International Journal of Pure and Applied Mathematics
Volume 117 No. 15 2017, 287-298
ISSN: 1311-8080 (printed version); ISSN: 1314-3395 (on-line version)
url: http://www.ijpam.eu
Special Issue

Congestion Contol Using Congestion Free Routers

[1]R Mohanasundaram, [2]N. Suresh Kumar, [3]V.Ashok and [4]S. Poorani

[1]School of Computer Science and Engineering,
VIT, Vellore, TN, India.

[2]School of Computer Science and Engineering,
VIT, Vellore, TN, India.

[3]Dept. of ECE,
Kongu Engineering College, Erode.

[4]Dept. of EEE, Karpagam Academy of Higher Education,
Karpagam University, Coimbatore, TN, India.

Abstract

The excessive use of multimedia applications has increased the congestion in network. The primitive scheduling algorithms cannot prevent congestion collapse and unfairness of applications due to their unresponsive behavior to network congestion. This issue also rises from the fact that these primitive scheduling algorithms lack the capability of preventing congestion collapse. To resolve these issues we propose a novel solution with the help of congestion free routers which ensures that feedbacks are exchanged by the routers at network borders. The solution provided aims at entailing two routers at edge of the network such that the core routers remains unaffected and carries out its activity like always. The proposed system aims at using various algorithms such as rate control algorithm, leaky bucket, feedback control algorithm and TCP friendly algorithm. These algorithms performs various important roles which facilitate the effectiveness of the algorithm like rate control algorithm controls the rate at which each flow enters the network and also tries to utilize the link to the maximum extent; similarly leaky bucket algorithm aims at regulating the flow’s traffic; whereas feedback control algorithm sets ground rules for the feedback that has to be exchanged by the routers at the edge of the network. TCP friendly algorithms facilitates with a window which will help in getting the acknowledgement when we have a TCP flow. The architecture of the routers at edge of the network is maintained in a way that will help to proposed solution to achieve its goals of congestion control. The ports of the routers at the edge of the network are modified such as the input ports of the out router carry out various tasks such as per flow monitoring of the bit rates whereas on the other hand per flow rate control is done by the output ports of the in router. The flow entering the network is classified also by these ports of the edge routers using various flow classification policies. There are two types of feedbacks that are exchanged between the routers at the edge of the network i.e. the forward feedback and the backward feedback these feedbacks increase the complexity at edge routers of the network which forms the first drawback of the proposed solution. The other issue here is the communication overhead as the edge routers need to know the rates of incoming and outgoing packets and also send feedback. Though this adds complexity to edge routers and the main network remains unaffected. The end systems are also not aware that the proposed solution is even implemented so one need not change any transport protocol and the drawback is that still the complexity at the edge routers will be high so here is where TCP friendly rate control mechanism comes to rescue as it will help reduce the complexity at edge routers at least for unicast flows. Hence congestion free routers are used for the congestion control which consists of the network edge routers and core network routers and the edge routers as mentioned above patrol the flow entering the network in a way that congestion in reduced to an extent.

Key Words: Congestion collapse, edge routers, feedback control algorithm, TCP friendly rate control mechanism.

