Design of Efficient Transport Protocol for Multimedia through Wireless Networks

P.Ramya, K.Radha

Abstract: Wireless Internet enables wireless connectivity to the Internet via radio waves. The rapid growth of wireless Internet, and broad band networking infrastructures, such as 3G and 3.5G, WLAN and WLAN-mesh and WiMAX, makes multimedia (audio and video) information available to us anytime, anywhere, on any device. The versatility of wireless internet has consumers demanding the service at an increasing rate. Therefore it is important to develop an efficient rate control protocol for the transmission of multimedia data through wireless networks which reduces all types of losses by satisfying multimedia constraints such as delay jitter, and to achieve a high throughput. In this approach, we make use of adaptive end to end loss differentiation algorithm for differentiating congestion losses from wireless losses and a function to differentiate burst wireless losses from transient wireless losses. Loss proportion increase and loss proportion decrease (PIPD) algorithm will be used for defining burst period in order to increase efficiency. Also evaluation will be performed by taking different decision factors into consideration and thus choose a suitable decision factor for reducing losses. The proposed approach can achieve high throughput, low losses, and good energy efficiency.

Keywords: Wireless Internet, multimedia, rate control, loss differentiation, RTT, throughput, TFRC, burst loss,Energy efficiency.

I. INTRODUCTION

Wireless Internet session takes both a wireless and wired path. Now-a-days Wireless Internet also provides real-time multimedia delivery (audio & video).Because of its potential the customer usage rate is exponentially increasing. Therefore there is a need to control the transmission rate and reduce losses. Rate Control Scheme can be used to adjust the transmission rate according to the network conditions without causing congestion in the network, providing high throughput and high energy efficiency.

TCP friendly rate control protocol *TFRC* [1] is the widely used protocol in the wired Internet. It does not perform well with wireless conditions such as fading channels, shadowing effects and handoffs, which causes performance degradation and there by influence energy consumption. TFRC is designed for applications that use a fixed packet size, and vary their sending rate in packets per second in response to congestion. The main disadvantage with *TFRC* in Wireless Internet is that it treats every packet loss as a congestion loss and correspondingly reduces the sending rate. A number of approaches have been proposed to improve congestion control in wireless networks, but they have problems in streaming multimedia, also they cannot address the issues such as TCP-friendliness, independence on lower layers, and the burst loss caused by deep fading, handoff, and roaming.

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To address this issue, in this paper we propose an Efficient Transport Protocol (ETP) which uses adaptive end to end loss differentiation scheme to differentiate wireless losses from congestion losses which is integrated with an equation based rate control mechanism which later adopts a loss proportion increase and loss proportion decrease (PIPD) algorithm [11] to control the rate. Thus the rate control algorithm behaves conservatively to achieve higher energy efficiency and aggressively to recover from burst losses. Also it requires no support in routers or base stations.

The rest of this paper is organized as follows. Section II gives a brief overview of background and related work. The proposed protocol is discussed in Section III. Evaluation is described in Section IV. Finally, Section V concludes this paper.

II. BACKGROUND AND RELATED WORK

Known schemes on wireless network have been mainly focused on improving TCP performance.

TFRC [1] is a rate control protocol for multimedia applications in the Internet. *TFRC* cannot handle heavy burst losses that occur during roaming and handoff in wireless network very well. Moreover, it is not power efficient due to its slow reduction in rate during such burst error states. Furthermore, it is sensitive to the large RTT variation possibly caused by asymmetric channels.

ARC [5] is the first equation based protocol that takes both wireless and congestion losses into the account.

ARC [5] uses the following equation for rate control:

$$S = \frac{1}{4.RTT}.\left(3+\sqrt{25+24\left(\frac{1-\omega}{\pi-\omega}\right)}\right) \tag{1}$$

Where S is the sending rate in packets per second, RTT is the round trip time, π is the total packet loss probability, and the ω is the wireless packet loss probability.

Although it provides an effective rate control while delivering multimedia over the wireless network, its main drawback is that *ARC* relies on MAC layer information for rate control and does not consider the burst wireless losses due to handoff, fading etc.

The end to end rate control protocol for multimedia streaming proposed in [11] is the first protocol that considers burst losses and recovers quickly, but it does not differentiate between wireless losses and congestion losses.

III. EFFICIENT TRANSPORT PROTOCOL (ETP)

For a multimedia application, it is necessary to adjust its transmission rate according to the congestion in the network, in order to reduce losses and thus maintain excellent QoS and effectively share the bandwidth with other connections.

Therefore we introduce rate control mechanism.

Rate control will be done in between application layer and transport layer. The transmission rate is controlled based on different factors considered.

