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AN IMPROVED CROSS-LAYER DESIGN OPTIMIZATION FOR TCP PERFORMANCE IN WIRELESS NETWORKS

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ABSTRACT

In this paper, we intend to optimize the cross-layer design in wireless networks to avoid the congestions and packet losses between the network nodes. The conventional TCP used in wired network cannot be adapted to wireless networks as it is. By considering this fact a novel congestion control algorithm is developed with the modified acknowledgement aggregating model to avoid packet losses and for congestion control in the network. The major reason for packet losses is due to high bit error rate in the networks. Instead of invoking a congestion control mechanism after a packet loss, the proposed cross layer mechanism uses the cross layer feedback from the above and below layers, which improves the TCP performance. TCP Reno-2 model has been used for the simulation purpose and the performance of the proposed system is evaluated in terms of end-to-end delay and end-to-end throughput of the system.

Keywords: Cipher wireless networks, TCP, ACK, cross-layer, bit error rate.

INTRODUCTION

With the recent technological advancements in wireless communication, wireless networks have gradually become a significant infrastructure in establishing reliable communication in the real world applications. In this type of communications, Transmission Control Protocol (TCP) is preferred, due to its connection-oriented, full-duplex and reliable transport protocol. After a survey Abolhasan M *et al.* said that when TCP protocol was designed for wired networks, the performance was inefficient. To improve the performance of the networks, a lot of research works were carried out. Transmission control protocol is adopted for establishing a reliable transport layer protocol in wired networks. TCP is prone to performance degradation in mobile wireless communications. This performance degradation is termed due to the packet losses because of huge bit error rates. The occurrence of packet losses is a different scenario in wired and wireless communication. Congestion at various network nodes and routers leads to packet losses in wired communications, whereas congestion control techniques followed in wired networks will not be suitable for wireless communications. This is because of the time-varying property of channels and interferences of other neighborhood nodes. An improved cross-layer mechanism has been proposed for improving the TCP performance by using the information from the upper and lower layers. To overcome the packet losses, a cross layer mechanism with TCP and medium access control layer is developed. Where the earlier one controls the flow of data by windowing techniques and the later adjusts the transmission power of individual nodes in the wireless networks (depends on the channel condition and interference). This proposal comprises the ability of setting priorities for applications by the users itself and which in turn increases the throughput of the applications. Other existing approaches allocate priority automatically. This minor contribution by the user to the network protocols, assist in increasing the throughput of the overall applications. This article is organized as follows. Section II discusses about the other existing related works, section III and IV presents the proposed system and explains how the TCP performance is improved with the state machine. Section V, discusses the simulation results and Section IV concludes the research work.

RELATED WORKS

A lot of research work was carried out to mitigate the effectiveness of TCP, in wireless networks. H. Elaarag *et al.* expressed that, the TCP was developed for a wired network not for a wireless network. Tang, Ken *et.al.* focused their research work on examining the fairness in sharing of bottlenecks for TCP performance over CSMA and FAMA. The study also shows that the MAC protocols without link loss protection breaks down the mobility factors. They suggest doing more research work for consistent performance of TCP and MAC layers in a multi-hop environment. Research article V. Jacobson *et.al.* found that the packet losses are caused only by the congestion in the networks. The problem of, optimization based rate control for multipath sessions were also discussed in the article. Apart from congestion in the network, high BER causes packet losses and leads to a degradation in transmission rate of TCP. An ACK regulator for the network models were developed by M. C. Chan *et al.* which uses Radio Network Controller. The purpose of using RNC is to regulate the flow of acknowledgements transferred between the nodes of the wireless networks. The novel idea in this proposal to attain the maximum throughput in the downlink is to control the number of acknowledgements sent back to the client through RNC. Thus the client operates at a congestion avoidance phase. Zaini, K.M *et al.* Compared the performance of TCP and TFRC as a part of the other routing protocols like AODV and DSR. The later protocol finds a better throughput result with DSR rather than AODV. In certain cases it is found that the throughput values are but, the changes are promising when compared with the AODV. S. Pilosof *et al.* Proposed that the

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upstream and downstream in the transmission control protocol do not share the wireless medium, when the ration is almost ten times higher than the other. For this kind of scenario, he proposed a modified receiver's advertised window field in the ACKs.

PROPOSED SYSTEM

A feedback system model has been developed as shown in Figure-1. This model consists of two controllers: they are source and link controller. The former controls the transmission rate based on the changes in cost of the link (because of the congestion and interference in the wireless network). The later controls the cost of the link by monitoring the aggregate traffic.

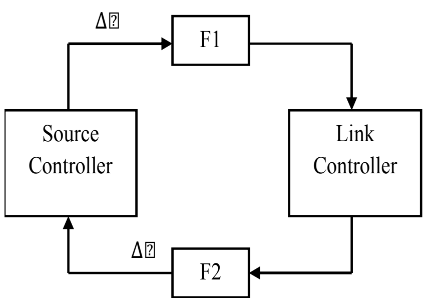

Figure-1. Cross layer feedback system.

