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## Review

## Congestion control for high-speed wired network: A systematic literature review



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## ABSTRACT

This paper presents a survey of congestion control approaches in high speed wired network by taking into account both directions of congestion control research: source based and router based congestion control. Various survey papers reported in the literature, regarding congestion control approaches, have considered source based approach and router based approach independent to each other and take either of them into account. Both research directions are closely related to each other for a particular network domain and are equally important. It is a practicable idea to take a holistic view and study both the approaches together. The main motivation of this work is to summarize both approaches, interaction between both approaches, identify major issue and challenges in congestion control and motivate further research on this topic.

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## Contents

1. Introduction	63
2. Related work	63
3. Congestion control in high speed networks	64
4. Discussion for two-fold survey: source based and router based for congestion control	64
5. Research method	65
5.1. Research questions	65
5.2. Search process	65
5.3. Inclusion and exclusion criteria	65
6. Observations	66
6.1. Whether congestion is assumed a challenging problem by the academician/practitioners? (RQ1)	66
6.1.1. Source based congestion control	66
6.1.2. Router based congestion control	66
6.2. What are the available methods for congestion control for high speed network?	66
6.2.1. Source based congestion control	66
6.2.2. Router based congestion control	69
6.3. What are the similarities, differences and possible integration of two approaches: source based and router based congestion control?	71
6.3.1. Comparison between source based and router based approaches of congestion control	71
6.3.2. Interaction/cooperation between source based and router based approaches of congestion control	71
6.4. What are the focused network performance parameters?	72
6.4.1. Source based congestion control	72
6.4.2. Router based congestion control	73
6.4.3. Observed trade-off between different performance metrics	73
6.5. What are the available tools for analyzing network congestion in high-speed network?	73

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7. Discussion .....	75
8. Conclusion .....	76
References .....	76

## 1. Introduction

The number of internet users as well as the number of applications using internet have increased drastically due to the emergence of high speed network, which in turn increased the amount of traffic in the internet. The main side effect of this increased load is the problem of congestion in the network. Congestion control is considered as a problem of distributed nature, which requires a solution distributed at source–destination ends (transport layer) as well as at intermediate routers (network layer) to handle network congestion. Consequently researchers have considered two aspects of research for congestion control; the first is source based and the second is router based congestion control. Afanasyev et al. (2010) have done a comprehensive survey of various source based congestion control algorithms for different network environments. Labrador and Banerjee (1999), Chatranon et al. (2004), Ryu et al. (2003) and Adams (2013) have presented a detailed survey of various router based congestion control algorithms. Chydzinski and Brachman (2010) argued that because both source based congestion control and router based congestion control schemes cooperate closely, they should be studied and hence designed both at the same time for a particular network environment. In spite of that, such a direction of research is firmly overlooked by the researchers.

The purpose of this literature survey is to review the congestion control research for high-speed network and characterize the different approaches to congestion control design, by considering their advantages and limitations. Unlike previous studies, we tried to collect, categorize, and analyze major congestion control approaches for high speed network by considering the two correlated aspects of congestion control design: source based and router based. In this way this survey will naturally strengthen the coherency between the two directions of congestion control research and traces a better picture of major issues, challenges and possible solutions of network congestion problem in high speed network.

The paper is organized as follows: in Section 2 of this paper, a brief review of previous surveys, conducted on high speed Internet congestion control, has been mentioned. The phenomenon of congestion control in high speed network is briefly defined in Section 3. In Section 4 we explore the reasons for the existence of two mechanisms: source based and router based for congestion control. Research methodology is explained in Section 5. Section 6 presents the main observations found during the survey. Section 7 includes the brief discussion. Finally Section 8 concludes the paper.

## 2. Related work

In the literature, the problem of congestion has been studied widely in the context of high speed network, wireless network, satellite network, ad-hoc network etc. Substantial survey work has been reported regarding congestion control. Some significant survey works related to the topic are as follows. Yang and Reddy (1995) have first proposed a taxonomy of congestion control approaches in packet switched network, based on the control theory. This taxonomy contributes a framework which helps in the comparative study of the existing approaches and set a path toward the development of new congestion control approaches.

Labrador and Banerjee (1999) have given a comprehensive survey of selective packet dropping policies for the best-effort service of ATM and IP networks. They discussed three router based congestion control schemes for IP networks, namely RED, RED In/Out (RIO) and Flow RED (FRED). They compared RED and RIO in terms of fairness. Ryu et al. (2003) have presented a review of AQM algorithms for congestion control. They also had done a survey of control-theoretic analysis and design of end-to-end congestion control with a router based scheme. As alternatives to AQM algorithms, they also surveyed architectural approaches such as modification of source or network algorithms, and economic approaches including pricing or optimization of allocated resources. Chatranon et al. (2004) have discussed the state-of-the-art in router-based mechanisms to address the TCP-friendliness problem and present a description of the most important algorithms, design issues, advantages and disadvantages in their survey. They have done a qualitative comparison of all the existing AQM schemes and a quantitative performance evaluation is performed to show the advantages and disadvantages of only those schemes that do not require full per-flow state information since they are more likely to be implemented in practice.

Ryu et al. (2004) have presented a review of recently proposed active queue management (AQM) algorithms for supporting end-to-end transmission control protocol (TCP) congestion control with a focus on recently developed control theoretic design and analysis method for the AQM based TCP congestion control dynamics. Finally, they surveyed two adaptive and proactive AQM algorithms, *PID-controller* and *Pro-Active Queue Management (PAQM)*, designed using classical proportional-integral-derivative (PID) feedback control to overcome the reactive congestion control dynamics of existing AQM algorithms. A comparative study of these AQM algorithms with existing AQM algorithms is also given by them. An exhaustive survey is made by Thiruchelvi and Raja (2008) on the recent advances in the area of AQM techniques. Further they classified the AQM mechanisms according to the type of metrics they used as congestion measure. From the survey they found that the performances of rate based AQM schemes are better than that of queue based schemes and existing rate based schemes such as AVQ and EAVQ may result in better performance in terms of, throughput, packet loss, and link utilization by the inclusion of more number of congestion measures.

Reddy and Lokanatha (2008) have first made an effort to comparatively analyze the high speed source based congestion control protocols based on various performance metrics like Throughput, Fairness, Stability, Performance, Bandwidth Utilization and Responsiveness and further they studied the limitations of these protocols meant for the High Speed Networks. Ho et al. (2008) surveyed state-of-the-art of fast retransmit and fast recovery mechanisms of source based congestion control algorithms to address the lost packet problem, and presented a description of some useful algorithms, design issues, advantages, and disadvantages. They also presented taxonomy for fast retransmit and fast recovery mechanisms of some existing transport protocols which provides a unified terminology and a framework for the comparison and evaluation of this class of protocols. Chandra and Subraman (2010) have presented a brief survey of major congestion control approaches and categorization characteristics, and elaborates the TCP-friendliness concept and then a state-of-the-art for the congestion control mechanisms designed for network.

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