# Multicasting Enabled Routing Protocol Optimized for Wireless Sensor Networks

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**Abstract.** TikiriMC is a wireless ad-hoc routing protocol, designed for resource constrained networking environments. It provides application programming interfaces to easily implement unicasting, broadcasting and multicasting. Flexible configuration of TikiriMC allows one to easily adopt it into a desired platform. TikiriMC uses tree network topology, where there can be many such trees in a single network. Root nodes of these multiple trees form a separate mesh network. Performance tests conclude that TikiriMC has a very low routing delay compared to other implementations.

**Keywords:** TikiriMC, Wireless Ad-hoc Routing, Wireless Sensor Networks, Wireless Multicast Routing.

## 1 Introduction

Wireless ad-hoc networking is vital on deploying Wireless Sensor Networks (WSN). Developing network protocols for WSN should be carefully designed by considering the resource constraints while providing necessary features such as multicasting. Even though there are many wireless ad-hoc routing protocols, most of them do not address the communication requirements of resource constraint WSN environments, such as low power consumption. It is a fact that, network communication is the most power consuming activity in a WSN.

It should be mentioned that, there are wireless ad-hoc routing protocols, which can be used in resource constraint environments. However there are situations where most of those protocols cannot be used because, most of them are not easily configurable to meet specific needs. For example, protocols designed for a particular hardware platform may have predefined memory and processing power limitations. The same configuration may not work with a different hardware platform even if it runs the same operating system. In addition to that, there may be application specific requirements such as memory configurations. TikiriMC is designed as a configurable ad-hoc routing protocol where a programmer can simply change some variables and create a fully customized version of it which then can be used for intended hardware platform or application.

Consequently, this research is focused on the design and development of a flexible, configurable ad-hoc routing protocol which would solve above mentioned problems while improving the efficiency of network routing.

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## 2 Background

Research on wireless ad-hoc routing protocols has begun to be used with wireless devices with high computation power such as laptops and PDAs. With the dawn of wireless sensor networking these ad-hoc routing approaches have been adopted to use in low resource utilized environments. Nevertheless, as the original design was to be used with devices with high resources, most of them fails to work in a sensor networking environment. However, new routing protocols, such as Lightweight Ad-Hoc Routing Protocol [1], have been developed using the concepts and features of the existing ad-hoc routing protocols but supports low resource utilized environments.

Multicast protocols are often used to communicate with a selected subset of a large set of nodes. Existing wireless ad-hoc multicast protocols can be divided to two categories. First category forms a shared multicast tree to route packets. This approach is efficient when the nodes are static and the network topology hardly changes. Duplication of packets in the network can be reduced by using multicast trees. Adhoc Multicast Routing (AMRoute) protocol [2] and Ad hoc Multicast Routing Protocol Utilizing Increasing Id-numbers (AMRIS) [3] are examples to this category. Second category forwards multicast packets via flooding or via a mesh network. This approach is efficient when there are mobile nodes in the network. In networks with high mobility multicast trees cannot be maintained properly. Flooding ensures the packet delivery, but increases packet duplication as well. On-Demand Multicast Routing Protocol (ODMRP) [4] and Core-Assisted Mesh Protocol (CAMP) [5] are examples to this category.

## 3 TikiriMC Design

TikiriMC is a more efficient and effective solution for handling the unique communication requirements of resource constraint wireless sensor networks. This section includes details of the design of functionalities of TikiriMC routing protocol.

TikiriMC routing protocol has a multiple tree-based network topology. Each tree starts from its own Root node, and can span for multiple levels of descendent nodes. In a particular tree, nodes without any descendent nodes (child nodes) are called Leaf Nodes. Apart from the Root node and Leaf nodes, the rest is called Sub-Root nodes.

There can be several trees in a particular network. In such a scenario the Root nodes of those trees create a mesh network among themselves, so that inter-tree communication is possible. Intra-tree communication is handled by the Root node and relevant Sub-Root nodes of a tree. If the receiver node of a transmission is in the same tree as the sender, the packet can be routed inside the intra-tree network, if not, the root node of the sender's tree should forward data packets to the inter-tree mesh network, which will then should be received by the root node of the tree of the receiver.

TikiriMC is designed as a configurable protocol. Depending on the resource constraints of the nodes, a single tree can be configured to be varied from a single

Root node to a tree with multiple levels of descendent nodes. So as a result, the whole network topology can be changed from a forest of trees to a single tree. Furthermore, it can also be changed to a complete mesh topology.

## 4 Implementation and Evaluation

TikiriMC is a protocol optimized for sensor networks, so it was decided to implement it on top of the Contiki [6] real time operating system specially designed for sensor networks. Each node is implemented to run two separate processes for beaconing and controlling. Networking primitives of the Rime communication stack [7] was used to implement packet routing. Beacon process was implemented using the announcement primitive, which can be configured to broadcast a 16 bit value periodically.

We decided to do the preliminary tests of the protocol using COOJA [8] network simulator which was also a part of Contiki operating system. A node arrangement of 25 nodes were used to test the protocol and same arrangement was used in all evaluations and comparisons with other protocols.

First TikiriMC was tested for network convergence. It is a vital part of the protocol as a duly converged network can route packets more effectively and efficiently. However the network convergence was found out to be time consuming. It took 260 seconds on average to converge a network of 25 nodes.

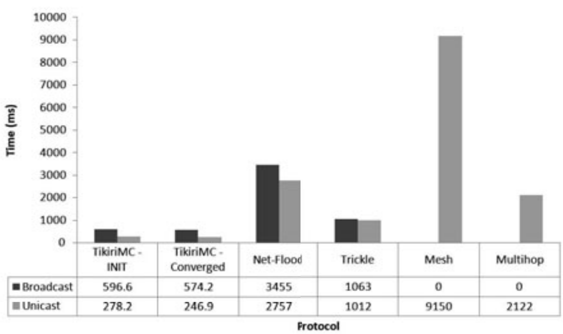


**Fig. 1.** Comparison of packet routing time of TikiriMC protocol with other protocols

Then TikiriMC was compared with four other protocols with respect to average time taken to broadcast a packet. It was tested by capturing the time taken to broadcast a 10 byte packet to all 25 nodes in the network. The results of these tests are illustrated in Fig. 1. As we can see, TikiriMC has only taken a fraction of time compared to other protocols. Nevertheless it was observed that noticeable number of duplicate packets are created in the inter-tree mesh network when sending packets. This is due to the flooding-like nature of the inter-tree mesh network.

## 5 Conclusions

Here, we present a new routing protocol, TikiriMC, for WSN which is capable of handling unicast, broadcast and multicast routing in resource constrained environments. This protocol uses a multiple tree topology where root of the trees form a mesh network. One interesting feature of TikiriMC is the ability to adapt it to the requirements of different hardware platforms and applications just by changing a simple configuration. TikiriMC multicasting is going to be implemented using both tree based and flooding mechanisms. This protocol is implemented on Contiki real time OS on top of Rime communication stack and preliminary tests were conducted using the COOJA network simulator. Performance evaluations convinced that the broadcasting delay of TikiriMC is very low when compared to other protocol implementations on Rime.

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