The function of the feedback system is shown in the Figure-1. It is basically a closed loop, where, source controller relays on the feedback from the link controller and vice-versa. With reference to Low our network is modeled with the following specifications.

N = Communicating nodes ; L = Communicating links
C_l = Capacity of the link (packets/sec)

With the above specifications, the communicating links were indeed as $l \in L$ with capacity c_l. At the same time source-sink pairs were indexed as a set of all the combinations of source and sink nodes ($i \in I$). The routing array for the network model is described in Equation (1).

$$AR_{li} = \begin{cases} 1, & l \text{ in the link } i \\ 0, & \text{otherwise} \end{cases} \quad (1)$$

For all the source-sink pairs, the corresponding transmission rate is denoted by $x_i(t)$, which is a rate of individual TCP flow and source-sink pair. By adopting shannon's capacity theorem, the maximum attainable capacity in the link is given in Equation (2).

T = Symbols period
K = Constant (based on a successful transmission)
SINR for link l is given as:

$$SINR_l = \frac{P_l G_{ll}}{\sum_{k \neq l} P_k G_{lk} + n_l} \quad (2)$$

G_{ll} - Path gain (tx. link l *to* rx. link l)
n_l – Thermal noise on link l
Congestion control algorithm:

Initialize node information
for each pocket do
initialize Start of Windowing frame= w_i
power in the layer (l^{th}) = P_l
Set required $SINR_l$
before start wait at source for X_i time
if(!dup_pockets)
update path gain of the link l,
else
update path gain G_{ll} & G_{lk}
endif
calculate the capacity of the link (C_l)
estimate the transmission power for the next time slot
if ($P_l(t+1) – P_l (t)$) <= Th
cont. transmission at $P_l(t)$
else
tx at min ($P_l (t+1)$,P_{lMax})
end if
update $SINR_l$ value
end

IMPROVING THE PERFORMANCE OF TCP

In the conventional wireless networks, TCP is used for avoiding collisions on the either side of the network. The proposed acknowledgement aggregating technique improves the performance of wireless networks by avoiding collisions and also reduces the packet loss. The state diagram for aggregating packets is shown in Figure-3. In the state diagram, the initial state i.e., the idle state is set for the time period when there is no acknowledgement to be handled by the TCP. When the TCP acknowledgement is received, the state is switched from idle to ACK pending state. ACK count is incremented by one and the aggregated ACK buffer is initialized to add the ACK with a header. Now, the final packet size is calculated and the ACK timer is started. When an additional acknowledgement is received, the ACK count is incremented by 1 and adds the ACK to the buffer.

This is same as the previous sate. Now the size of the final packet is calculated and compared with the allowable MTU. If the size of the aggregated packet is more than the allowable MTU, the state is switched to send ACK state, if not it is switched to idle state. After reaching Send ACK state, the state machine settles on finalizing the aggregated packet. Size of the MTU is verified such that it does not exceed the max allowable MTU size. If the condition fails, one of the ACK is removed from the packet and the final is packet is formatted and finalized. Now the final packet is transmitted and on the arrival of new ACK, the current state is set to ACK pending state and new ACK buffer is created. If the size of the MTU is verified successfully, the state machine directly moves to finalize the aggregated packet and itself sends the packet. After this, the current state is set to idle. The flow is explained in Figure-2.

