Efficient Bandwidth of Multicast Packets in RPR Topology for Supporting Wireless and Mobile Devices

Navapong Nongnuch g4629590@au.edu
Wuttichai Kwanmetakun wuttichaikwn@au.edu
Pisai Setthawong pisai@ieee.org
Surat Tanterdtid surat.t@egat.co.th
Telecommunication Science Department, Faculty of Science and Technology
Assumption University, Thailand

ABSTRACT

The IEEE Working Group 802.17 has recently standardized, the new ring topology network architecture, named Resilient Packet Ring (RPR), to be used mainly in metropolitan and wide area networks. This paper presents the multicast data in RPR network. The existing standard for multicast data is to striped out the packet by source node. The bandwidth is consumed from source node back to source node same as the broadcast data to all nodes on the ring. To gain the consumption of capacity and to increases the efficiency of bandwidth resource management in the RPR network or the infrastructure of the wireless stations, we propose in this paper to change from data being striped out by source to data are being striped out by the last node in multicast group. The Topology Discovery is modified to support the multicast frame and join the multicast group. We use the Enhanced Spanning Tree Algorithm [2] to discover the bridges of the expansion RPR network to map with the RPR ring ID. We will use and write C++ on OMNET++ simulation program to simulate the idea and test our system.

Keywords

Resilient Packet Ring, Multicast Traffic, Spatial Reuse, Topology Discovery, Spanning Tree Algorithm

1. Introduction

The Resilient Packet Ring (RPR), or IEEE Standard 802.17, is a packet-based dual ring network that can be used for implementing local area networks (LAN) and metro area networks (MAN) at high data rates of many gigabits per second.

One of the major benefits of RPR is bandwidth efficiency. Bandwidth is consumed only between the source and destination nodes. Packets are removed at their destination, leaving bandwidth available to downstream nodes on the ring. This is known as "Spatial Reuse".

1.1 Spatial Reuse

In RPR, traffic on one ring flows in the clockwise direction and traffic on the other ring flows in the counter-clockwise direction. When a node needs to send a packet, it determines which ring will have the shortest path to the destination. It will then transmit the packet on that ring. Once the packet reaches its destination, it is removed by the destination node from the ring.

The spatial reuse of bandwidth is achieved by stripping packets at the destination nodes. Spatial reuse is useful if traffic source and destination are evenly distributed among the neighboring nodes in the ring.

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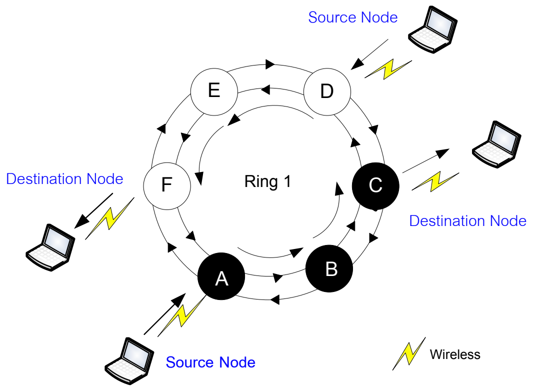

Figure 1 Spatial reuse allows node A to send to node C and node D to send to node F at the same time

1.2 Spanning Tree Algorithm

RPR can be extended by interconnecting multiple RPRs using Bridge or IEEE Standard 802.1x. Bridging does not support loop connections so the Spanning Tree Algorithm (SPA) is the method used to avoid loops in the bridged network. The SPA is necessary for preventing loops at remote and local sites in the inter-ring RPR network.

1.3 Broadcast and Multicast Traffic in RPR Network

RPR is a natural fit for broadcast and multicast traffic. For unicast traffic, nodes in the ring have the choice of stripping packets from the ring or forwarding them. However, for broadcast and multicast, the nodes can simply receive the packet and forward it, until the source node strips the packet. This makes it possible to multicast or broadcast a packet by sending only one copy around the ring.

1.4 Problem Statement

In fact, for multicast traffic, the last node in the multicast group may not be the last node from the source node, but the multicast packet must still be sent around the entire ring. As a result, bandwidth is consumed as inefficiently as broadcast packets. For inter-ring RPR networks, the flooding of multicast packets is another problem because the standard for bridging is to flood multicast packets on all the interconnected rings, so the bandwidth in the bridged RPR network will become full with flooding packets and significant bandwidth is wasted.

2. Background

Multicast packets are transmitted to a set of nodes whose multicast group membership is identified by a group MAC address carried within the destination address field of the multicast packet. A multicast packet is sent in one of two ways: (i) unidirectional flooded or (ii) bi-directional flooded. To transmit data packet over a RPR ring, each data packet of RPR MAC client is supplemented with additional information by the RPR MAC control entity at the RPR MAC layer with a 1-byte TTL (time to live) field. A flooded packet traverses a sequence of nodes and is stripped from the ring based on the expiration of the TTL field. The packet expires when the TTL field reaches zero, which indicates that the packet has passed through the intended number of nodes.