1. Introduction

The use of multimedia applications has increased with the growth of internet. All applications involving multimedia are not very tolerant and a lot of emphasis needs to be given to bandwidth; delay is also not affordable when it comes to such multimedia applications. When it comes to file transfer and web browsing we have TCP which is very reliable as every packet that is either lost or corrupted will be transmitted again by TCP but when there is congestion TCP slows down and hence TCP cannot be used to transport interactive videos or sounds. UDP here is beneficial then TCP but it has no mechanism to check or control congestion. So UDP tries to keep its transmission rate unchanged even when the network is going to enter a state which is likely to have congestion and this might end up consuming maximum amount of the link's capacity. TCP has the ability to decode its signal without the requirement of an external source for its synchronization and TCP is also very responsive to congestion and these are also the reasons for the fact that TCP reduces the good put to zero. This is known as congestion collapse [1]. When internet has TCP flows congestion control is ensured but in the case of UDP this situation drastically changes because co-existence of various transport protocol is next to impossible and congestion is very well possible. The solution to this problem is achieved by the recent research which throws light on Network Border Protocol [2]. In this case there are traffic shapers at the edge of the routers which monitors all the data flow and adjusts their sending rate accordingly. One another solution to this is Data Gram Congestion Control Protocol (DCCP) [3] which takes the best of TCP and UDP and has congestion control features. DCCP is still under research and a lot experiments are being carried out because selection of a responsible protocol is very important as Internet has become an essential entity today. In this paper we intend to focus on network border protocol. The network border protocol keeps a check on the rates of incoming and outgoing packets. If the rate of incoming packets is faster than the rate of outgoing packets then this means there is buffering in the network or the network is discarding some of the packets. The network border protocol ensures that the rate of incoming packets and outgoing packets is the same. This helps to avoid congestion collapse due packets that are not delivered. NBP's congestion collapse comes at a cost as there will be some complexity at the edge routers as they are monitoring the rates of individual flow. The other issue here is the communication overhead as the edge routers need to know the rates of incoming and outgoing packets and also send feedback. Though this adds complexity to edge routers and the main network remains unaffected. The end systems are also not aware that network border protocol is implemented so one need not change any transport protocol. The network border protocol is used for congestion control [4]. But the drawback is that still the complexity at the edge routers will be high so here we propose using TCP friendly rate control mechanism which will help reduce the complexity at edge routers at least for unicast flows.

2. Background

Rate Control Algorithm

The rate control algorithm operates in a manner very similar to TCP. The algorithm deals with congestion collapse due to packets that are not delivered by having per-flow transmission rates that prevents congestion collapse. Just like TCP it has two phases slow-start and congestion avoidance [5]. In network border protocol, the slow-start phase is the first phase that the incoming new flows might experience, it is later only when it experiences nascent congestion it enters the congestion avoidance phase. Whenever a backward feedback is received at the ingress router, rate control algorithm is invoked. Now the backward carries three essential information with it, first is the timestamp, second is the list of flows arriving from ingress router and third is the egress rates of each flow after monitoring. Now based on this information the algorithm base round trip time is updated after current round trip time is overhauled. The base round trip time (RTT) is best round trip time between the two routers at the edge of the network.

Now deltaRTT is calculated based on the difference between base round trip time and current round trip time. If deltaRTT is positive it means there is buffering of packets in the network as the packets are taking longer to traverse then they once used to. Whenever the buffering of the network is equal to more than one of the flow's packets at each router hop, rate control algorithm deduces a nascent congestion. In this process the first step is to calculate the product of deltaRTT and flow's ingress rate. Now if this value of the product is greater than product of the size of the largest possible packet and number of hips between ingress and egress routers then it is assumed that there in congestion. A flow is likely to enter a phase that is congestion avoidance if it is in the slow start phase. If the flow is in congestion avoidance phase already the ingress rate is reduced by a constant value till the point it is equal to egress rate. If congestion occurs network border protocol reduces the rate at which TCP packets enter the packet by reducing the ingress rate. Now either because of longer round trip time or losing packets TCP detects congestion and eventually reduces transmission rate. So now rate of ingress becomes more than transmission rate of TCP and this means that the only situation in which network border protocol regulates TCP sources s when congestion occurs.

Leaky Bucket Algorithm

Leaky bucket is one of the best algorithms for traffic flow control in this case we can imagine it to be a bucket with a minute opening at the bottom. So any packet may enter the bucket at various rates but must exit the bucket at a constant rate only from the hole. Also the bucket size is assumed to be infinite so there is no situation in which packets are lost or discarded because bucket has reached its maximum limit.

Feedback Control Algorithm

When the feedback sh**ould be exchanged and how t**he feedback should be exchanged is determined by the feedback control algorithm. The format for feedback packet is ICMP. Three important functionalities of feedbacks include letting the egress routers known which sources for the flows are associated to the ingress routers that they are managing. Second functionality of feedbacks is carried out by the backward feedback which communicates the per-flow bit rate between the egress and ingress routers. Third functionality of feedbacks is very important because they help the ingress routers to detect congestion based on edge to edge round trip time.

