ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijircce.com

Vol. 4, Issue 12, December 2016

Congestion control in ATM-based Broadband ISDNs Using Support Vector Machine

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ABSTRACT: Broadband Integrated - Services Digital Network (B-ISDN) has grown-up to a huge extend and nowadays it is a crucial part of our day-to-day life. To develop network utilization and robustness for ATM networks there is raising facts that reactive congestion controls are essential. This paper presents a novel approach to the problem of congestion control arising to the user-to-network interface (UNI) of the ATM-based broadband integrated services digital networks (B-ISDNs). Our approach employs an adaptive rate based feedback control algorithm using Support Vector Machine (SVM). The reinforcement learning NN controller provides an adaptive optimal control solution. This is achieved via the formulation of cost function and it is defined in terms of two major objectives: (1) to reduce the cell loss rate (CLR), i.e., organize congestion and (2) to preserve the quality of the voice/video traffic via maintaining the original coding rate of the multimedia sources. The results show that the NN control system is applicable to any type of multimedia traffic and it maximizes the performance of the system. Hence, our novel approach is very efficient in controlling the congestion of multimedia traffic in ATM networks.

KEYWORDS: Congestion control algorithm; ISDNs; ATM Networks; SVM; QoS.

I. INTRODUCTION

Nowadays high-speed transmissions and heterogeneous traffic are some of the most essential requirements that a communication network must satisfy. Therefore, the design and management of such networks must consider these requirements. Traffic and congestion control techniques are decisive to a successful operation of ATM networks. They support different types of services and this fact makes them less predictable networks. A Network is assumed to be in the state of congestion when the whole demand for resources exceeds the total existing resources. In other words we can say a network is in a state of congestion when the excellence of the service delivered to the user decreases, whenever there is enhance of load in a network. Take an example of downloading a 1 GB file .When there is no congestion; the file gets downloaded in only some minutes, but on day when there is congestion in a network similar file gets downloaded in hours. The problem of congestion has become an significant issue these days. The enhanced demand for communications services of all kinds, has engendered the increase of Broadband integrated Services Digital Networks (B-ISDN) which is expected to offer a single and professional transport for voice, video-conferencing, video-phone, high speed data transfer, home education, video on demand as well as a number of services which are yet to be developed. The integration of these vastly different types of traffic in a common medium with frequent switching and multiplexing is potential due to the development of asynchronous transfer mode (ATM). At the current time, the traffic level for existing and novel services is increasing.

A. QUALITY OF SERVICES

A set of parameters are negotiate when a link is set up on ATM networks. These parameters are used to calculate the Quality of Service (QoS) of a link and quantify end-to-end network performance at ATM layer. Cell Transfer Delay

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Vol. 4, Issue 12, December 2016

(CTD): The stoppage experienced by a cell amid the first bit of the cell is transmitted by the resource and the last bit of the cell is received by the destination. Utmost Cell Transfer Delay (Max CTD) and Mean Cell Transfer Delay (Mean CTD) are used.

- Peak-to-peak Cell Delay Variation (CDV): The dissimilarity of the greatest and lowest CTD experienced during the connection. Peak-to-peak CDV and immediate CDV are used.
- Cell Loss Ratio (CLR): The fraction of cells that are lost in the network due to fault or congestion and are not received by the destination.
- Peak Cell Rate (PCR): The maximum immediate rate at which the user will transmit.
- Sustained Cell Rate (SCR): The normal rate as calculated over a long interval.
- Burst Tolerance (BT): The utmost burst size that can be sent at the peak rate.
- Maximum Burst Size (MBS): The greatest number of back-to-back cells that can be sent at the peak cell rate. BT and MBS are interrelated as follows: Burst Tolerance = (MBS - 1) (1/SCR- 1/PCR).
- Minimum Cell Rate (MCR): The minimum cell rate preferred by a user.

B. ATM-BASED BROADBAND ISDNS

Conventional telecommunication networks are specific; there are clear dealings between services and networks. A lot of the telecommunication services have their own networks and those networks are naturally not very well suited for supporting other services than those primarily planned to be supported. The novel services will require superior bit rates per user than the obtainable networks can offer. It would be ineffective to build a new network for every new service. Therefore, the new knowledge should also be able to support future services; services that we identify nothing about when the technology is developed. The novel system should also be able to carry al1 the services provided by the offered specialized networks. The B-ISDN idea is to support al1 kinds of services in a single network. B-ISDN desires an extremely supple switching technology. The ATM technology has been developed to be able to complete the needs of the B-ISDN. While ATM careful as a transfer mode for transmission very high data rates, B-ISDN is a network measurement exploiting ATM technology.