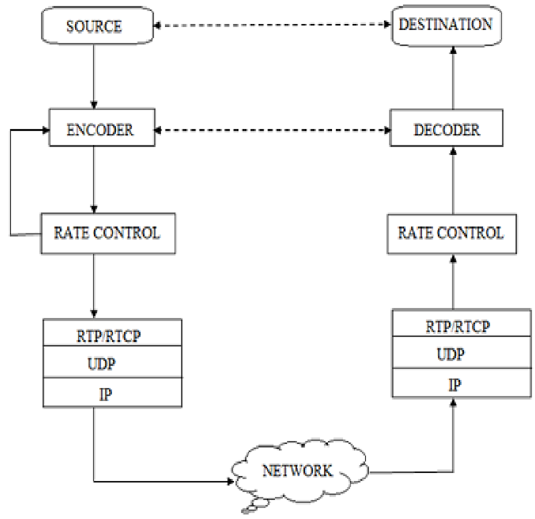

Fig.1 Structure of proposed protocol

With the above considerations we propose a new protocol which consists of following approach.

A. End-to-End Loss Differentiation

There are two types of losses in Wireless Internet, that is, congestion loss and wireless loss. The proposed protocol can detect packet losses caused by the errors in wireless channels using the robust loss differentiation scheme proposed in [4], is integrated with an equation based rate control mechanism, for performance improvement while delivering multimedia data over the wireless Internet. In this paper the end to end loss differentiation scheme proposed in [4], which is a robust scheme and is not affected by the variation of network parameters, is implemented for estimating the wired and wireless packet loss ratios, which are used in equation based rate control.

The loss differentiation algorithm as follows:

The current packet loss is considered to be a congestion loss if the following equation is satisfied otherwise; it is taken to be a wireless loss.

$$T \geq \overline{T} - T_{dev}\left(\left(\frac{T_p}{\overline{T}}\right)^{K} - 1\right) \qquad (2)$$

In (2) T is the roundtrip time, $\bar{T}$ is the average value and T_{dev} is the deviation of the roundtrip time. These parameters are updated like in the normal TCP. T_p is the end to end delay without queuing delay and k is a constant, which is normally taken to be equal to 3 [4].

After differentiating the losses, the loss probabilities are estimated using two state Markov models for both wired and wireless networks as given in [5].

B. Burst wireless loss detection:

Wireless burst losses due to wireless conditions such as fading channels, shadowing effects and handoffs influence energy consumption. Under such conditions, data transmission would better be reduced until the communication channel recovers.

In order to detect the wireless burst losses, a burst-thrust function defined in [11] is used.

$$g(k) = \begin{cases} 1, & k < \theta \\ \sqrt{k-\theta}, & k \geq \theta \end{cases} \qquad (3)$$

Where θ≥ 0, and can be practically set to max(4, Prevrate*RTT/2) where Prevrate is the previous rate,

θ is the decision factor and k is the number of packets lost due to wireless loss.

The proposed protocol uses the above approach to detect the burst wireless losses and this is then integrated with the rate control mechanism.

C. Proportion Increase and Proportion Decrease

If burst loss is detected, burst recovery period is invoked. The burst recovery period uses loss proportion increase and loss proportion decrease (PIPD) is used for aggressive behavior. PIPD uses wireless packet loss ratio to reduce the rate during burst loss and g(k) to recover quickly from burst loss.

D. Loss Ratio

Packets have different loss patterns in different types of networks. In the proposed protocol we used two Gilbert models to describe the burstiness of these two types of packet losses i.e. congestion and link losses, respectively. Consequently, we can estimate packet loss ratio and packet error ratio. Here we consider three states namely Probe, steady and burst recovery.

The initial state is the Probe state. In this state the initial sending rate is estimated with the help of transmission of dummy packets and arrival of corresponding acknowledgements. After 2*RTT, the Steady state is reached where RTT is the round trip time. In noisy wireless channel round trip time (RTT) will fluctuate sharply. Therefore in the proposed work we used the method mentioned in [7] to measure the “average” RTT during a period of time. As a result, the rate adjustment performs more smoothly, while achieving good throughput.

If a burst wireless loss is detected it enters the Burst Recovery state. After the burst loss period is over, Steady state is retained.

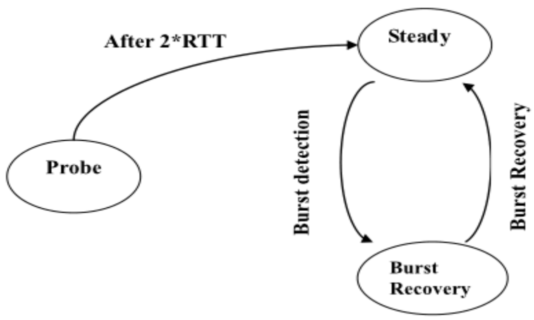

Fig.2 Different states in the proposed protocol

Fig.2 shows the state model and transitions between the states in the proposed protocol.

