RATE ADJUSTMENT MODES FOR RESILIENT PACKET RING NETWORKS

Ahmad M. Al-Banna and Saleh R. Al-Araji
College of Engineering and Information Sciences
Etisalat University
Sharjah, UAE
Email: alarajis@ece.ac.ae

KEYWORDS
High Performance Area Networks, Communication Networks and Protocols, Resilient Packet Ring (RPR), RPR Fairness algorithm

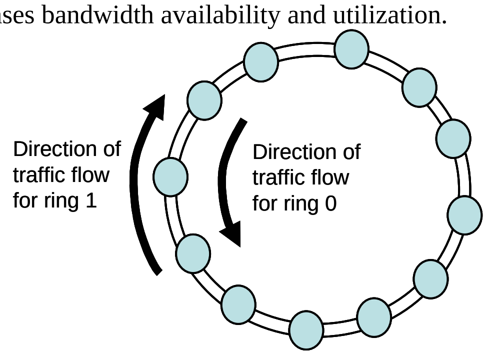
ABSTRACT

The RPR rate adjustment modes are analyzed and simulated with short and long distances between stations using Java based model. The conservative and aggressive modes were investigated. The former mode in most cases is more stable than the aggressive mode. The instability of the aggressive mode, which will lead to rate oscillation, is clearly shown when the separation between stations is large.

1.0 INTRODUCTION

Today's networks require a migration of packet-based technologies from Local Area Networks to Metropolitan Area Networks (MANs). The fast increase of data traffic in MAN networks is challenging the capacity limits of existing circuit-oriented technologies like SONET and ATM. Carrying an increased data traffic over voice-optimized circuit-switched makes the capacity inefficiently managed and difficult to provision new services. Packet-based transport technology is considered to be the only alternative for scaling metropolitan area networks to meet the demand [1,2]. An IEEE 802 Resilient Packet Ring (RPR) Standard Committee is currently working to set the standards for this new packet based technology that will solve the problems associated with the circuit switched technology.

Resilient Packet Ring (RPR) Figures 1 , for MAN, and WAN regional networks, is a new media access control (MAC) protocol closely related to Ethernet but designed to optimize bandwidth utilization and facilitate services over a ring network. It is designed to provide the carrier-class attributes normally associated with SONET and SDH. RPR is a set of switching nodes interconnected along a bi-directional, double fiber ring. Data is transmitted and load balanced on both rings. Unlike ring-based LAN technologies, RPR packets do not have to circulate the full ring, which effectively increases bandwidth availability and utilization.



Figures 1: Typical 12 Node RPR Ring Topology.

The RPR MAC will offer the following features:

- New data link layer technology (new MAC layer)
- Ring protection and fast restoration
- Support of multiple classes of service
- Controlled dynamic bandwidth on the ring
- Controlled latency and jitter
- Controlled traffic congestion

RPR implements a three level classes based on traffic priority scheme. The aim of the class based scheme is to let class A be a low latency and low jitter class, class B be a class with predictable latency and jitter, and finally class C be a best effort transport class. On the other hand RPR ring does not discard frames to resolve congestion. Hence when a frame has been added on to the ring, even if it is a class C frame, it will eventually arrive at its destination.
Class A traffic is divided into subclasses A0 and A1, and class B traffic is divided into class B-CIR (Committed Information Rate) and B-EIR (Excess Information Rate). The two traffic classes C and B-EIR are called Fairness Eligible (FE).
The bandwidth around the ring is pre-allocated in two ways. The first is called “reserved”, which can only be used by class A0 traffic. If stations are not using their pre-allocated A0 bandwidth, this bandwidth is wasted. In this way TDM-like traffic can be sent by RPR stations as A0 frames. The other pre-allocated bandwidth is called “reclaimable”. A station that has class A1 or B-CIR traffic to send, preallocates “reclaimable” bandwidth for these types of traffic. If not in use, such bandwidth can be used by FE traffic. In

Proceedings 18th European Simulation Multiconference
Graham Horton (c) SCS Europe, 2004
ISBN 3-936150-35-4 (book) / ISBN 3-936150-36-2 (CD)

addition, any bandwidth not pre-allocated is also used to send FE traffic. The distribution and use of unallocated and unused reclaimable bandwidth is dynamically controlled by the fairness algorithm.

