An Improved Node Scheduling Scheme for Resilient Packet Ring Network

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ABSTRACT:
Priority Queue (PQ) algorithm is used as the scheduling scheme for Resilient Packet Ring network (RPR). The scheduler handles a specific queue on the basis that all the higher priority queues have been served and emptied. This approach ensures low delay for higher priority classes of traffic. However, it often leads to the starvation of lower priority queues. For both single transit and double transit buffer architecture, traffic on the ring, which is a mixture of HP and LP transit traffic, has higher priority over the transmit HP traffic. This could cause the LP traffic on the ring to block the transmit HP traffic from gaining access onto the ring. To improve the quality of service for high priority traffic transmission, we propose using Bitwise Round-Robin (BRR) algorithm to alternately select packets from the transit buffer and the high priority transmit buffer. Simulation results show certain improvement on overall delay and delay jitter performance of RPR networks by using our scheme.

KEYWORDS: Index Terms-Resilient Packet Ring, IEEE 802.17, Bitwise Round Robin, Scheduling, Single Transit Buffer, Double Transit buffer**.**

1. INTRODUCTION

Resilient Packet Ring (RPR), an IEEE 802.17 standard, is a ring network based on a highly scalable and resilient technology for the efficient transfer of packet based traffic across a network [1], [2]. RPR networks offer multiple performance benefits: such as spatial reuse, bandwidth efficiency, ease of management, resilience and scalability. These advantages make RPR a very attractive alternative for high speed MANs and LANs.

RPR has two ring architectures: Single Transit Buffer (STB), and Dual Transit Buffer (DTB) [1], [2], [3]. Fig. 1 shows the Single Transit Buffer configuration and Fig. 2 shows the basic architecture of DTB in RPR. For both STB and DTB architectures, a high priority and low priority transmit buffer exists at the client side.

In the STB architecture, a single transit buffer amalgamates Low Priority (LP) and High Priority (HP) traffic from the transit buffer into one mixed traffic buffer on the ring. In the DTB architecture, two transit buffers exist for LP and HP traffic. When the traffic arrives from the ring, it is either dropped or destined from that node, or placed in the high priority or low priority transit buffer, according to the traffic classification. In STB architecture, only one queue is considered for transit traffic which is called primary transit queue (PTQ). PTQ acts like a FIFO and the priority of service is only based on arrival time. Therefore LP and HP are mixed with each other's in this buffer. In STB, transit traffic has the highest priority. The main advantage of this architecture is its low complexity of hardware implementation. However it is possible that the ring LP traffic blocks the access of LP and HP transmit traffic to node [2].