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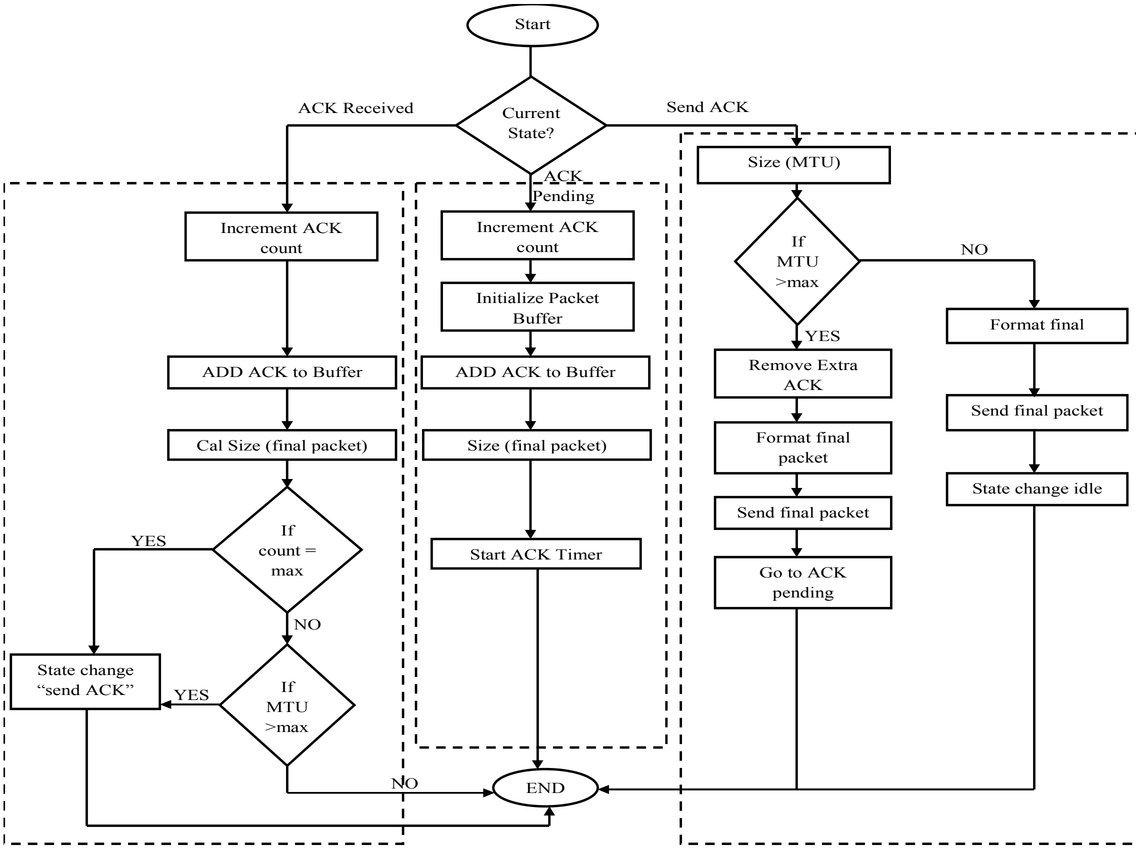

Figure-2. Flowchart for TCP packet handling mechanism.

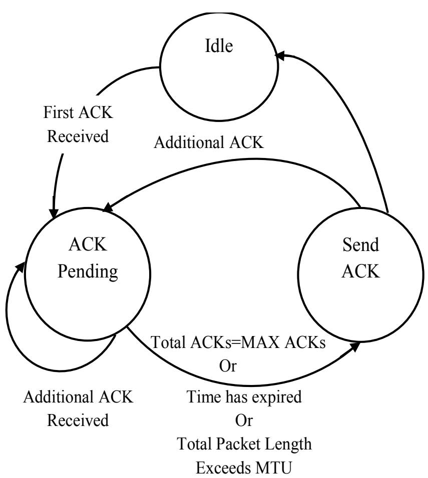

Figure-3. State diagram for TCP packet handling mechanism.

SIMULATION RESULTS

In this section, benefits of the proposed cross-layer are shown by comparing the simulation results with Tang, Ken *et al.* Simulations were carried out to test the congestion control in the wireless network with the improved TCP mechanism based on the SINR values.

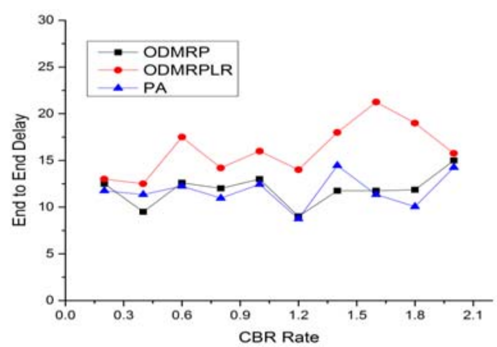

Figure-4. CBR vs end-to-end delay.

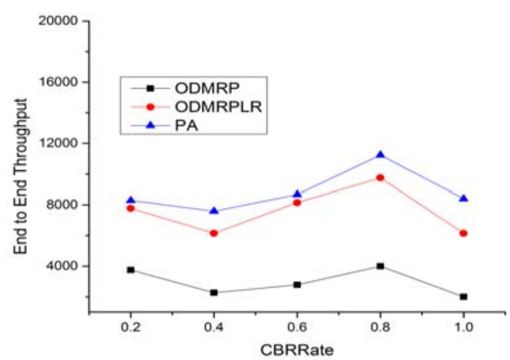

Figure-5. CBR vs end-to-end throughput.

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The simulation environment is designed as a two pairs of transmitters and receivers (model of TCP Reno-2) in the presence of attackers and there is no attack. Matlab software is used for the simulation purpose. Figure-4 shows the simulation analysis of end-to-end delay vs constant bit rate stream in the wireless networks. It is well clear that the E-E delay is maintained at the low level when compared with other existing systems Naderan-Tahan *et al.* Though the end-to-end delay is monitored in the simulation, an individual simulation is carried out to estimate the end-to-end throughput of the network corresponding to the CBR rate. Figure-5 shows that the proposed cross-layer mechanism outperforms the other existing methods.

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