The objective of the fairness algorithm is to distribute unallocated and unused reclaimable bandwidth fairly among the contending stations and use this bandwidth to send class B-EIR and class C traffic, i.e. the fairness eligible (FE) traffic. Class A0 traffic is obviously not affected, since bandwidth is reserved for this class exclusively. Classes A1 and B-CIR are indirectly affected, as will be explained below.

The fairness algorithm starts working to distribute bandwidth fairly when the bandwidth on the output link of a station is exhausted (the link is congested). The most probable cause of congestion is the station itself and its immediate upstream neighbors. Hence by sending a so called fairness message upstream (on the opposite ring) the probable cause of the congestion is reached faster than by sending the fairness message downstream over the congested link [5]. In the proposed work, the impact of RPR fairness algorithm on traffic congestion will be analyzed, and simulated.

2.0 FAIRNESS ALGORITHM

The fairness algorithm is within the MAC control sub-layer. There are two fairness instances in each station, one for each ringlet that will support independent fairness operation in each ringlet. The use of fair rates prevents one station from occupying the shared bandwidth with respect to other stations on the ringlet.
The fairness algorithm controls the access of fairness eligible traffic (class C and class B Excess Information Rate (EIR)) to a ringlet is as follows:

- The traffic congestion is controlled.
- The activities of the controlled congestion will have a minimum effect on the throughput.
- A fair rate limit would be applied across stations contributing to congestion.

2.1 IDENTIFYING CONGESTION

A station is congested when one or more of the following conditions are identified:
i) If the secondary transit queue (STQ) is exceeding certain limit.
ii) If the transmission rate exceeds the link bandwidth.
iii) When the traffic is delayed excessively while awaiting transmission.
Congestion is undesirable scenario as it can result in a failure to meet the end-to-end commitments relative to the service classes.
Condition (i) is applicable only in the case of a dual-queue MAC. Conditions (ii) & (iii) are applicable only in the case of a single-queue MAC.

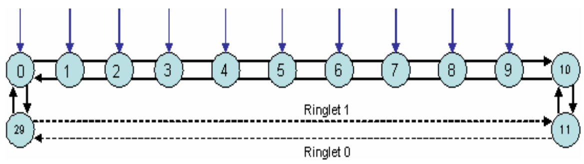
2.2 RATE ADJUSTMENT MODES

There are two modes of rate adjustments in RPR namely “ Aggressive” and “Conservative”. The former provides responsive adjustments that favor utilization of capacity over rate stability. Where as the conservative mode provides highly damped adjustments that favor rate stability over utilization of capacity.
The main difference between conservative and aggressive fairness is the way the fair rate is initially estimated, and how it is adjusted towards the real fair rate.
In the conservative mode, the congested station calculates the initial fair rate either by 1) dividing the available bandwidth between all upstream stations that are currently sending frames through this station or by 2) use its own current add rate. A timer is used to ensure that additional rate changes is made only when the congested station have had time to see how this new fair rate affects the congestion (i.e., gets better or worse). The period of this timer is referred to as the Fairness Round Trip Time (FRTT). FRTT is an estimate of the time it takes for a congested station to see the full effect of the fairness message it sent to upstream stations. FRTT consists of two parts: 1) the propagation delay for a class A frame when transmitted from the congestion domain head (i.e. the congested station) to the congestion domain tail (the station at the other end of the congestion domain) and back (LRTT – Loop Round Trip Time). 2) The difference between the propagation delay for a class C and a class A frame is sent from the tail to the head (FDD – Fairness Differential Delay). LRTT needs to be computed on initialization of the ring and when the topology changes, while FDD is computed when a station becomes tail of a congestion domain and thereafter at configurable intervals. FDD reflects the congestion situation, i.e. the STQ fill levels on the transit path from head to tail. As the congestion domain changes, so does the FRTT. LRTT and FDD frames are special types of control frames.
In the Aggressive mode, the congested station makes a first estimate of the fair rate equal to the rate the station itself lately have been able to add to the ring. Since the station is congested, this means that it has been able to send very little traffic onto the ring recently. Hence this estimate is probably too low, but it is used as a starting point and a way to alleviate congestion. When congestion is indeed removed, the (previously congested) station will not send any more fairness messages upstream, or more correctly it will send fairness messages with a default fair value representing the full link rate (such frames are sent all the time with preset intervals as heart beats.) A station receiving a fairness message indicating no congestion (i.e., full link rate) will increase its add traffic (assuming the station’s demand is greater than what it is currently adding). In this way (if the traffic pattern is stable) the same station will become congested again after a while, but this time the estimated fair rate will be closer to the real fair rate,

and hence the upstream stations do not have to decrease their traffic rate as much as previously [5].