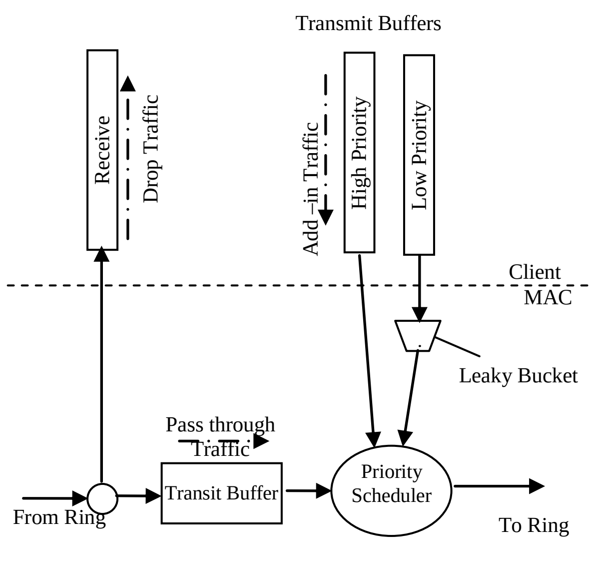

Fig. 1. Basic Architecture of STB in RPR

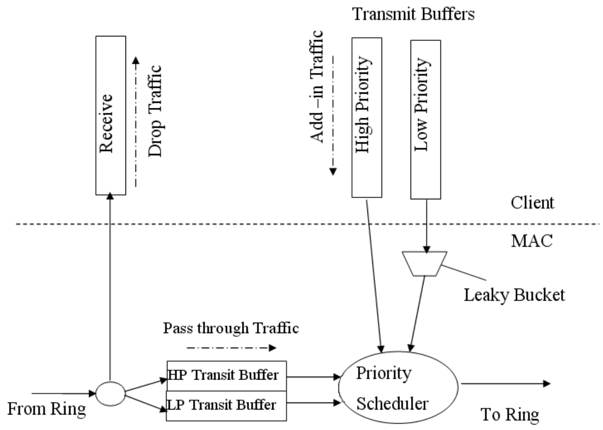

Fig. 2. Basic Architecture of DTB in RPR

In DTB architecture, two queues are considered for transit traffic: primary transit queue (PTQ) and secondary transit queue (STQ). PTQ and STQ acts like a FIFO and the priority of service is only based on arrival time. In DTB, HP transit traffic has the highest priority. A high priority and low priority transmit buffer exists at the client side. Frames with high priority (A class) are passing the high priority transit buffer, and those with low priority (class B and C) are passing the low priority buffer. For transit frames in DTB structure, high priority buffer and low priority buffer exist. The algorithm recommended for service in RPR is the priority queue algorithm [3], [4], [5]. In this algorithm always queues with high priority are serviced at first and if they were empty, the other queues are served. When the traffic arrives from the ring, it is either dropped or destined from that node, or placed in the high priority or low priority transit buffer, according to the traffic classification.

The main advantage of this method is its low complexity, but there are some drawbacks in its performances:

1-If the HP transit traffic is high, the HP transmit traffic faces high delay.

2-The LP transit traffic has the lowest priority. In case of having high LP transmit traffic for it, its delay will be very high.

In [6], the authors proposed using Deficit Round Robin for improving the scheduling in RPR node. There was no other report on using more advanced scheduling scheme in RPR node.

We propose using Deficit Round Robin Plus (DRR+) for scheduling in RPR nodes. In this method, the bitwise round robin (BRR) is used for queues with high priority traffic, and deficit round robin (DRR) is used for queues with low priority traffic. Between these two traffics, priority queue is used for scheduling.

The paper is organized as follows: Section II describes the RPR technology. An overview on BRR is provided in Section III. Section IV contains our proposed scheduling scheme. Simulation results and analysis are presented in Section V. Conclusions will be drawn in Section VI.

2. OVERVIEW OF RPR AND ITS NODE ARCHITECTURE

RPR connects nodes into a point-to-point, full duplex ring topology. When an RPR station is the receiver of a frame, it removes the frame completely from the ring, instead of just copying the contents of the frame and let the frame traverse the ring back to the sender. When the receiving station removes the frame from the ring, the bandwidth otherwise consumed by this frame on the path back to the source, is available for use by other sending stations. This is generally known as spatial reuse [7]. A subnet that connects all the nodes and moves traffic in one direction around the ring is called a ringlet. RPR spatially reuse the ring bandwidth by letting the destinations strip the packets. Hence one packet may flow on one segment of a ringlet while other packet flows on another part of the same ringlet at the same time. Each node is connected to two ringlets, and has a full duplex connection to the outside. Each ringlet interface includes transmit, transit and drop buffers. Packets on their way into the ring are stored in the transmit buffer, while packets that are stripped form, the ring are stored in the drop buffer. Packets that are traveling on the ring are stored in each nodes' transit buffer to be processed.

Each node of RPR has a high priority and low priority transmit buffer at the client side [2]. Real time data such as video and voice can be classified as high priority traffic, which suffers more from packet loss and delay. Low priority traffic can be attributed to other non-essential or noncritical data, which may suffers from delay and packet loss, but still meets the application requirements. The transit buffers can be configured such that it can have one transit buffer, or two transit buffers.

In the RPR transit buffer architecture, a transit buffer combines mixed low priority and high priority traffic. The advantage of this configuration is that it simplifies the hardware implementation. However the traffic on the ring, which is a mixture of high priority and low priority traffic, can block the transmitted high priority and low priority traffic waiting to gain access onto the ring.

3. THE BITWISE ROUND ROBIN

Round-robin (RR) is one of the simplest scheduling algorithms for processes in an operating system [8], [9].

As the term is generally used, time slices are assigned to each process in equal portions and in circular order, handling all processes without priority (also known as cyclic executive) . In Bitwise Round Robin rather than servicing each packet, every bit in round robin fashion. Fig. 3 shows a weighted BRR scheduler, where we consider three queues with weights 2,1 and 1 [10].

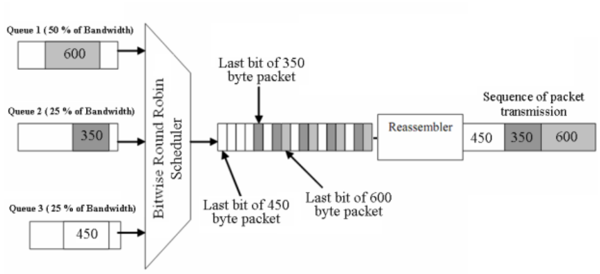

Fig. 3. The Bitwise Round Robin Architecture

The scheduler each time service 2 bits from the first queue and one from the second and third queues. Based on this policy the last bit of packet with 600 bits will be transmitted before the last bits of those other two packets. To implement this method, we can services all packets with DRR and with small quantum size, e.g. one bit. In this situation, there will be no need to have a time-list plan. It is also possible to consider weights for each queue.