TCP Friendly Rate Control Mechanism

It is a mechanism for congestion control with most of the TCP features. Here a window is maintained for the packets that are waiting for acknowledgement. The size of the window is updated after every round trip. The size of the window is increased by one if there is no packet loss and decreased if there has been a packet loss. So essentially TCP's window size depends on the round trip time and loss of packets in the network.

Network Border Protocol

Network border protocol is a mechanism for congestion avoidance in which per-flow state is maintained by edge routers and the same with perform flow classification while routers at the core network are not allowed to perform any of these functions [8]. If edge routers are dealing with the flow directed into the routers they are called ingress routers and if edge routers are dealing with the flow directed out of the network it is called egress routers. There can be multiple ingress or egress routers if multiple networks are required to maintain end-to-end connectivity. Ingress routers maintain per-flow rate control whereas egress performs per-flow rate monitoring. Per-flow rate controlling helps the ingress router to keep a check on the rate at which each flow's packets are entering the network. Rate monitoring helps egress routers to deduce how fast is each flow's packet is exiting from the network [9]. Egress and ingress routers communicate with each other with the help of forward and backward feedback.

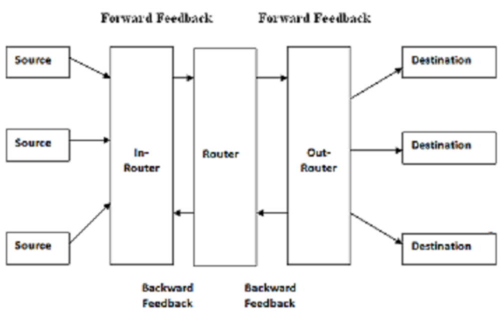


Figure 1: Network Border Protocol

3. Problem Definition

Existing Problem:

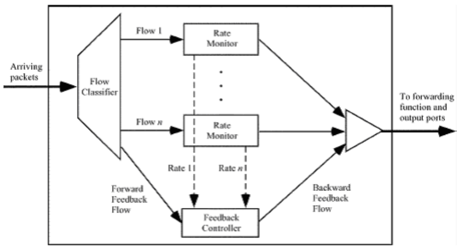
Define Internet suffers from two major problems because of end to end congestion control. These problems arise due to undelivered packets and competing traffic flows. The competing traffic flows leads to inequitable bandwidth allocation and undelivered packets might cause congestion collapse. There are certain drawbacks due the fact that TCP application are very responsive to congestion and reduce their transmission rate and end up having a really small bandwidth because they are competing with applications that are not very responsive. TCP's bandwidth allocation depends on the round trip time so applications with small round trip time get a more bandwidth as compared to applications with large round trip time [7]. TCP also handles congestion control but slows down during congestion because of the fact it retransmits every lost or corrupted packet. Also congestion collapse and inequitable bandwidth allocation are caused by streaming media traffic because of their unresponsive nature towards congestion.

Proposed system:

The proposed system involves the use of congestion free routers which are basically edge routers that are placed at the end of a network which patrol the flow's packet in order to avoid congestion collapse and inequitable bandwidth allocation. If the incoming packets are more than the outgoing packets it means there is buffering or packets are being discarded. CFR ensure that flow's packet rate for entering the network is not greater than the flow's rate foe leaving the network. This kind of patrolling makes it possible to prevent undeliverable packets from entering the network and hence prevent congestion collapse and inequitable bandwidth allocation. This congestion collapse prevention comes at a cost as there will be some complexity at the edge routers as they are monitoring the rates of individual flow. The other issue here is the communication overhead as the edge routers need to know the rates at which packets are leaving and entering the network and also send feedback. The other issue here is the communication overhead as the edge routers need to know the rates of incoming and outgoing packets and also send feedback. The complexity can be reduced with TCP friendly rate control as it has a window that waits for packets that yet to receive acknowledgement. Hence we propose the use of this mechanism along with congestion free routers in order to reduce the complexity at edge routers.