3.0 SIMULATION RESULTS

An RPR ring was simulated to generate the results for both aggressive and conservative rate adjustment modes [3]. Instead of using the usual OPNET simulation tool for RPR, the authors simulated these conditions with Java based program that was recently developed by Simula Research Laboratory, Norway [4].
The number of stations used in this simulation is 30 as shown in Figures 2. Station 0 to 9 send class C greedy user datagram protocol (UDP) traffic on ringlet (0) to station 10, with aging and advertising intervals of 100 microseconds each. The distance between each RPR station on this ring is 50 Km resulting a delay of 0.25msec [6]. The link speed is 622 Mbps and the Packet size is 500 Byte. Table 1 shows the sending start and stop time of the UDP traffic from the different stations 0-9 to station number 10.

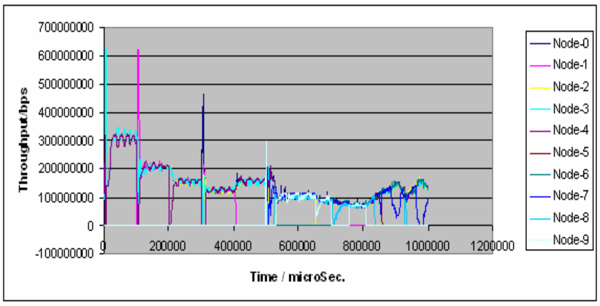


Figures 2 RPR Ring with 30 Stations

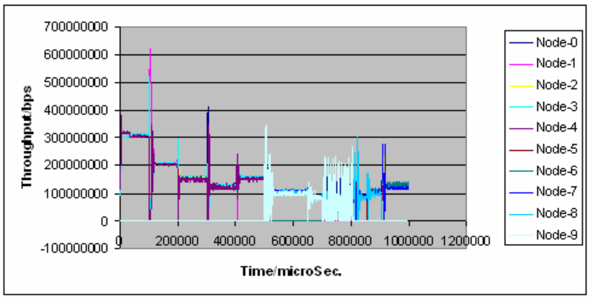
Table 1: Start-Stop Stations Timing

Station Number	Start Time (second)	Stop Time (second)
0	0.3	0.8
1	0.1	0.4
2	0.2	0.5 and Start Again at 0.65 and stop at the 1 second
3	0	1
4	0	1
5	0.7	0.85
6	0.7	1
7	0.5	1
8	0.5	0.9
9	0.5	0.8

The simulation plots for conservative and aggressive modes are shown in Figures 3 and 4. It can be seen from the plots that the aggressive mode shows more oscillation in the region between 0.7-0.9 sec when compared with the conservative mode. This is due to the high number of starting and stopping flows in that time frame.

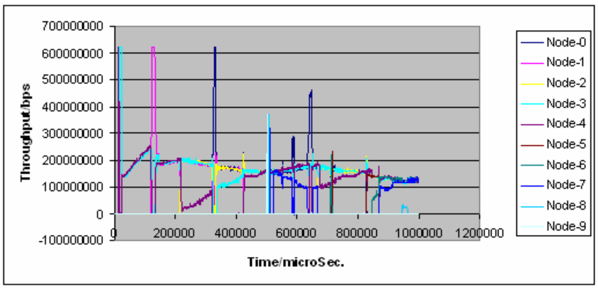


Figures 3: Conservative Mode for all Stations 0-9 Sending UDP Traffic to Station 10