4. THE PROPOSED SCHEDULING SCHEME FOR RPR NODES

To improve the service quality for HP traffic, we propose using bitwise deficit round robin (BRR) for RPR in both STB and DTB mode.

Fig. 4 shows the proposed block diagram of STB using BRR.

In the DTB architecture, two transit buffers exist for LP and HP traffic. When the traffic arrives from the ring, it is either dropped or destined from that node, or placed in the high priority or low priority transit buffer, according to the traffic classification.

Fig. 5 shows the overall view of proposed scheduling system for RPR nodes based on DRR+. In this method, the BRR is used for scheduling between queues with high priority traffic, and DRR is used for queues with low priority traffic. To schedule between these two systems, we used the priority queue. Here the HP transmit traffic can have access to the network with the priority as HP transit traffic and based on the weight considered for it. Also in this plan, the LP transit traffic based on the weight considered for it and with the same priority as LP transmit traffic can have access to the ring. Fig. 6 shows the proposed DTB node architecture.

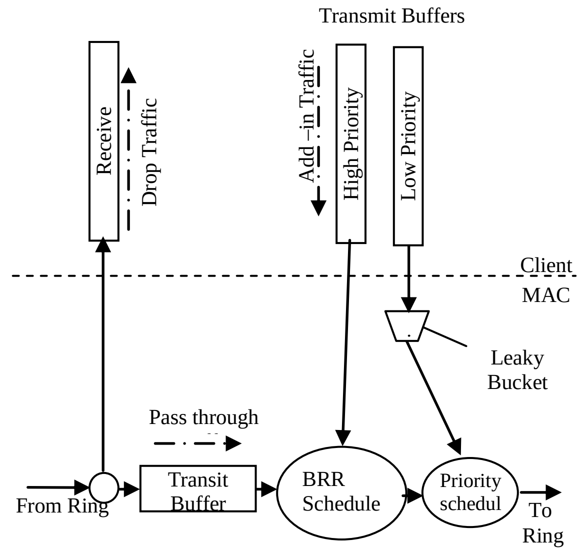

Fig. 4. The proposed architecture for STB in RPR

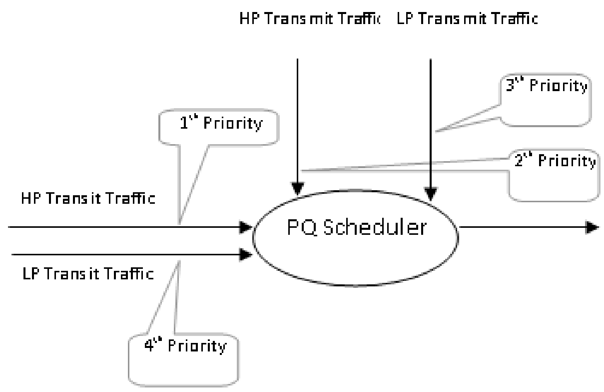

Fig. 5. Recommended scheduling between transmit traffic and transit traffic in DTB architecture of RPR based on PQ

