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ECC: Economically Congestion Control in Communication Networks

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Abstract - Congestion control is a vital issue in computer networks, especially the Internet. It has always been one of the basic subjects in the field of research. According to the increasing number on the Internet users, its function and services, the traffic of the Internet is highly being increased. By developing in technology however, capacity of data transferring is increasing; but all these developments do not guarantee the utilization of the Internet when it faces traffic overload. For this reason, improvement in congestion control mechanism is a matter that guarantees the utilization of the Internet and lost against network overload. We believe that this issue can be evaluated in accordance with the theories in economy science. The main goal of these theories is to maximize public welfare for people in the society. On the other hand, economy is also the best mathematical tool in order to help recognize hidden dependencies among different network demanding. On this base, we have designed an economical system to give initial services for networkers by early servers. In this system, the width of the band needed for each service proposed as goods. Early servers and their contributors play the role of producers, and all the users are consumers. Proposed algorithm is paved in NS-2 simulated networks and has been compared with XCP and TCP algorithms. The results of this simulation show the success of the proposed way in high utilization and less packet losing.

Keywords : congestion control, economy science, micro economy, producer, consumer.

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Abstract - Congestion control is a vital issue in computer networks, especially the Internet. It has always been one of the basic subjects in the field of research. According to the increasing number on the Internet users, its function and services, the traffic of the Internet is highly being increased. By developing in technology however, capacity of data transferring is increasing; but all these developments do not guarantee the utilization of the Internet when it faces traffic overload. For this reason, improvement in congestion control mechanism is a matter that guarantees the utilization of the Internet and lost against network overload. We believe that this issue can be evaluated in accordance with the theories in economy science. The main goal of these theories is to maximize public welfare for people in the society. On the other hand, economy is also the best mathematical tool in order to help recognize hidden dependencies among different network demanding. On this base, we have designed an economical system to give initial services for networkers by early servers. In this system, the width of the band needed for each service proposed as goods. Early servers and their contributors play the role of producers, and all the users are consumers. Proposed algorithm is paved in NS-2 simulated networks and has been compared with XCP and TCP algorithms. The results of this simulation show the success of the proposed way in high utilization and less packet losing.

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I. Introduction

Congestion happens when the total number of demand precedes the capacity of the network. The result of this situation is increasing in round trip time, losing in packets and probability of congestion destruction. In such a situation, connection capacity is usually occupied and routing will be low. The goal of studies and research in the field of congestion control is to design and analyze contributed algorithm to share with network sources among competitive users.

According to the binary role of the network users, as senders and receivers, they can be simulated to an economical system. From the point of micro economy, there are three main elements in each economy system: goods, producers and consumers. The main goal of micro economy theory is to use the selfish trends of market staff in a way that it lasts in economy mediation and maximum social welfare.

Since the factors affecting in economical markets are naturally selfish and want to achieve their own interests, we believe that the behavior of network users can be modeled in accordance with micro economy theory.

In the current study, using the theory of micro economy, we give a framework in which the producer are initial servers, and service routers who give services to other nodes. Consumers, in this economy are all network senders. The goods are as the same as band width. The given framework includes the affairs that are inspired by micro economy with the related algorithm.

a) ECCP Algorithm

Demand and contribution are economical models in which the effect of price on the amount is checked in a competitive market. Price effects on the consumers' demand. As a result, economy will get to its mediation in attention to price and amount. The amount of demand from the consumer side depends on the price of the product. Demand rule says that by fixing other factors, demands are less in high prices and high in low prices. In competitive markets, balanced price and balanced amount of goods are determined by demand and contribution. In higher prices, lack of demands is possible and results in over contribution. This over contribution puts pressure on the price and causes the price to return to its previous level (balanced price). After all, the price tends to be fixed and progressive.

b) Function of ECCP Algorithm

Our proposed algorithm works in two separate levels:

i. *Router*

When a packet is sent by a sender, at first time, related fields are encoded by 0, and when it is received by the router, the receiver labels the same fields and resends to router. Now the pack comes to the router, the price and the shipping costs of the packet are calculated by router and resent to the sender in the same fields. According to the price, the amount of asset and costs are known for the senders and they send other packets.