For multicast traffic only a single multicast transmission can take place on each directional ring, preventing RPR from capitalizing on spatial reuse and thus reducing it to legacy ring networks that do not support spatial reuse. We propose a more bandwidth efficient multicast approach for RPR which allows for spatial reuse by exploiting the database of the member multicast group and TTL.

For inter-ring RPRs, the bridge is used for connecting the RPR rings together. The standard bridge will flood the multicast packet on all its interfaces because it does not know the destination interfaces for forwarding the packet to the nodes in the multicast group. As a result, in large inter-ring RPR networks, the network will be filled by the flooding of packets.

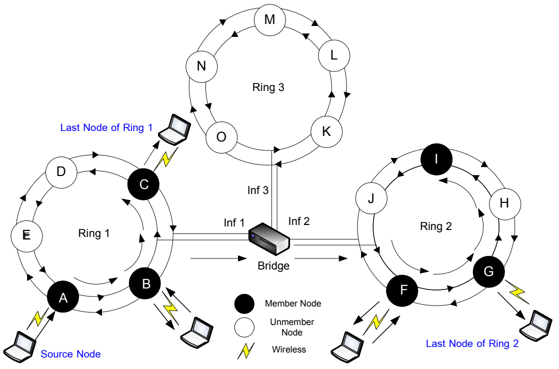

Figure 2The inter-ring RPR network for supporting Wireless Network.

3. Proposed Solutions and Enhancement

Our proposed solution has 2 parts: one for multicast traffic in a single ring and the other for multicast traffic in bridged networks. In RPR, the multicast packet is striped at the source node. The bandwidth is consumed from source node back to source node. In order to significantly decrease the bandwidth consumed by multicast traffic in the RPR network, we propose the multicast packet to be striped at the last node in the multicast group. By doing this, we can still retain the spatial reuse function that is the benefit of unicast packets.

For multicast traffic in bridged networks, the proposed solution decreases flooding and increases bandwidth utilization by controlling the flooding of multicast packets by the bridge. The flooding from the standard multicasting can be eliminated by using destination strip. The Enhanced Topology Discovery (ETD) and Enhanced Spanning Tree Algorithm (ESTA) [2] reduce the flooding from bridges. The Enhanced Spanning Tree Algorithm is the method for managing the bridge behavior to support the inter-ring RPR traffic by mapping the id RRP rings and the adjacent bridges for decreasing the flooding of packets from the bridge. The initialization of ESTA is to build the bridge's forwarding table that maps the bridge addresses and address of the nodes in the ring. The ETD manages the multicast group and TTL for destination strip. The existing topology discovery is updated by adding the special field to the topology discovery's table to collect the members of the multicast group.

3.1 Registration to be Subscriber in Multicast Group

The sender node queries broadcast message to all nodes in the RPR network to invite to be subscriber in the multicast group. The interested nodes will be subscribed to the multicast group after they reply with the confirmation message to the sender node. If the node does not intend to subscribe to the multicast group, it does not do anything with that message.

For bridged RPR networks, the packet traffic crosses the bridge so the topology discovery's table and the bridge's forwarding table have to be modified for recovering the member of the multicast group and the adjacent bridge to the member node.

The bridge's forwarding table is created by the Enhanced Spanning Tree Algorithm that is flooded on every network topology change or aging time. The Enhanced STA is modified from the standard STA for increased compatibility with the RPR network by collecting the bridge topology that interconnects between RPR rings.

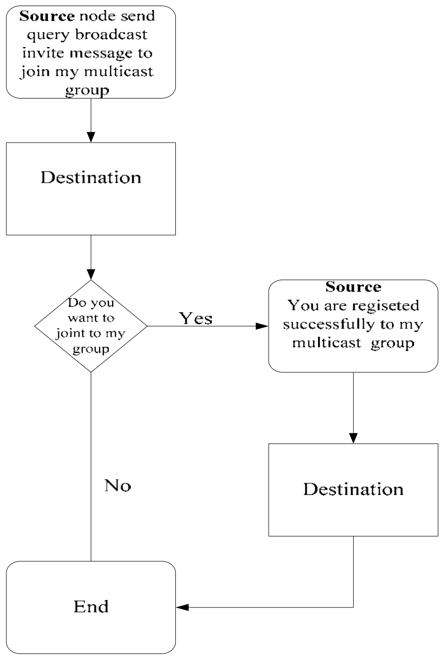

Figure 3 Flowchart of the registration process to be subscriber in multicast group

3.2 Sender forwards the packet in the RPR network

After the sender node recognizes which nodes and the number of nodes that are members in the multicast group, it will set the TTL to be the number of subscribers in multicast group (TTL at sender node = the number of subscribers in multicast group). TTL is decreased by 1 every time the message data passes a member in the multicast group. These nodes only copy and forward the packet. TTL will not be decreased if it passes the node that is not a subscriber in the multicast group. It only forwards the packet. The packet will be striped out at TTL = 0 (last node of multicast group).