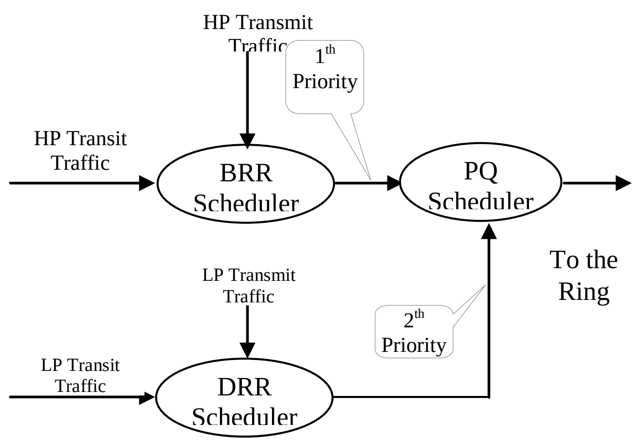

Fig. 6. The overall structure of proposed scheduling for DTB in RPR

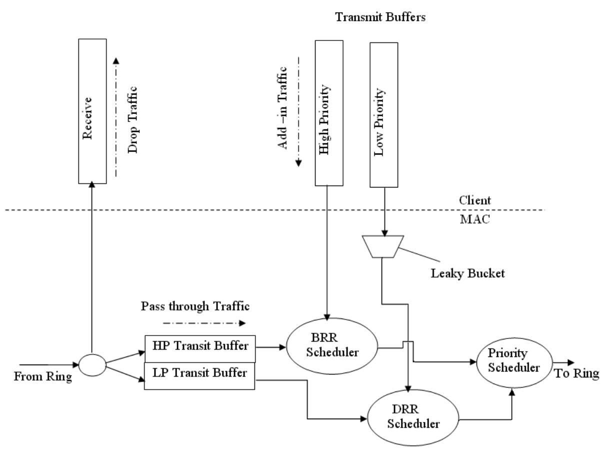

Fig.7. The proposed architecture for DTB in RPR

5. SIMULATION RESULTS

In this section, we examine the scheduling scheme in RPR. We compare its performance with recommended RPR scheduling [2] and RPR based on DRR [6]. We consider an RPR ring with 10 nodes as depicted in Fig. 8 with three types of traffic scenarios. Table 1 shows the parameter setting of network [12], [13], [14].

In our simulation, four nodes (Node No. 6, 7, 8, 9) are transmitting packets to node 10. We investigate the traffic at node 9. The traffic of each node is 33 Mbits/s where 10 Mbits/s of it belong to HP and 23 Mbits/s belongs to LP. This traffic result to congestion in node 9, as it can handle only 100 Mbits/s to node 10. We report the result for STB and DTB in two subsections.

A. Simulation Results for STB

If we use classic RPR scheduling scheme, at first the transit buffer is serviced. The HP transit traffic is queued at node 9, since its traffic has lower priority compare to the LP traffic of other nodes. Priority queue, DRR and BRR are the three scheduling methods we examine.

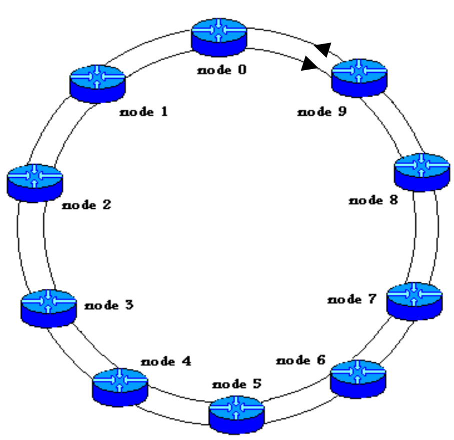

Fig. 8. RPR Network Topology for Simulation

Table 1. Simulation Parameters for RPR System

Parameters	Values	
Link Capacity	100 Mbit/s	
Queue Size	1 Mbit	
Packet Size	%60	64 Byte
	%20	512 Byte
	%20	1518 Byte
Traffic Generated in Nodes: 6,7,8, and 9	HP	10 Mbit/s
	LP	23 Mbit/s

When using DRR and BRR, the weight of transit traffic with high priority is related to its guaranteed service rate. The remaining portion is allocated to the transit buffer. For example if the allocated HP transit traffic is 10 Mbits/s, when we have 100 Mbits/s the weight of HP transit traffic is 1 and the weight of transit buffer will be 9.

The quantum allocation to each queue increases the workload of nodes, and the total delay of system. However the explicit priority of transit traffic will be no more exist and the transit traffic of HP nodes also will be serviced. Also it is possible to add the buffer size of transit buffer to be able to handle the delay for this queue.

We run the simulation for 2 seconds. Fig. 9 shows the delay for HP traffic in node 9. As it shows, since the priority is always given to transit traffic, the delay for the basic scheme is very high. On the other hand in DRR and BRR scheduling, as we have a weight for HP node traffic, the delay is much reduced.

Fig. 10 shows a clear comparison between delay in BRR and DRR methods which shows the lower delay in BRR.

Fig. 11 shows the comparison of jitter for node 9 when using DRR and BRR scheduling methods. As it shows BRR has lower jitter compare to DRR.