4. Architectural Components

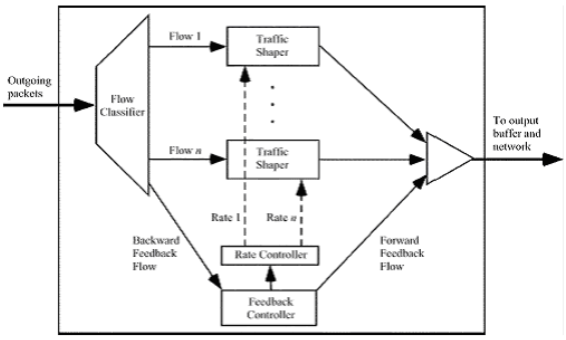
The routers at the edge needs to be modified in a way that ingress (in -router) performs per-flow rate control and out-router performs monitoring per-flow of the rates of bit[6]. In-router sends packets to the input port of the out-router and classification based on the flow is done.



Input port of an InRouter

Figure 2: Port of Input of In-router

The classification of flow policy is used by in routers to classify based on the flow. The flow classification is done on the basis on port numbers, source and destination network addresses but in case of IPv6 classification is done on the basis of packet header's flow label. The feedback controller sends these rates to in-router in the form of a backward feedback whenever a forward feedback is received. Each output port of in-router is a per-flow traffic shaper, feedback controller and flow classifier. Now packets are classified into flows by using flow classification policy and the rate at which these packets enter the network is restricted by traffic shapers. The controller of feedback generates the forward feedback that goes to the out-router and it also receives the backward feedback from the out router and passes the information of the backward feedback to the rate controller.



Output port of an InRouter

Figure 3: Output Port of In-router

5. Implementation

Source module: The in-router receives packets from this module.

In-Router module: In-router has a per-flow traffic shaper, feedback controller and flow classifier. Now packets are classified into flows by using flow classification policy and the rate at which these packets enter the network is restricted by traffic shapers. The controller of feedback generates the forward feedback that goes to the out-router and it also receives the backward feedback from the out router and passes the information of the backward feedback to the rate controller.

Router module: Takes the packets like a regular network router.

Out-router module: This module monitors the rate and a rate monitoring algorithm is used to keep a check on each flow's bit rate. These rates are sent by the controller of feedback to in-router in the form of a backward feedback whenever a forward feedback is received.

Destination module: This module accepts the packets from the out-router and stores the message into a file.

6. Results

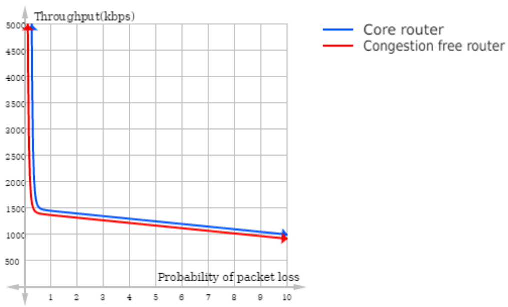


Figure 4: Probability of Packet Loss v/s Throughput Graph

The above graph describes the probability of the packet loss with various throughput values analyzing two cases i.e. when the core router is used and when congestion free router is used. Here congestion free router implies the implementation of the proposed solution with one core router along with routers at the edge of the network. As it is clearly implied by the graph that the probability packet loss is less with the congestion free router. If the rate of incoming packets is faster than the rate of outgoing packets then this means there is buffering in the network or the network is discarding some of the packets i.e. there is a loss of packets but in case of congestion free routers it ensures flow's packet rate for entering the network is not greater than the flow's rate for leaving the network and hence there is no packet loss and this fact is evident from the graph.

7. Conclusion

The network border protocol along with TCP friendly, rate control, leaky bucket and feedback control protocol help to avoid problems such as congestion collapse and inequitable bandwidth allocation. Congestion Free routers are used for this congestion control which consists of the network edge routers and core network routers and the edge routers as mentioned above patrol the incoming flow. Though this might cause increase in complexity and communication overhead. TCP friendly protocol helps to reduce the complexity at the edge routers. Hence with this, we can avoid the maladies due to congestion.

References

[1] Floyd S., Fall K., Promoting the Use of End-to-End Congestion Control in the Internet, IEEE/ACM Transactions on Networking (1999).