If there is no burst wireless loss in the steady state, after estimating available bandwidth through (1), the rate is updated through the additive increase and multiplicative decrease (AIMD) method [7]. If burst wireless loss is detected using burst-thrust function then source enters into Burst Recovery by reducing its data rate using the loss proportion increase and loss proportion decrease (PIPD) algorithm [11] .At the end of a burst period it recovers quickly using the previous burst-thrust function value and gets back to the *Steady* period. In this way proposed protocol reduces the wastage of energy by providing the minimum service while achieving high throughput.

E. Error Model

Gilbert-Elliot model will be used for error calculation in wireless transmission channels. For the simulation of the wireless channel errors we used the three state Markov model. Since two state Markov model is not sufficient to generate long-term burst losses, so three state Markov model with a third state of long-term burst is used.

IV.SIMULATION & PERFORMANCE EVALUATION

The proposed protocol is implemented in Network Simulator2 to evaluate its performance over wireless internet. Network simulator 2, widely known as NS2 [6], is simply an event driven simulation tool that has proved useful in studying the dynamic nature of communication networks. It is used to simulate both wired and wireless networks. Different performance evaluation parameters include

1) Throughput

We evaluated the throughput of ETP at different number of nodes. The throughput performance of ETP and TFRC is shown in Fig.3 for different number of nodes and the throughput performance of ETP is much higher than TFRC.

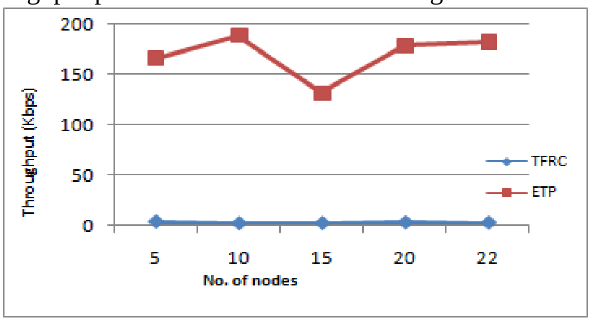

Fig .3 Throughput performance of ETP, TFRC at different number of nodes

2) Energy efficiency

Energy efficiency is the most important measurement in case of mobile devices and wireless network as the wireless devices run on battery power. The concept of energy efficiency evolves as new standards are established in the industry and regulatory compliance is enacted. This is defined below in (4).

$$EnergyEfficiency = \frac{Average\ \ no.of\ successful\ \ transmissions}{unitenergy} \qquad (4)$$

The energy efficiency of ETP and TFRC is shown in Fig.4 at different number of nodes and ETP performs better than TFRC.

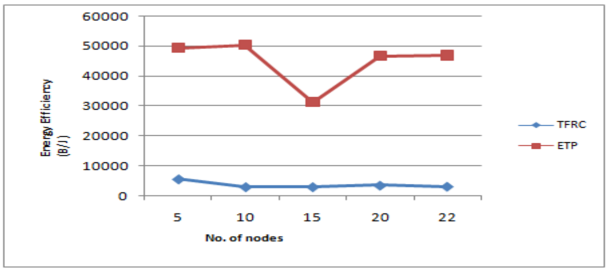

Fig .4 Energy efficiency of ETP, TFRC at different number of nodes

3) Fairness Index

The fairness performance of ETP is evaluated using (5).

$$F.I = \frac{\left(\sum_{i=0}^{n} Throughput_i\right)^2}{n\left(\sum_{i=0}^{n} Throughput_i^2\right)} \qquad (5)$$

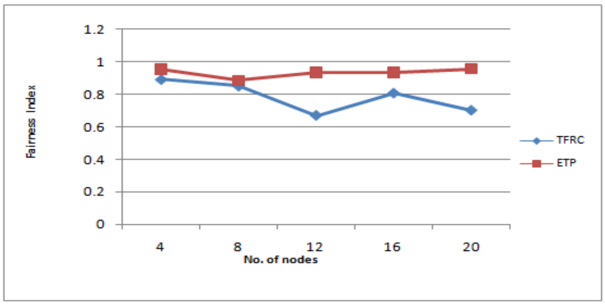

Fig .5 Fairness Index of ETP, TFRC at different number of nodes

Fig.5 shows that the fairness index of ETP for different number of nodes is almost above 0.9.

4) Sending rate & Data received with time

The rate variation of ETP is shown in the Fig.6 as a function of time. However it is observed that the sending rate of ETP is better than TFRC.