C. ATM ARCHITECTURE

ATM will arrange the means to transport, at broadband cost, the traffic generated by a wide range of multimedia services. ATM is suitable for the multimedia traffic environment because it offers a great flexibility and efficiency in the use of available resources. All available resources in the network are shared by all services, so the statistical sharing of the resources can lead to greater efficiency. ATM is a connection-oriented technology (similar to the telephone networks) in the sense that before two systems on the network can communicate, they should inform all intermediate switches about their service requirements and traffic parameters.

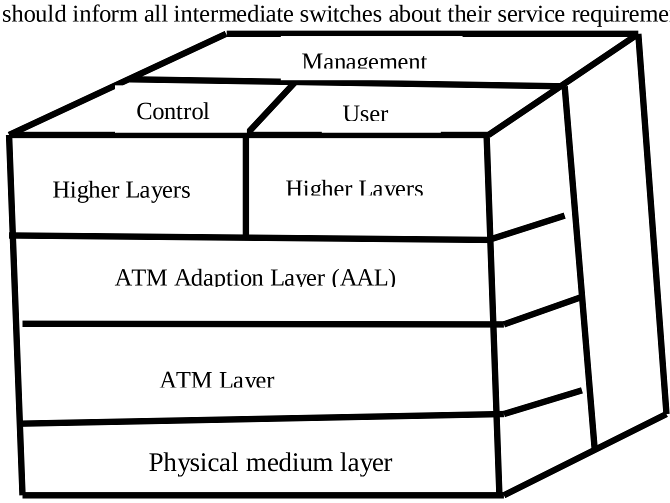

Fig.1 ATM Network Architecture

In ATM networks, each connection is called a virtual circuit or virtual channe1 (VC) because it allows the ability of each connection to be shared by links using that link on a demand basis rather than by flat allocations. The links allow the network to guarantee the quality of service (QoS) requirements by preventive the number of VCs. Typically, a user declares major service requirements at the time of link setup, declares the traffic parameters and may agree to control

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these parameters dynamically as demanded by the network. In below figure layered model of ATM is shown. The physical-medium layer is responsible for the proper bit transmission. This layer is also responsible for electro optical conversion since, in 6-ISDN, the physical medium may be optical fiber. The ATM layer contains al1 the details of the ATM technique, and it is common to al1 services. The data unit of this layer is an ATM cell. This layer performs the cell header functions and cell-based multiplexing / de-multiplexing. The ATM adaptation layer (AAL) provides the higher service layers with the necessary functions which are not provided by the ATM layer, such as, preserving timing, data frame boundaries. Four types of AALs were proposed, each supporting a different type of traffic or service estimated to be used on ATM networks. The flexibility needed to support variable transmission rates is provided by transmitting the necessary number of cells per unit time. ATM network is connection-oriented. It sets up a virtual channel connection (VCC) going through one or more virtual paths (VP) and virtual channels (VC) earlier than transmitting information. The cells is switched according to the VP or VC identifier (VPI/VCI) value in the cell head, which is really set at the connection setup and is transmitted into novel (VPI/VCI) value while the cell passes each switch. ATM resources such as bandwidth and buffers are shared among users; they are allocated to the user only when they have a little to transmit. So the network uses statistical multiplexing to improve the effective throughput.

D. CONGESTION CONTROL IN ATM NETWORKS

The idea of congestion in the network layer is a extremely simple one. The performance of some systems will degrade if the quantity of work that the system is forced to do is more than it can manage with. In this situation, if there are lots of packets present in a given part of the subnet, we speak that the subnet is congested. This position is shown graphically in figure.

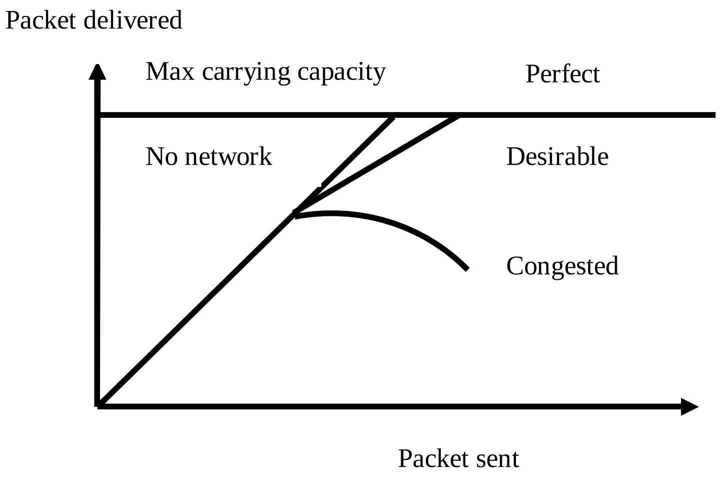

Fig.2 Packet Sent V/s Packet Delivery.

