the issue of network performance versus code simplicity
  – Non-storing mode nodes can keep the benefit of being slim implementations
Proposed Changes (1/3)

• A new MOP that allows a node to choose either to implement the storing or non-storing mode features along with the following changes

  – Both storing and non-storing mode should parse SRHs

  – DODAG root should store routes

  – Non-storing nodes send hop-by-hop DAO

  – Storing nodes keep a table of all the targets in its sub-DODAG and has the capability to attach SRHs
Proposed Changes (2/3)

- DAO messages should indicate if the DAO-initiating node is a storing mode or not using a flag

![Proposed Changes Diagram]
Proposed Changes (3/3)

• Operational Changes for Storing Mode Nodes:

  – Packet without a SRH: If next hop is a storing-mode node, forward as in [RFC6550]. If next hop is a non-storing node, insert the SRH into the packet and forward.

  – Using the storing status flag, a node constructing a SRH MAY choose to construct a SRH only up to the next storing mode node.

  – For packets with SRH, a storing mode node SHOULD obey the route specified in the SRH to comply with the strict source routing requirements in [RFC6554].
Discussions

• *draft-ko-roll-mix-network-pathology* as a WG draft?

• Can we simplify this process even further?