PERFORMANCE EVALUATION OF WIDELY IMPLEMENTED CONGESTION CONTROL ALGORITHMS OVER DIVERSIFIED NETWORKING SITUATIONS

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Abstract— Gone are the days when the network just used to be either wired or wireless. In today’s era of Internet of Things, every single machine is connected to Internet. Each device is having wireless connectivity to the Access Point to get connected to the world of Internet which, may be Fiber or Microwave signals further, reaching to the end host by means of again wireless Access Point. The fragile packet when enters the complex network of Internet, face brutal blockage, hindering its timely arrival on the destination. Multiple researchers have been working on this problem for the last a decades and have achieved success in improving the situation by means of one or the other congestion control algorithms. But, when the demand of the Internet is now not limited to just the computers and smart phones, increasing its proximity including every single device we use, how efficient and robust these algorithms are required to be gauged. In this paper we have evaluated the performance of existing stellar congestion control algorithms in the diversified heterogeneous networking circumstances. This paper is an effort towards demonstrating how the existing mechanisms fit the current requirement and fix the problem and to what extent.

Keywords— Cubic TCP, XCP, RCP, RCP+, RCP++, Congestion Control, NS2, Heterogeneous Network, Wireless Network, Throughput.

I. INTRODUCTION

Widely implemented topology in Internet is Heterogeneous networks which are a combination of wired and wireless networks. Due to high bandwidth availability at wired links and high delayed products at wireless links, bottleneck situation is generated at Access Point and it has to face severe congestion consequences. Some of the most known and recent protocols developed to provide faster and lighter congestion control are TCP (Transmission Control Protocol), Rate Control Protocol (RCP), Explicit Congestion Control Protocol (XCP), RCP Plus (RCP+) and RCP Plus Plus (RCP++). Whenever, traffic exceeds the network capacity, congestion is likely to take place. Consider the networking situation from ISP’s angle. Customers may create bottleneck condition when all the internet users start sending data at their full speed. In metro cities, much of the corporate work is depended on Internet especially during crowded office hours. ISP’s networks, when combined for the entire city, makes it a large crowded network, where end users are generally wireless making it even a larger scale wireless network. The intriguing part of data network is that, the traffic is bursty and in most situations, bursty traffics are unpredictable and random by behavior. The irregular pattern of traffic makes the situation even more difficult to control and networking processes induce complexity into the computation as well. In such a situation of traffic bursts under large wireless networks, it is advantageous that nodes are able to buildup connectivity with any node of its choice being wireless by nature and traffic patterns can be settled tactfully in favor of congestion control. This raise question that whether the existing congestion control mechanisms are enough to handle the current communication demands and does it fit the current technology scenario? And therefore, it is desirable to survey upon congestion control mechanisms available and already deployed and how much are they capable of handling the current situations and demands. This paper is a small effort in this direction which helps the researchers to know the mechanisms evolved to control congestion, how they benefit the current communication scenario and how much still they are lagging behind of fulfilling demands of current internet. In this paper we have taken most adapted congestion control protocols that are efficient to certain extent and weak at certain parameters.

The paper is categorized in following sections. First of all, we introduce problem statement in Introduction. In second section, we provide short description of every single congestion control algorithm taken into consideration for performance evaluation. Section three is all about the methodology used and further followed
by experimental configurations and set up details provided with explanation on what is used and why. Section four is all about obtained results and detailed analysis. Section five is all about conclusion and further followed by future aspects, acknowledgement and references before we end.

II. EXISTING CONGESTION CONTROL ALGORITHMS:

In this section we are going to discuss the basic behavior of esteemed congestion control algorithms. We start with TCP, XCP, RCP, RCP+ and RCP++. 
1) TCP:
TCP is the protocol widely accepted and implemented in the network world in all the diversified network situations, compatible with each networking device and each network mechanism[1]. Researchers prefer experimenting with TCP as it is the only protocol in real world with all the simulators support and easy equipments configuration for model based or real time experimentation testing. But, few problems are observed in TCP protocol. While the global network access speeds increased dramatically on average in the past decade, the standard value of TCP’s initial congestion window has remained unchanged. In spite of avoiding congestion in the early stages on the Internet, TCP is finding it increasingly difficult to cope with the growth of communication network capacities and applications. TCP’s inability to properly utilize network links is one of the problems of TCP [6]. Any delay or packet loss can cause TCP to dramatically reduce its congestion window and hence under-utilize the link [6]. There have been many improvements proposed for TCP to change its behaviour for slow start and AIMD behaviour like High Speed TCP, Scalable TCP, Cubic TCP, etc.
2) XCP:
The fundamental algorithm of XCP has been developed and published by Dina Katabi of MIT and Mark Handley of ICIR. XCP is a feedback-based congestion control system that uses direct, explicit, router feedback to avoid congestion in the network. Explicit Congestion Control Protocol is another famous solution to congestion that extracts congestion information directly from routers and achieves fairness, maximum link utilization and does efficient use of bandwidth, which is by nature scalable too. XCP maintains per flow congestion state in packet. This needs changes in all the routers and this require large queuing capacity in routers which is difficult to deploy. Simulations indicate that XCP is powerful and scalable. XCP delivers the highest possible application performance over a broad range of network infrastructure, including extremely high speed and very high delay links that are not well served by TCP[5]. By doing so, it achieves maximum link utilizations and wastes no bandwidth due to packet loss as proved by the authors of [5]. XCP is novel in separating the efficiency and fairness policies of congestion control, enabling routers to quickly make use of available bandwidth while conservatively managing the allocation of bandwidth to flows[5].