Congestion control is a meticulous challenge in the ATM environment because of its exclusive traffic characteristics, high connection speed, diverse service requirement and the varied characteristics of the traffic ATM is estimated to support. Most traffic sources in ATM networks are bursty. A bursty source generates a large amount of traffic at some high peak rate for a short period of active time and generates little or no traffic for some idle time. If bandwidth were allocated based on peak rate, network resources would be wasted when the source is ideal. A layered and distributed congestion-control framework has been apply to the design of congestion control in ATM networks, which is portioned into three control domains, the cal1 layer, the burst layer and the cell layer. In the cal1 layer, link admission control (CAC) should be used, by investigative the load, service requirements and traffic characteristics.

This paper is organized as follows. In the next section, we discussed about the related work. Section 3 describes the congestion control methods. Section 4 presents about the Congestion control in ATM-based Broadband ISDNs as proposed method. Results and discussion shown in Section 5 and Section 6 concludes the paper.

II. Related work

The guess that statistical multiplexing can be used to enhance the link utilization is that the users do not take their peak rate values simultaneously. But since the traffic demands are stochastic and cannot be predicted, congestion is inescapable. Whenever the whole input rate is greater than the output link capability, congestion happens. Under a congestion situation, the queue length may become very huge in a short time, resulting in buffer overflow and cell loss. So congestion control is essential to ensure that users get the negotiated QoS. The following obtainable work is

Saverio Mascolo(1999) states that there is a huge bandwidth delay products in high speed communication networks thus ensuing in adverse conditions on closed-loop congestion control algorithm. By means of the mixture of classical theory and Smiths principle a law for congestion control for high speed communication networks can be considered. This control law is transformed into discrete values and window form for ATM and internet. Deepak Bansal And Hari Balakrishnan(2001) states that congestion results in reduction of transmission rate that is problematic for voice and video applications ,therefore an algorithm that is nonlinear in nature is needed naming this algorithm as binomial Algorithm. The Binomial algorithm makes use of TCP style for Addictive increase and multiple decreases for increasing and decreasing the transmission rate. In addictive enhance the rate of improve is inversely proportional to power p of current window size and for multiple decreases; rate of decrease is proportional to power z of present window size. Aloke Chaudhuri quotes in his patent that the computational properties of neural networks can be used for selecting the optimal route in a communication network. The traffic management and choice of optimal route are based on the output measurements of the network. Links in a network is monitored to obtain the historical data. This statistical data is used to train the neural networks for predicting the best connection by taking into consideration the factors like quality of service, cell rate and rate of the connection. Mirza Waseem Hussain(2015), focus has shifted from desktops and laptops to handheld devices like tablets, phablets, mobile phones, PDA etc. About 900 million computers are connected to internet. In an hour 383 thousand TB of data transmission takes place. As the traffic on internet increases giving rise to the problem of congestion. One of the latest approaches to control the congestion is based on Neural Networks.

DU Shu-xin(2004), a method for solving the problem of congestion control arising at the user network interface (UNI) of ATM networks. The controller output signals include the source coding rate and the percentage of the sources that send cells at the corresponding coding cost. The control methods not only reduce the cell loss rate but also guarantee the excellence of information fed into the multiplexer buffer. Simulations with 150 ADPCM voice sources fed into the multiplexer buffer showed that the projected methods have advantage over the performance indices such as cell loss rate (CLR) and voice quality. Guiomar Corral, propose high-speed transmissions and heterogeneous traffic are some of the most essential requirements that a communication network must satisfy. Traffic and congestion control methods are decisive to a successful operation of ATM networks. They carry diverse types of services and this truth makes them less predictable networks. Congestion can be defined as a state of network elements in which the network cannot guarantee the recognized connections the negotiated QoS. This system to cut short-term congestion in ATM networks. Yen Chieh Ouyang, Ching-Wen Yang and Wei Shi Lian states the feedback rate regulator is used by applying the technique of neural networks for ATM networks in which the prediction of incoming load is prepared. Several leaky buckets are used for many sources and these leaky buckets can be used to monitor the source. Several leaky buckets (MLB) for variable bit rate can be used to predict the load of the traffic. The capability of buffer and rate of leak can be adjusted. Inward traffic load can be predicted by using finite duration impulse response (FIR) and this information gathered is passed to remark rate regulator.