Price Calculation

Moment price is a function of utilization, queue length, available band width and round trip time. The relationship between factors and moment price as P_i comes below.

a. *Utilization*

Moment price has direct relation with utilization, since by the time utilization goes up it means that the

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whole band width is being used, so we probably will evident the loss of the packets and congestion. In this case, we suppose that when the utilization goes high, the price goes high.

$$P_i \propto Utilization$$

b. *Queue Length*

The moment price also has a direct relationship with queue length. In this case we propose that if the length of queue increases, the price will go up. According to this situation, sender, with the amount of asset in his hand, cannot buy lots of packets in high price. As a result, the length of the queue decreases and so as the congestion and packet loss will be vanished.

$$P_i \propto Queue$$

c. *Band Width*

From other hand, the price that we have proposed for the packet has a reciprocal relation with the band width, because if we had extra band width we would try to occupy all the band width to maximize the utilization of the system, so we have to decrease the price in order for the sender to have more packet demands.

$$P_i \propto \frac{1}{Spare\ BandWidth}$$

d. *Round Trip Time*

At last we suppose that the price has reciprocal relation with sending and receiving time of the packet.

$$P_i \propto \frac{1}{RTT}$$

According to what was mentioned, we can generally get the moment price with the below formula:

$$P_i = U * \frac{Q}{SB * RTT}$$

The price which has been calculated above is the moment price of the packets, but in order not to make moment decisions about price and shopping packets, we extract a function in which moment price and mean of previous prices are entered and then we will decide whether we buy the packets or not. The mentioned function is as below:

$$P_T = \alpha \frac{\sum_{i=n-1}^{n-M} P_i}{M} + \beta P_n$$

As it is seen in above relation, for moment and average price, there is a special weight proposed that declares α and β orderly.

Based on the studies and research, we proposed 0.85 and 0.15 for α and β orderly

II. Cost Calculation

Each sender wants to send some packets (according to the congestion windows size) with certain price, so the shipping cost for each sender comes from the formula below:

$$Cost \propto Cwnd_i * P_t$$

From other hand, the overall cost of certain number of sent packets comes from the formula below.

$$C = \frac{Cwnd_i}{Rtt_i} * P_T$$

III. Calculation of Sender's Asset

In this stage, we calculate the total asset of a source to help him make clear of putting a number to the congestion window based on his asset and packet prices. For this reason, the relative asset of a source is being calculated as below.

If the whole available band width is proposed as SB, and the number of senders as f, so the formula will be:

$$ASSET_i = \frac{SB}{f}$$

In order to get the final asset of each sender, we subtract the costs from his relative asset.

$$ASSET_T = \left(\frac{SB}{f}\right) - \left(\frac{Cwnd_i}{Rtt_i} * P_T\right)$$

According to whatever mentioned, we have calculated moment price, final price, costs of senders, senders' relative asset and senders' final asset in router so far.

Now it's the time to put field packets in above amounts and send them to the sender to determine the area of the congestion window with them and start to resend the packets.

Therefore, we propose the amount of a field equals to the final price of the packet and final asset of the packet, and then send it to the sender.