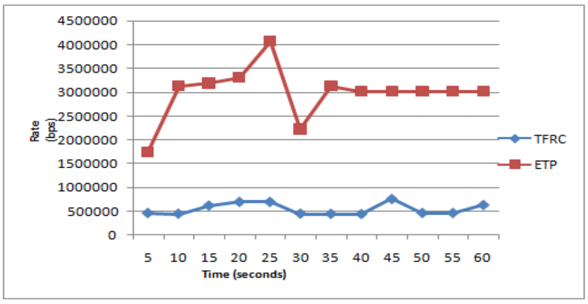

Fig .6 Sending rate of ETP, TFRC with time

With pareto traffic at the wired network and three state Markov model for wireless network, the data received at the receiver is also evaluated and it is observed that ETP acts as conserved in case of burst periods and recovers quickly. But TFRC performs poorly since it assumes all the losses as congestion losses and responds slowly. Fig. 7 shows the outputs of both ETP and TFRC.

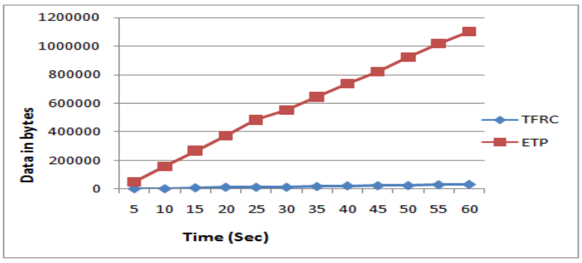

Fig .7 Total data received for ETP, TFRC with time

5) Bandwidth

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The maximum capacity of a network for sending data is known as “bandwidth”.

$$Bandwidth = \left(\frac{Number\ \ of\ bytes}{Time}\right) * 8 \quad (6)$$

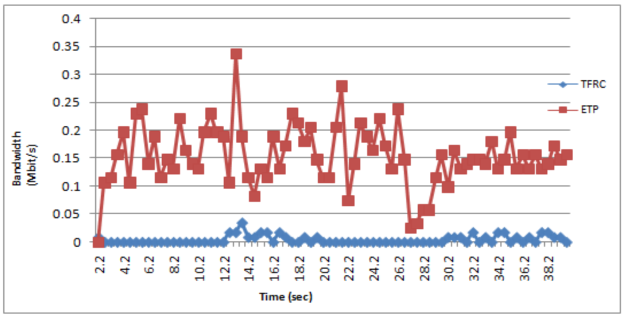

Fig .8 Bandwidth of ETP, TFRC with time

Fig.8 shows that the ETP provides high bandwidth when compared to TFRC.

6) Packets lost

Packet loss directly affects the quality of the application. Fig.9 shows the number of packets lost with time for both ETP and TFRC. From the result it is observed that the packets lost are less for ETP when compared to TFRC.

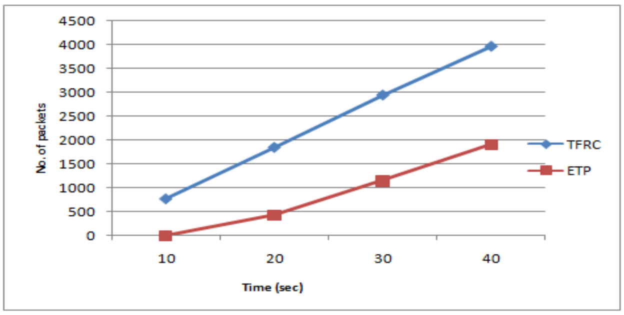

Fig .9 Packets lost with time for ETP and TFRC

7) End to End delay

It is the time taken for a packet to be transmitted across a network from source to destination.

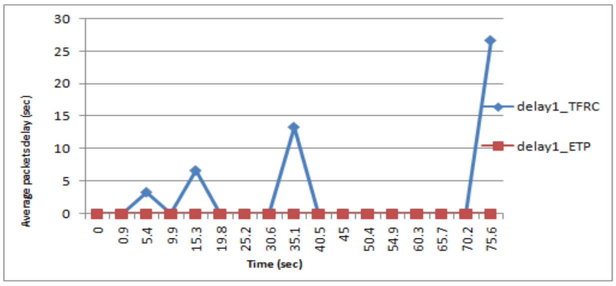

Fig .10 Packets lost with time for ETP and TFRC

Fig.10 shows the average packet end to end delay for ETP and TFRC and it is observed that the delay is almost zero for ETP.

V. CONCLUSION

In this paper we proposed the equation based rate control protocol for delivery of multimedia data over the wireless network. The proposed protocol uses adaptive end to end loss differentiation for differentiating congestion losses from wireless losses and a function to differentiate burst wireless losses from transient wireless losses. Loss proportion increase and loss proportion decrease (PIPD) algorithm is used for defining burst period in order to increase efficiency. Also evaluation is performed by taking different decision factors into consideration and thereby reduced losses. Thus we designed an efficient rate control protocol which reduces the wireless losses and reduce power consumption.

VI. ACKNOWLEDGMENT

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