For bridged RPR network, when the source node sends the packet to the multicast members across the bridge, the multicast address of the packet is checked and the packet is forwarded following the enhanced bridge's forwarding table. After the packet is forwarded to the bridge directly connected to the destination ring, the bridge will calculate the TTL for the multicast members and the shortest ringlet to reach the node members by using the information from the enhance topology discovery's table for the destination ring.

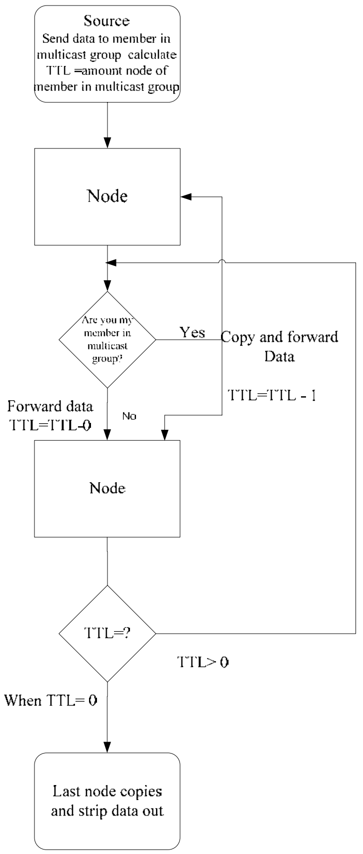

Figure 4 Flowchart Sender computes TTL= amount subscriber in multicast group

4. Analysis of Proposal Enhancement

In Figure 5 Node A is the source node that wants to send multicast packets to members of the multicast group (Nodes B, C, and D). The multicast packets pass through nodes B, C and D; and also pass through nodes E and F even through they are not members of the multicast group, before the packet is striped out by node A. The bandwidth will be consumed from node A to node F and the hop count is 6 hops. In the same time node E also sent the unicast packet to F, the bandwidth was allocated by the multicast packets that came from node A. In Figure 6 Node A is the source node which sends multicast packets to only members of the multicast group (nodes B, C, and D) before the packet is stripped out by node D, which is the last node of the multicast group. The bandwidth will be consumed only between node A and node D and hop count is 3 hops. Also in the same time node E sent the unicast packet to node F, the bandwidth was not allocated because the multicast packets that came from node A was stripped out by node D. The proposed solution decreases the consumed bandwidth, reduces end-to-end delay and re-enables spatial reuse.

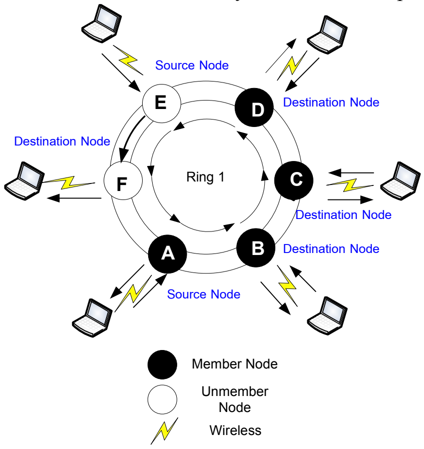

Figure 5 Multicast traffic strip data out at source node (Standard)

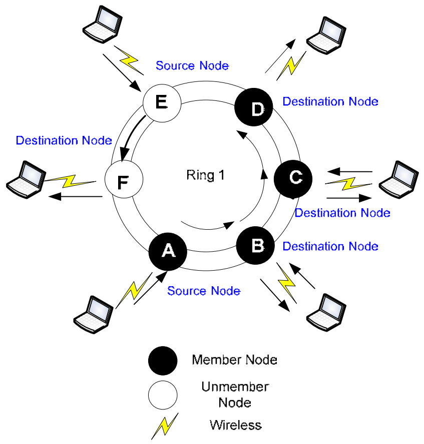

Figure 6 Multicast traffic strip data out at the last node of multicast group (Proposed)

The receive rate of the nodes from the scenarios shown in Figures 5 and 6 are shown in Figures 7 and 8. In Figure 7, node E sends packets to node F .A part of the bandwidth is allocated to the multicast packets that are sent from node A. In Figure 8 Node A sends multicast packets to the group members and the multicast packets are striped out at node D (last node of multicast group). As a result, node E can send packets at the full link capacity of 2.4Gbps to node F at the same time. Spatial reuse is achieved.