P_T
finance_T

Figure 1 : ECCP Algorithm Fields

a) Sender

When a packet sent by router received by sender, the sender will check the related fields and make decision according to its amount, so two cases will appear:

i. If the amount of final asset proceeds final price, it means that the source can send more packets in band width. The number of packets (congestion windows size) comes from the formula below:

$$Cwnd_i = \frac{ASSET - \cos t_T}{P_T}$$

According to relative asset, final cost and final price:

$$Cwnd_i = \frac{\left(\frac{SB}{f}\right) - \left(\frac{Cwnd_i}{Rtt_i} * P_T\right)}{\alpha \frac{\sum_{i=n-1}^{n-M} P_i}{M} + \beta P_n}$$

ii. If the final asset of the source is less than final price, the source cannot send any packet, but in order to get a feedback from network situation and calculate needed fields, we just send one packet to get the amount of router fields and make sender able to decide on new amounts. In order to do this:

$$Cwnd_i = 1$$

b) Simulation

In order to simulate the proposed algorithm, we have used NS-2 software. The properties of simulation is as below: three hundred senders want to send data in which there is a bottle neck between two routers. Band width for sending data is 30 Mb/s.

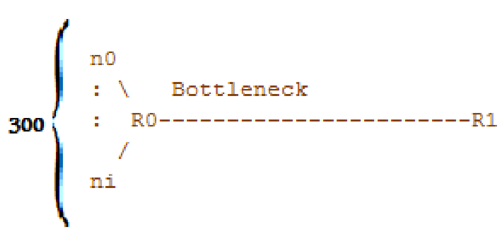

Figure 2 : Typology Simulation

c) Simulation Results

According to simulation, the results are given:

i. *Utilization*

Figure 3 shows the results related to utilization based on proposed algorithm.

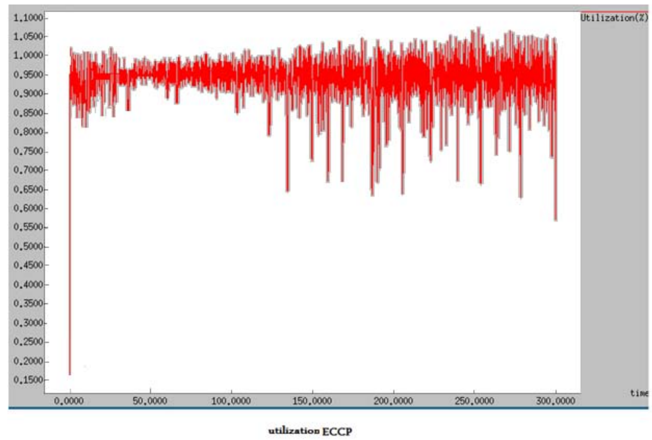

Figure 3 : Proposed algorithm utilization

Figures 4 and 5 show the results of utilization based on TCP and XCP protocols.