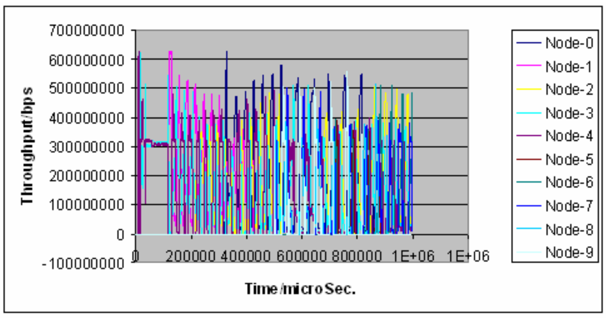


Figures 4: Aggressive Mode for all Stations 0-9 Sending UDP Traffic to Station 10

The network is now simulated with a new distance between each node of 400Km while keeping the same specification as above. The resulting propagation delay of from this change of distance is 2msec. It can be seen from the plots of Figures 5 and 6 that the conservative mode has minimal oscillation when compared with aggressive mode.



Figures 5: Conservative Mode for all Stations 0-9 Sending UDP Traffic to Station 10



Figures 6: Aggressive Mode for all Stations 0-9 Sending UDP Traffic to Station 10

From the figures of throughput versus time shown below, it can be seen that the conservative mode in general is more stable than the aggressive mode particularly at large distances between stations. The figures shown are only samples of the total simulation results.

4.0 CONCLUSIONS

The simulation results have clearly shown that the conservative mode of UDP traffic in an RPR mode is more stable than the aggressive mode and not normally subjected to oscillation. In the aggressive mode, increasing the distance between RPR stations will dramatically affect the traffic pattern and it will lead to oscillation. The Aggressive rate adjustment is therefore not recommended for large distance separation between stations.

5.0 REFERENCES

1. Minoli, D., Johnson, P., and Minoli, E., " Ethernet-Based Metro Area Networks ", McGraw Hill, 2002.
2. IEEE 802.17 RPR Draft 2.6, September 2003, Las Vegas, NV, USA.
3. Ramakrishnan, K. K., Interactions between Class A1, Class B and Class C Traffic with Conservative Mode, IEEE802.17RPR Interim Meeting, Montreal, PQ, Canada, May 2003.
4. Gjessing, S., and Maus, A., A Fairness Algorithm for High-speed Networks based on a Resilient Packet Ring Architecture, IEEE Proceedings of the International Conference on Systems, Man and Cybernetics,2002.
5. Davik, F., Gjessing, S., Uzun, N., Yilmaz, M., IEEE 802.17 Resilient Packet Ring Tutorial, March 2004.
6. Stein Gjessing, The Simula RPR Simulator implemented in Java, Simula Research Laboratory Technical Report 2003-12, December 2003.

AUTHOR BIOGRAPHIES

AHMAD M ALBANNA was born in Dubai, UAE and completed his B.Eng degree, with first class honors, in Computer Engineering at Etisalat College of Engineering, Sharjah, UAE in 2001. After graduation, Mr. Al Banna joined Etisalat (the Telecom Company in UAE) working as an Internet Backbone engineer and later was promoted to his current position as a project manager in the IP Development Department and at the same time working on his MSc. Thesis in the field of Resilient Packet Ring (RPR). His e-mail address is : albanna@emix.net.ae

Professor SALEH AL-ARAJI received the B.Sc., M.Sc., and Ph.D. degrees from the university of Wales Swansea (UK) in 1968, 1969, and 1972 respectively. Since September 2002, Professor Al-Araji was appointed Professor and Head of Communications Engineering Department at the College of Engineering and Information Sciences, Etisalat University, Sharjah, UAE. Prior to that and for six years he was working at the Transmission Network Systems, Scientific-Atlanta, Atlanta, Georgia, USA as Senior Staff Electrical Engineer. During the academic year 1995/1996, Prof. Al-Araji was a visiting professor at the Ohio State University, Columbus, Ohio. He was also visiting professor at King's College, University of London, England, during the summers of 1988 and 1989. Prof. Al-Araji was professor and Department Head at the University of Baghdad, Iraq, and the University of Yarmouk, Jordan.
Prof. Al-Araji was awarded the British IERE Clerk Maxwell Premium for a paper published in 1976 and the Scientific-Atlanta award for outstanding achievement in 2000. He was an Iraqi National member of URSI commissions C and D, and the ITU (CCIR Group 8). He has published over 40 papers in international Journals and Conferences and holds 5 US Patents and one International Patent. Prof. Al-Araji is a senior member of the IEEE. His e-mail address is : alarajis@ece.ac.ae