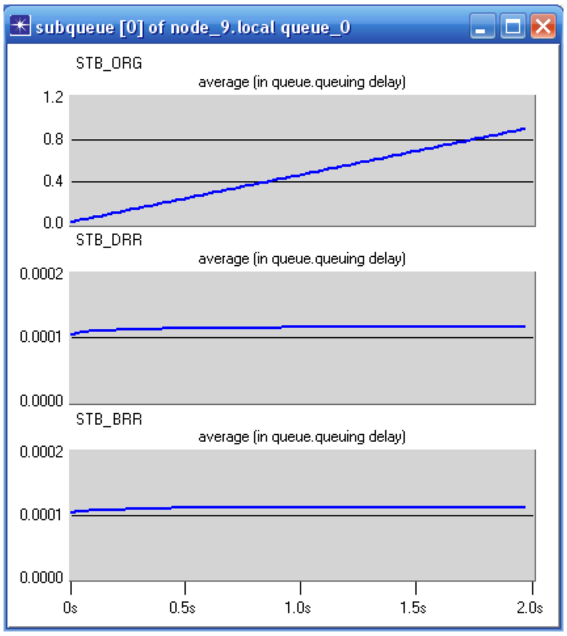

Fig. 9. The Delay in Node 9 based on different schemes

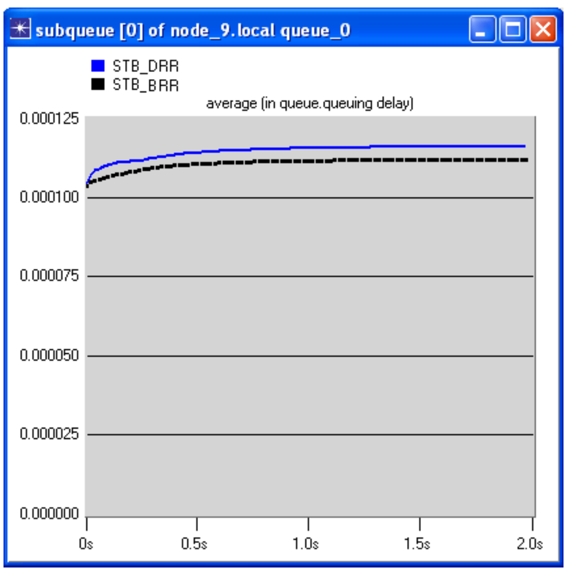

Fig. 10. The exact comparison between Delay in Node 9 using DRR and BRR

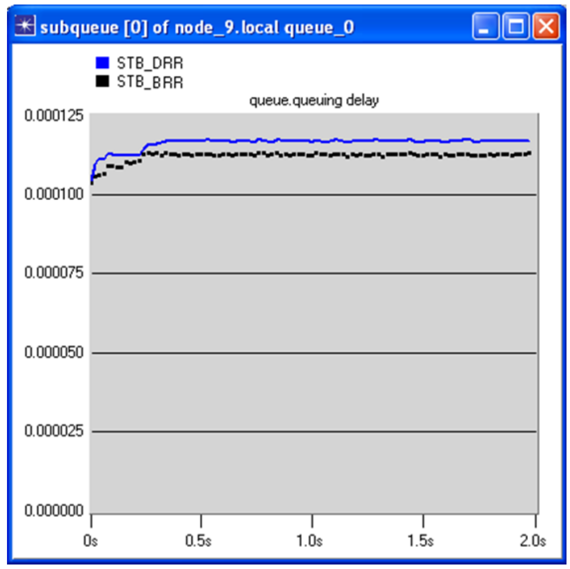

Fig. 11. The Jitter in Node 9 based on different schemes

B. Simulation Results for DTB

For using DRR+, the weight of transmit traffic with high priority is related to its guaranteed service rate. The remaining portion is allocated to transit buffer with high priority. In our simulation, the weight considered for transmit buffer with HP traffic is 1 and the weight considered for transit buffer with HP traffic is 9.

The delay for HP transmit traffic from node 9 is depicted in Fig.12. As the results show the delay for DRR is a little lower than standard system, but using DRR+ reduces the delay to almost 50%.

It should be noted that in this case the congestion in node 9 is due to high LP traffic and the HP traffic does not face difficulty to transmit.

The delay in HP transit traffic is depicted in Fig. 13. Considering the fact that absolute priority of HP transit traffic is no more exist in the DRR and DRR+, its delay has been increased. However compare to the gain achieved in reducing the delay for HP transmit traffic, it is negligible.

The jitter of HP transmit traffic is depicted in Fig. 14, and its standard deviation is depicted in Table 2. As the figure and table show, the jitter in scheduling system based on DRR+ is lower than the scheduling based on DRR, and the recommended scheduling in RPR. The jitter of HP transit traffic is depicted in Fig. 15, and its standard deviation is depicted in Table 3. As the figure and table show the jitter for HP transit in scheduling system based on DRR+ is almost similar to the scheduling based on DRR, and the recommended scheduling in RPR.

