Data Network performance modeling and control through prediction feedback

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***Abstract*—Performance modeling of a network is challenging especially when it involves multimedia traffic. The present day networks extensively make uses of the internet for the content transfer in real time. In such a communication system, reliability and in time data transfer is critical. The system has to support the streaming of the content data from the mobile to infrastructure and vice versa. In this paper, a modeling method for the network and its traffic shaping is introduced and simulation model is provided. The performance with this model is analyzed.**

***Index Terms*—Artificial Neural Networks, Delay, Network Performance, Random Early Detection, Simulation**

I. Introduction

THE present day data network predominantly supports real-time traffic over the wireless medium. In a wireless network, the reflections and multi path result in increased self similarity [1] for the signal at the receiving end. The self similarity of the network refers to the invariance of the shape of the autocorrelation function of the traffic parameter when observed over multiple time scales. The self similarity imparts long range dependency in to the traffic. As a result of long range dependency, the traffic turns bursty resulting in under or over utilization of the resources, increased cell loss etc.

In order to reduce the loss of multimedia data over the wireless medium, it is required to pump-in less data by controlling the degree of compression (and improving channel coding) when the channel is more noisy. To make it possible, a feedback on the channel status in terms of percentage loss of the data packets over the channel is required to be transferred to the source. Based on this input, a decision has to be taken on the data transmission rate.

For a perfect synergy between the feed forward (FF) and the feedback (FB) path, the properties of forward path that impart aberrations to the signal have to be annulled by generating appropriate signals in the feedback path. Ideally, the controller generating the feedback signal should have the same characteristics of the network. I.e., it should be a network in its own sense.

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In a real-time network scenario, there will be limited support to overcome congestion. The best way to fix this issue is to avoid the congestion to happen. So, a proactive control algorithm is preferred over an active one [2]. A good controller has to foresee the trends in the network traffic variations and provide inputs to the traffic source well in advance. The source would get sufficient time to adjust the traffic rate or provide sufficient redundancies with the appropriate channel coding schemes so that it would not flood the channel when it is disturbed. In the simulation model, the proactive queue management model GREEN [3] together with a neural network is considered.

The neural network model that satisfies the aforementioned requirements of the controller is provided in section II. The properties of the network are reflected in to this model. Model of the controller provides a mechanism to control the behavior of the network. Performance improvement as a result of this controller model is provided in section III. Section IV consolidates the results.

II. The model

A differentially fed neural network (DANN) [4] has all the characteristics required for a controller mentioned in section I. It is interesting to note that, a neural network exhibits these properties only when differential feedback of different orders is provided from the output to the input of the network. The resulting structure would have its output self similar, long range dependant (on the historical data), autoregressive with its spectrum obeying the power law and the output forming a space of Bayesian estimators for different orders of differential feedback [5] etc.

If the network is congested, data packets cannot be transmitted. So FB packets need to be slowed down. However, if the network is free, data packets can be easily transmitted calling for faster FB packet transmission. Here the sources maintain their transmission rate (which otherwise gets slowed down). The constraint is intermediate storage. Therefore, if transmitted, both are transmitted. Else, none are transmitted. Generally the feed back traffic is very small compared to the feed forward traffic. At any point of time, some weightage has to be given for the transmission of FF and FB packets. It depends up on available resources, transmission rate queue and the number of FB packets in the queue etc.

The feedback packets may be intercepted and processed by the intermediate switches to control the rate of transmission.

A small change in the traffic over a small time scale will have a profound impact on the traffic envelop over a longer time. With this idea, a traffic controller has been tried in the feedback path over feedback packets.

The rate of transmission depends up on the resource allotted. But the allotment of resources itself depends up on the transmission rate. This criss-cross dependency is as though two ANNs (or models) connected back to back as shown in figure 1.It reduces to DANN as shown in figure 2.

The dependency is a result of pileup due to previous transmission rates and previous allotments. This architecture implies a differential (delayed) feedback from the output. Thus the proposed architecture better catches this type of dependencies. The feedback on the status of the network resources controls the transmission rate. A shifted feedback has a strong influence on the resources as well as the characteristics of the network.

III. PERFORMANCE WITH THE MODEL

To generate self-similar input traffic, the superposition of the ON/OFF sources with heavy-tailed distribution is used. In this simulation study, we verify that the proposed active queue management scheme can keep an average queue length and the variation of queue length small when the input traffic is generated by self similar traffic sources. Figure 3 shows the simulation network. Here both the network and the control model may be seen. The DANN gets the training data from the background GREEN algorithm. GREEN is taken as the controller for comparison. For some time, the DANN will be in learning phase. Then it predicts the data k steps in advance. This is given as the feedback to the source [6]. The source then re-computes the transmission rate. It may be seen that the cell loss ratio has been reduced with feedback. In each case, 42 data points computed with GREEN are used for training. The Input consists of 20 sources supporting FTP that exist over the entire simulation time. The maximum buffer size is taken as 8000 with the packet size of 512.