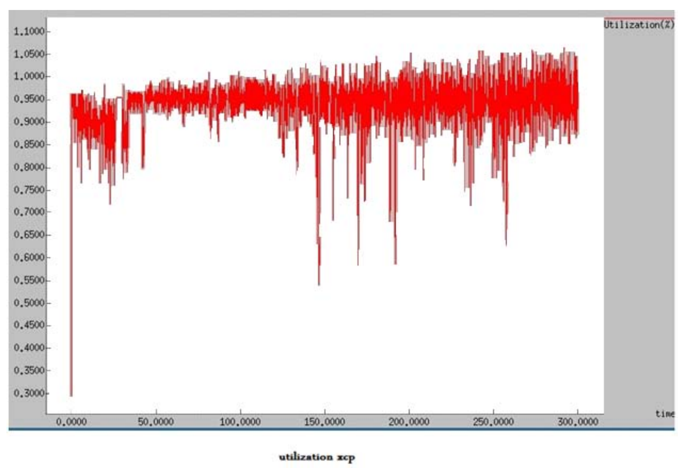

Figure 4 : Utilization of XCP protocol

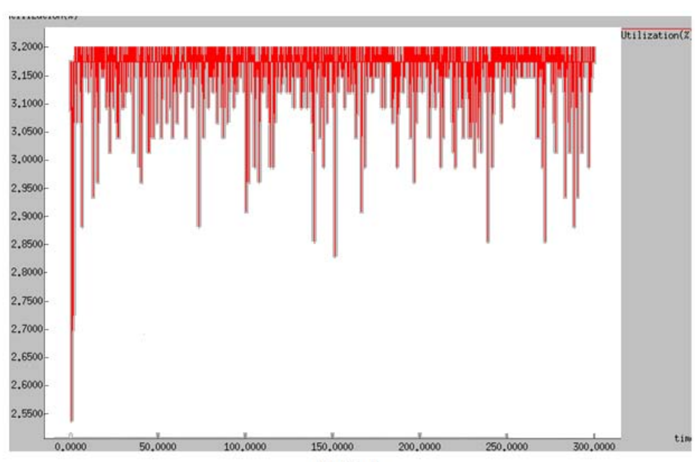

Figure 5 : Utilization of TCP protocol

We can easily see the high utilization of proposed algorithm related to XCP and TCP.

As it is seen, XCP protocol has been descended in early stages, and after sometimes more descending is seen. In TCP also we see more movements while our proposed protocol has less descending.

ii. *Losing of the Packets*

Figure 6 shows the results of losing packets based on proposed algorithm.

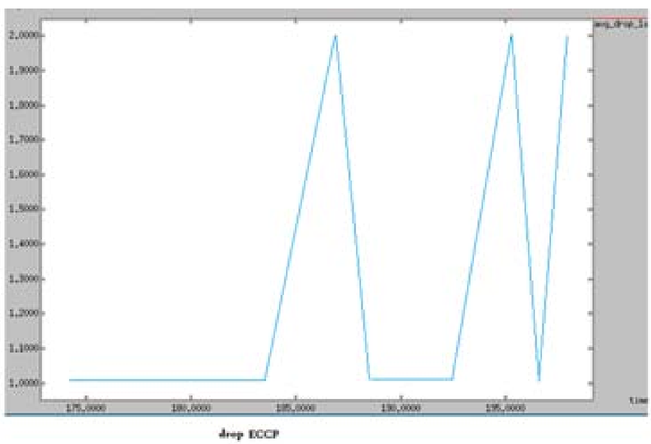

Figure 6 : Losing proposed algorithm

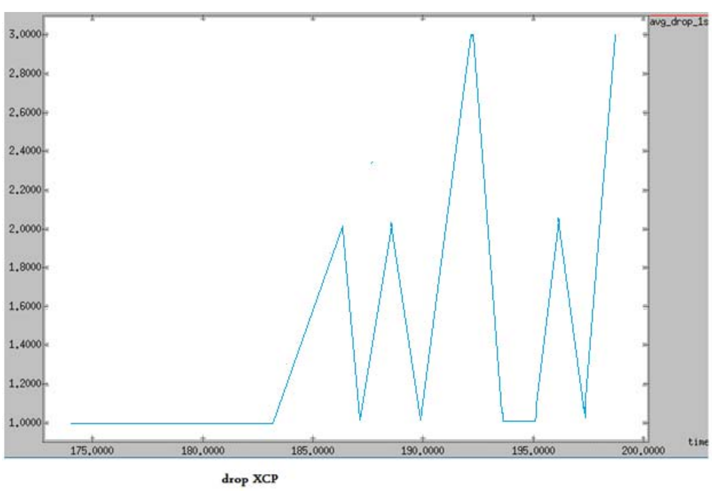

Figure 7 : Losing of packet in XCP

One of the advantages of XCP is that, the number of lost packets is zero, but as it was seen in figures above, the number of lost packets in simulated model in ECCP protocol is less than XCP protocol which cannot be prepared with TCP model.

IV. Conclusion

In this study, we worked on the evaluation of economic affairs for having better band width in computer networks, particularly on the Internet. For this aim, we modeled the behavior of networkers using theories in micro economy. According to the theories in micro economy, the percent of changes in demanding products can be evaluated based on product price. For this reason, an algorithm has been designed to control the calculated price in router in accordance with senders' demanding. By this we can control the congestion in the network and improve utilization.