The delay for LP transmit traffic from node 9 is depicted in Fig.16. Since in recommended DTB scheduling and in DTB with DRR scheduler, the lowest priority is considered for LP transit traffic, it is natural that LP transmit traffic congest the network and LP transit traffic faces high delay. However in the proposed scheduling based on DRR+, the LP transit traffic has the same priority as LP transmit traffic, and have the chance to transit.

The delay in LP transit traffic is depicted in Fig. 17. The PQ and DRR algorithm do not consider any chance for LP transit traffic in this situation and its delay will be very high. But using DRR+, both LP transit and transmit traffic with considering the priority of HP traffic will have the chance to be serviced (based on their weight).

The jitter for LP transit traffic in node 9 is depicted in Fig.18 for DRR+ only. The delay and jitter in the other two scheduling methods are extremely high.

Similarly, the simulation shows that for other nodes the HP transmit traffic and the LP transit traffic face lower delay when we use DRR+.

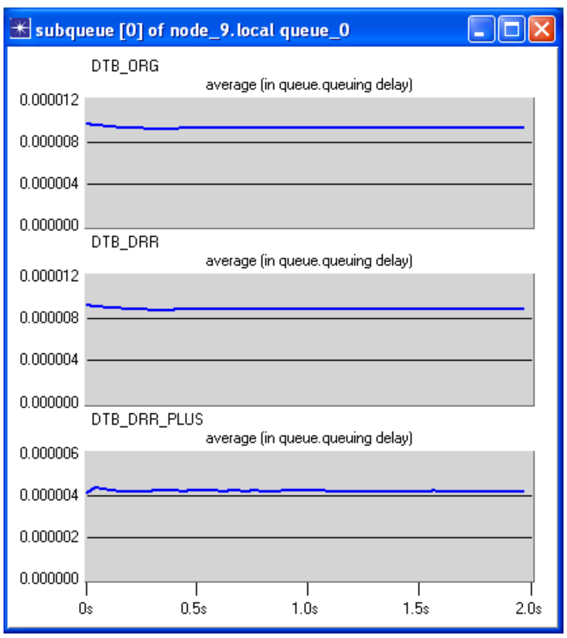

Fig. 12. The comparison between Delay in Node 9 for HP transmit traffic

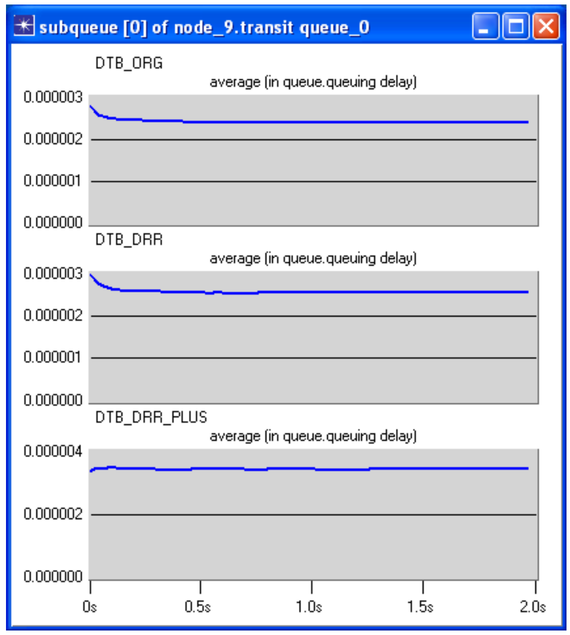

Fig. 13. The comparison between delay in Node 9 for HP transit traffic

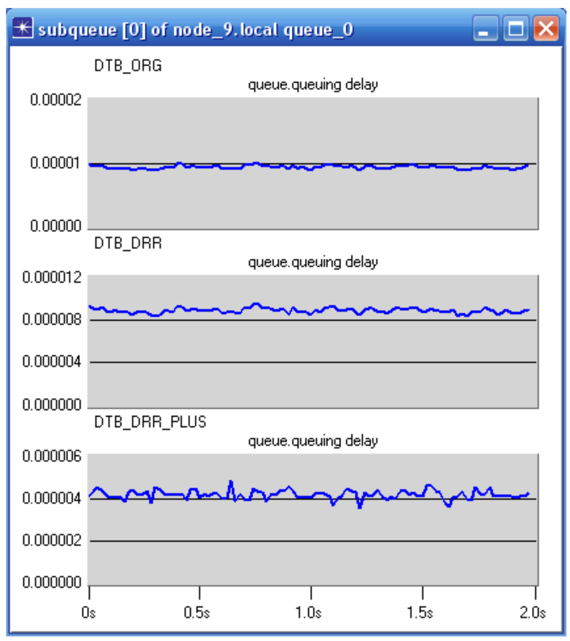

Fig. 14. The Jitter for HP transmit traffic in Node 9 based on different schemes

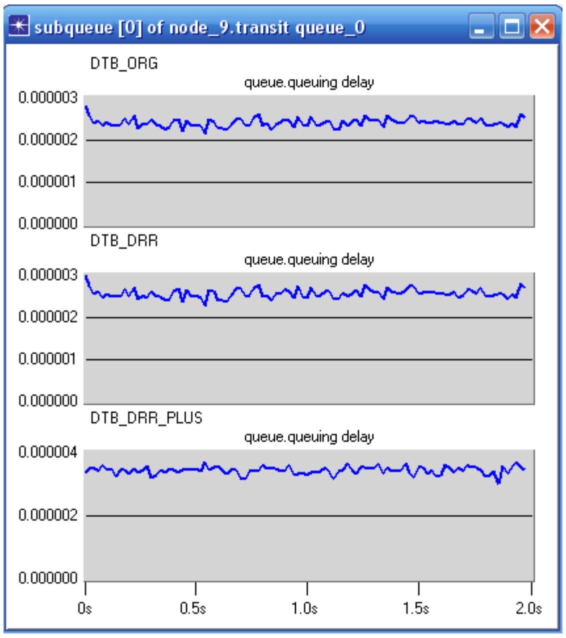

Fig. 15. The Jitter for HP transit traffic in Node 9 based on different schemes

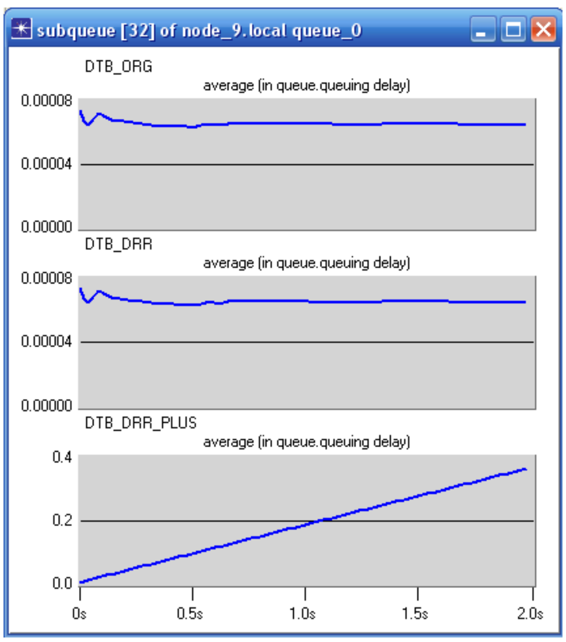

Fig. 16. The comparison between Delay in Node 9 for LP transmit traffic

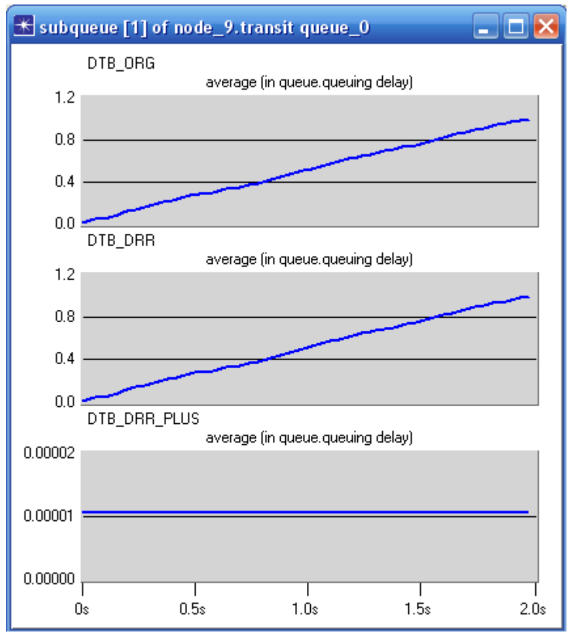

Fig. 17. Delay of LP transit traffic for all methods in node 9.