The total cell loss ratio of an ordinary GREEN scheme is found to be 7.4%. With a neural network prediction, it has been reduced to 6% and with first order differentially fed neural network, it is reduced further to 0.55%. A 6 step prediction has been used in the experiment.

Simulation time is set to 40 sec and 180 samples are taken. Matlab version 6 and Simulink have been used to carryout the simulation. Table I shows the loss rate reduction with increase in shift.

IV. CONCLUSION

Modeling and controlling the multimedia traffic is challenging. In this paper, the characteristics of a typical home network are listed and related to the properties of a neural network. The neural network is then inserted in to the network in the feedback path to indicate the congestion status and adjust the transmission rate of the content sources. Presence of the controller in the feedback path ultimately leaves a well behaved network.

REFERENCES

[1] W.Willinger, M.S.Taqqu, R.Sherman and D.V.Wilson, "Self-similarity through high Variability: Statistical analysis of Ethernet LAN traffic at the source level", *IEEE/ACM transaction on networking*, Vol 5, pp71-86,1997

[2] C. Hollot, V. Misra, D. Towsley and W. Gong. A Control Theoretic Analysis of RED, *INFOCOMM 2001*

[3] Wu-chun Feng; Kapadia, A.; Thulasidasan, S. GREEN: proactive queue management over a best-effort network, *IEEE GLOBECOM*, pp 1774 - 1778

[4] Manjunath.R, Gurumurthy.K.S., Information geometry of differentially fed artificial neural networks, *TENCON 2002*, Vol 3, PP 1521 – 1525

[5] Manjunath.R, K.S.Gurumurthy, Bayesian decision on differentially fed hyper planes, *ITSim2003*

[6] Manjunath.R, K.S.Gurumurthy, (2004) Maintaining Long-range dependency of traffic in a network, CODEC'04

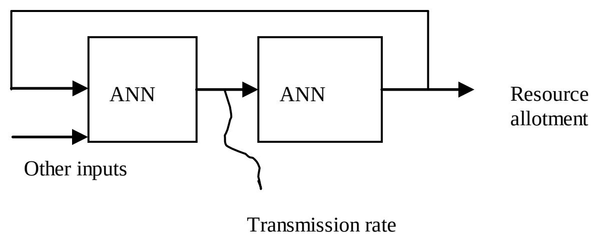

Fig.1. Resource allotment

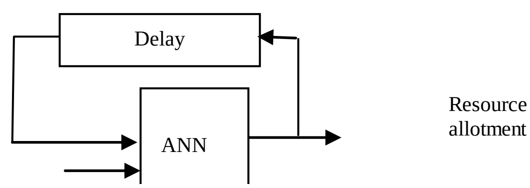

TABLE I

PERFORMANCE WITH THE PROPOSED RUNNING OVER GREEN

Sl.No.	Shift	Loss. probability	Queue variance
1	0	7.4%	136.8258
2	1	6%	133.3290
3	2	5%	133.9068
4	4	0.725%	135.5478
5	6	0.55%	136.1364

Fig.2. Simplified DANN architecture

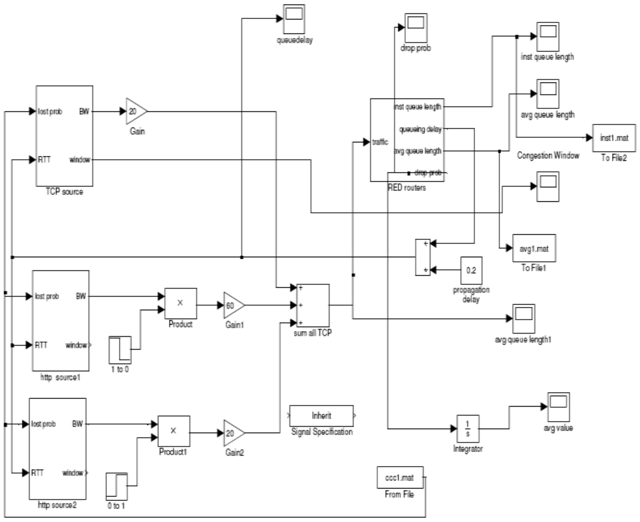

Fig. 3. Simulation model