3) RCP:
Nandita Dukkipatti proposed RCP (Rate Control Protocol) that enables typical large Internet Sized flows to complete in one to two orders of magnitude faster than the existing (TCP SACK) and XCP congestion control algorithms. In RCP, the function of providing same rate to all the flows based on the above stated two congestion control mechanisms is done by Router. And to complete the flows faster, RCP provides with extreme quick computation the excessive bandwidth to the flows. This is the reason behind faster completion of flows by RCP. It is observed through experimentation that proposed RCP is reducing Flow Completion Time (FCT) for typical Internet Size flows by one to two orders of magnitude which in comparison of TCP and XCP are performing remarkable. Talking about the mechanism used by RCP, an improved congestion control mechanism, RCP achieves it by simply emulating processor sharing at each router.

4) RCP+:
Research team of Dr. Bhargavi Goswami, Dr. Atul Gosai and Udittaranay Kar came up with a congestion control mechanism and named it RCP+. RCP+ wins upon existing congestion control algorithm with three characteristics, 1) RCP+ is more flexible to be implemented on wireless networks in comparison of RCP. 2) It allows multiple variants of TCP to co-exist in the same networks with RCP+ and work with each other smoothly. 3) And it performs well in large scale wireless networking scenario too. RCP+ is a congestion window based congestion control algorithm where the base equation is similar to RCP and implementation has far more benefits to the world of networks in co-existence with RCP and TCP. RCP+ is most suitable for networking condition where, multiple flows are having diverse characteristics and their demands vary frequently. RCP+ is having the added advantage of coexistence with other wired and wireless TCP, XCP, RCP and DCCP protocols. RCP+ is flexible like TCP and so is expected to have wide implementation over current demands of Internet. RCP+ approach is quite simple in comparison of both, RCP and TCP. Its behaviour is a pure combination of RCP and TCP.

5) RCP++:
Research team of Ishani Mehta, Udittaranay Kar and Dr. Atul Gosai came up with an improved version of RCP+ and named it RCP++. RCP++ is based on Improved AIMD and RCP+ algorithm. They use congestion window mechanism of improved AIMD algorithm to use the spare capacity of congestion window after occurrence of congestion event. Here they used Improved AIMD mechanism as well as
modified rate change equation of RCP+. The only limitation of this protocol observed on simulation environment is that it works for smaller no of nodes. If the number of nodes increases, its performance degrades to great extent. To make RCP++ work for more no of nodes, further improvements are necessary[4,7].

III. EXPERIMENTAL SETUP

We have implemented proposed model in NS-2 simulator and version is 2.35. Following given Table-1 is the list of configuration settings of our modeling with respect to topology specified by our experiment. The scenario consists of network of wireless nodes starting from 10 to 50 nodes. The flows present in the network are variable by nature, few of them are large and few of them are small.

<table>
<thead>
<tr>
<th>TABLE 1: CONFIGURATION TABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
</tr>
<tr>
<td>Configuration</td>
</tr>
<tr>
<td>No. Of Nodes</td>
</tr>
<tr>
<td>Queue Length</td>
</tr>
<tr>
<td>Queue Type</td>
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<tr>
<td>Network Type</td>
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<tr>
<td>Network Type</td>
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<tr>
<td>Intermediate Nodes</td>
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<tr>
<td>Mobility</td>
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<td>Maximum Speed</td>
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<td>Pause Time</td>
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<tr>
<td>Routing</td>
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<td>MAC</td>
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<tr>
<td>PHY</td>
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<tr>
<td>Antenna</td>
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</tbody>
</table>

Figure 1 Overview of Networking Scenario.

We have built the simulation model with few fixed parameters stated in the Table 1 with constant values; whereas, few are varying for the entire experiment, for example, number of nodes. The access point is presumed to be the gateway/router. The Packet Size is fixed to 1500 bytes for larger flows and smaller flows are given the size up to 1000 bytes starting from 100 bytes.
between moving nodes as there is freedom to get connected to any node in the wireless range in absence of guided media. RCP+ wins upon existing congestion control algorithm with three characteristics, 1) RCP+ is more flexible to be implemented on wireless networks in comparison of RCP. 2) It allows multiple variants of TCP co-exist in the same networks with RCP+ and work with each other smoothly. 3) And it performs well in large scale wireless networking scenario too. Our results, and many others in the literature, indicate that there is no existing single congestion-control method that is the best in all situations. Then too, by presenting our work, we would like to show the direction to networking research community that brings the era where the congestion control is prolific in wireless and heterogeneous networks which is social enough to co-exist with all other congestion control protocols.

IV. RESULT ANALYSIS:

We present the results for TCP, XCP, RCP, RCP+ and RCP++ as incremental number of nodes v/s throughput plots. Here, x-axis is number of nodes and y-axis is throughput. Graph 1 represents the overall throughput observed with respect to number of nodes starting from 10 nodes to 50 nodes. It was observed that RCP+ is well defined networking algorithm that reaches to its optimum data rate in small duration of time in comparison of all other existing congestion control algorithms. Analysis indicates that the algorithm is fair initially and tries to stay stable even when the throughput is degrading. Thus, for medium range of networks, RCP+ is behaving stable and performs to its optimum for longer duration.

V. CONCLUSION

In this paper, we have evaluated the performance of the entire list of prominent congestion control algorithm in today’s era having impact widely upon the world of internet. We have evaluated performance of TCP, XCP, RCP, RCP+ and RCP++. The matrix of evaluation was Throughput. It was observed during the experimentation that the behaviour of all the nodes working on RCP+ and other protocols was affected by their basic characteristics. Routing protocols affect performance of networks because it works well under AODV protocol in comparison of DSDV protocol. It is also affected somewhat by mobility and synchronization

VI. REFERENCES