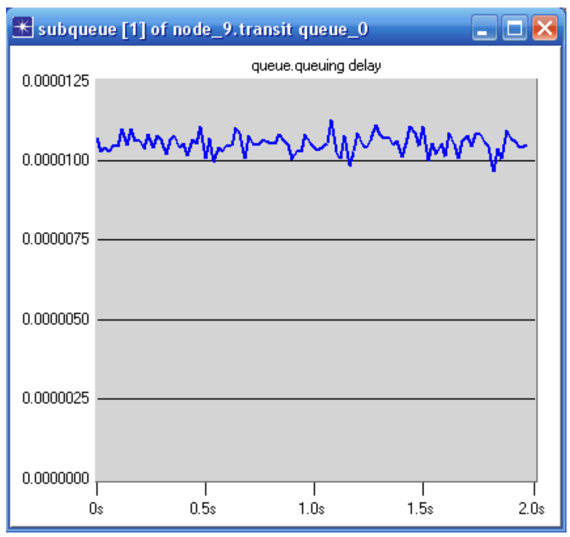

Fig. 18. The jitter for LP transit traffic for DRR+ in node 9

Table 2. The jitter standard variation for HP transmit traffic

Scheduling Scheme	Jitter standard Deviation
DTB_ORG	2.85×10^{-7}
DTB_DRR	2.47×10^{-7}
DTB_DRR_PLUS	2.21×10^{-7}

Table 3. The jitter standard deviation for HP transit traffic

Scheduling Scheme	Jitter Standard Deviation
DTB_ORG	1.03×10^{-7}
DTB_DRR	1.12×10^{-7}
DTB_DRR_PLUS	1.26×10^{-7}

6. CONCLUSION

We propose a new scheduling scheme for RPR nodes based on BRR. The scheduling scheme is able to consider weight to HP node traffic and HP transit traffic and service both traffic frequently. Simulation result shows our proposed schedulers ability to preserve the packet delay, and packet delay variation for node traffic. The BRR algorithm only adds a complexity of order O(1).

REFERENCES

[1] F. Davik, M. Yilmaz, S. Gjessing, and N. Uzun, **"IEEE 802.17 Resilient Packet Ring Tutorial"**, *IEEE Communications Magazine*, Vol. 42, No. 3, pp. 112-118. 2004.

[2] M. Yilmaz, N. Ansari, **"Resilient packet rings with heterogeneous links"**, *IEEE Symposium on Computers and Communications (ISCC)*, 2012.

[3] K. Lee, D. Lee, H.-W. Lee, N. Myoung, Y. Kim, and J.-K. Kevin Rhee **"Reliable Network Design for Ethernet Ring Mesh Networks"**, *Journal of Lightwave Technology*, Vol. 31, Issue 1, pp. 1-9, 2013.

[4] M. Nurujjaman, S. Sebbah, M. Assi Chadi; and M. Maier, **"Optimal capacity provisioning for survivable next generation Ethernet transport networks"**, *IEEE/OSA Journal of Optical Communications and Networking*, Vol. 4, Issue. 12, pp. 967 – 977, 2012.

[5] F. Alharbi, N. Ansari, "**SSA: simple scheduling algorithm for resilient packet ring networks IEE Proceedings-Communications"**, Vol. 153, No. 2, pp. 183-188, 2006.

[6] J. Zhu, A. Matrawy, I. Lambadaris, and M. Ashourian, **"A New Scheduling Scheme for Resilient Packet Ring Networks with Single Transit Buffer"**, *Proceedings of IEEE GLOBECOM workshop*, pp. 276-280, 2004.

[7] D. Schupke, A. Riedl, "**Packet transfer delay comparison of a store-and forward and a cut-through resilient packet ring",** *International Zurich Seminar on Broadband Communications (IZS)*, Zurich, Switzerland, Februray, 2002.

[8] L. Kleinrock, **Queuing Systems**, *New York: Wiley-Interscience*. 1975.

[9] M. Shreedhar, **"Efficient fair queuing using deficit round-robin"**, *IEEE/ACM Transactions on Networking*, Vol. 4, No. 3, pp. 375–385, Jun 1996.

[10] P. Csallinan, **"A comparative evaluation of sorted priority algorithms and class based queuing using simulation"**, *Proceedings Simulation Symposium*, (SS 2000)., pp. 99–105.

[11] S. Chuck, **"Supporting Differentiated Service Classes: Queue Scheduling Disciplines"**, *white paper*, Juniper Networks, January 2002.

[12] Guidance for IEEE 802.17 RPR Performance Simulations. http://standards.ieee.org/about/get/

[13] X. Liu, H. Wang, Y. F. Ji, **"Resilient burst ring: extend IEEE 802.17 to WDM networks"**, *IEEE Communications Magazine*, Vol. 46, Issue, 11,, pp. 74-81, 2008.

[14] M. Yilmaz, N. Ansari, **"Weighted Fairness and Correct Sizing of the Secondary Transit Queue in Resilient Packet Rings"**, *Optical Communications and Networking*, IEEE/OSA Journal of Vol. 2, Issue, 11, pp. 944-951, 2010.