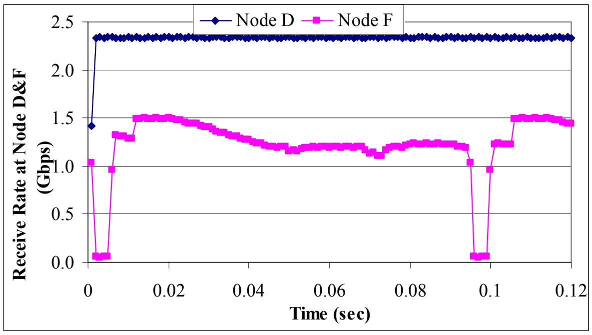

Figure 7 Receive rate multicast packet (standard)

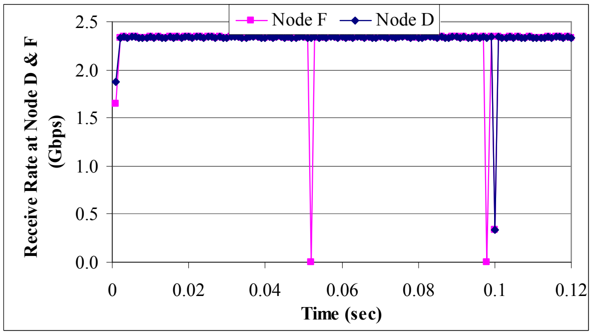

Figure 8 Receive rate multicast packet (proposed)

In Figure 9, end-to-end delay of the multicast packets is compared between the standard and the proposed solution in the RPR network.

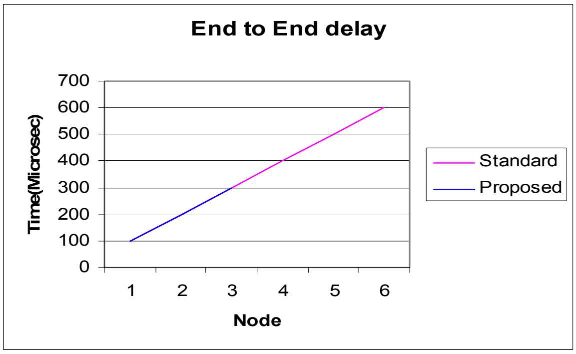

Figure 9 Comparison of multicast packet (standard) with multicast packet (proposed)

For the bridged RPR network, after applying the enhanced STA and Topology Discovery for inter-ring multicasting to the scenario shown in Figure 2, the simulation results are shown in Figure 10. Multicast packets are sent to the multicast members from the source node and the link utilization of enhanced multicasting is compared with standard multicasting.

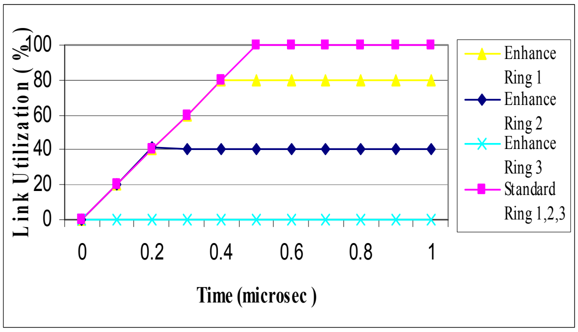

Figure 10 Comparison of the percentage of throughput between enhanced multicasting and standard multicasting in the Inter-ring RPR topology

The efficient bandwidth utilization of the enhanced multicasting is compared with the standard multicasting. It can be observed that the link utilization of the enhanced multicasting is lower than the link utilization of the standard multicasting because the flooding of inter-ring packets is reduced.

5. Conclusion

The multicast traffic in the RPR network using our formal proposal consumes less bandwidth than the existing standard RPR network; thus, increased bandwidth efficiency in RPR networks can be achieved. That is, spatial reuse is possible even with multicast traffic. This is because the proposed solution strips the multicast packet at the last node of the multicast group in the RPR network.

For bridged RPR networks, when the flooding of packets in the bridged network is decreased, the bandwidth efficiency increases. Thus, the problem statement is to find a method to decrease the flooding of packets as much as possible. This paper proposes a solution for multicasting that reduces the occurrence of flooding of multicast packets in the bridged RPR network As the infrastructure of the backbone network can decrease the unwanted flooding of packets, the wireless devices or other clients that are connected, can get more efficiency.

6. References

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