[2] Surendar, A., Arun, M., Periasamy, P.S."Hardware based algorithms for bioinformatics applications - A survey",(2013) International Journal of Applied Engineering Research, 8 (6), pp. 745-754..

[3] Suter B., Lakshman T.V., Stiliadis D., Choudhury A., Design Considerations for Supporting TCP with Per-Flow Queueing, Proc. of IEEE Infocom '98 (1998), 299–305.

[4] Ashakiran G.N., Panduranga Rao M.V., Basavaraj Patil S., Congestion control mechanism using network border protocol, International Journal of Science and Research 1(2) (2012), 35-39.

[5] Mohanasundaram R., Periasamy P.S., Clustering Based Optimal Data Storage Strategy Using Hybrid Swarm Intelligence In WSN, Wireless Personal Communications (2015).

[6] Mohanasundaram R., Periasamy P.S., Hybrid Swarm Intelligence Optimization Approach for Optimal Data Storage Position Identification in Wireless Sensor Networks, The Scientific World Journal (2015).

[7] Mohanasundaram R., Periasamy P.S., Swarm Based Optimal Data Storage Position Using Enhanced Bat Algorithm In Wireless Sensor Networks, International Journal of Applied Engineering Research 10(2) (2015), 4311-4328.

[8] Mohanasundaram R., Periasamy P.S., A Meta heuristic Algorithm for Optimal Data Storage Position in Wireless Sensor Networks, Pakistan Journal of Biotechnology (2016), 463-468.

[9] Braden B., Clark D., Crowcroft J., Davie B., Deering S., Estrin D., Floyd S., Jacobson V., Minshall G., Partridge C., Peterson L., Recommendations on queue management and congestion avoidance in the Internet (No. RFC 2309) (1998).

[10] Demers A., Keshav S., Shenker S., Analysis and Simulation of a Fair Queueing Algorithm, Proc. of ACM SIGCOMM (1989), 1–12.

[11] Aarthy S.L., Prabu S., A computerized approach on breast cancer detection and classification, Iioab journal 7(5) (2016), 157-169.

[12] Aarthy S.L., Prabu S., An approach for detecting breast cancer using wavelet transforms, Indian Journal of Science and Technology 8(26) (2015).

[13] Gopinath M.P., Prabu S., Classification of thyroid abnormalities on thermal image: a study and approach. Iioab journal 7(5) (2016), 41-57.

[14] Gopinath M.P., Prabu S., A Comparative study of Techniques Involved in Thermal Image Diagnostic System. International Journal of Applied Engineering Research 9(24) (2014), 26393-26416.

[15] Prabu, G., Surendar, A.”Virus detection by using a pattern matching algorithm for network security”,(2015) International Journal of Applied Engineering Research, 10 (10), pp. 9565-9569.

[16] RAJESH, M. "A SYSTEMATIC REVIEW OF CLOUD SECURITY CHALLENGES IN HIGHER EDUCATION." The Online Journal of Distance Education and e-Learning 5.4 (2017): 1.

[17] Rajesh, M., and J. M. Gnanasekar. "Protected Routing in Wireless Sensor Networks: A study on Aimed at Circulation." Computer Engineering and Intelligent Systems 6.8: 24-26.

[18] Rajesh, M., and J. M. Gnanasekar. "Congestion control in heterogeneous WANET using FRCC." Journal of Chemical and Pharmaceutical Sciences ISSN 974 (2015): 2115.

[19] Rajesh, M., and J. M. Gnanasekar. "Hop-by-hop Channel-Alert Routing to Congestion Control in Wireless Sensor Networks." Control Theory and Informatics 5.4 (2015): 1-11.

[20] Rajesh, M., and J. M. Gnanasekar. "Multiple-Client Information Administration via Forceful Database Prototype Design (FDPD)." IJRESTS 1.1 (2015): 1-6.

[21] Rajesh, M. "Control Plan transmit to Congestion Control for AdHoc Networks." Universal Journal of Management & Information Technology (UJMIT) 1 (2016): 8-11.

[22] Rajesh, M., and J. M. Gnanasekar. "Consistently neighbor detection for MANET." Communication and Electronics Systems (ICCES), International Conference on. IEEE, 2016.