III. Congestion control algorithm

In order to predict short-term congestion in a ATM network, support vector machine techniques have been implemented. SVM is a class of supervised learning algorithms. Pattern recognition problems can be solved by using SVM. Also forecasting, constructing intelligent machines, regression estimation problems and the problems of dependency estimation are some of the SVM application areas.

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ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

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Vol. 4, Issue 12, December 2016

When ANN is compared with SVM, it has some important disadvantages. Firstly, for error function to be minimized has many local minima, this learning process can fail. Secondly, knowledge algorithm cannot control the complication of architecture of ANN; therefore this architecture determines the overview abilities. SVM is used for classifying data points of linear separable data sets. Also, SVM can be applicable to linear and nonlinear circumstances. By using SVM, the separating margin between two classes is tried to be maximum. For linear separable training pairs of two classes, the respective decision hyper plane in n-dimensional feature vector $g_i(y)$ is given in the following equation:

$$g_i\,(y) = W_iT.\,Y + w_{i0} = 0$$

Where $g_i\,(y)$ = Output feature vector

$W_iT = \{w_1, w_2\ldots\ldots w_n\}$ T = weight vector

n = the number of attribute w_{i0} = a scalar called threshold / bias value

y = Input feature vector

To resolve it, let's consider two input attributes A_1 and A_2 .If y_1 and y_2 are the two values of attributes A_1 and A_2 on the decision hyper plane then the following is valid.

$$g_i\,(y_1) = wT_1y_1 + w_{i0} = 0$$
$$g_j\,(y_2) = wT_2y_2 + w_{i0} = 0$$

Subtracting two equations will Yield the following:

$$g_{ij}\,(y_1,y_2) = 0 \Rightarrow wT(y_1 - y_2) = 0$$

Where $(y_1 - y_2)$ is a vector parallel to the decision boundary and is directed from y_1 to y_2. Since the dot product is zero, the direction for WT must be perpendicular to decision boundary.

Thus, any point that lies above the separating hyper plane satisfies i.e. for any square Ys is located above the decision boundary, we can show that

$w_1y_1+w_2y_2 + w_{i0} = k > 0$

Similarly, any point that lies below the separating hyper plane satisfies i.e. for any circle yc located below the decision boundary, we can show that

$w_1y_1+w_2y_2 + w_{i0} = k < 0$

If we label the squares as class +1 and all the circles as class -1, then we can predict the class label Y for any test example z in the following way:

$$Y_i = \begin{cases} 1, & \text{if } w.\,z + b > 0; \\ -1, & \text{if } w.\,z + b < 0; \end{cases}$$

The weights can be adjusted so that the hyper planes defining the "sides" of the margin can be written as

H1: $w_1y_1+w_2y_2 + wi0 \geq 1$, for Yi = +1

H2: $w_1y_1+w2y2 + w_{i0} \leq - 1$, for Yi = -1

That is, any tuple that falls on or above H1 belongs to class +1, and any tuple that falls on or below H2 belongs to class -1. Connecting the two inequalities of Equations and we get

Yi $(w_1y_1+w_2y_2 + w_{i0}) \geq 1$, for all i

The margin can be computed by subtracting the second equation from the first equation. This is equivalent with

1. Having a margin of $\frac{1}{\|w\|} + \frac{1}{\|w\|} = \frac{2}{\|w\|}$
2. Requiring that $wT_iy + w_{io} \geq 1, \quad \forall\, y \in w_1$

$$wT_iy + w_{io} \leq - 1, \quad \forall\, y \in w_2$$

Compute the parameters w, wioof the hyper plane so that to:

Minimize J (w, w_{io}) = $\frac{1}{2}\|w\|^2$ Yi $(wT_iy_i + w_{io}) \geq 1$, i =1, 2…………N

Obviously, minimize norm make the edge maximum. This is a nonlinear quadratic optimization task subject to a set of linear inequality constraints. This problem can be solved by minimizing Lagrange function. The Karush-Kuhn-Tucker (KKT) conditions that the minimize of above equations has to satisfy are

$\frac{\partial}{\partial w}L(w, wio, \lambda)=0$and $\frac{\partial}{\partial wo}L(w, wio, \lambda)=0$ where $\lambda i \geq 0$

 DOI: 10.15680/IJIRCCE.2016. 0412149

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i=1,2…………..N

$\lambda_i[Y_i(wT_iy_i+w_{io})-1]=0$ i =1,2…………..N

Where λ is the vector of the Lagrange multiplier λi and L(w, wio, λ) is the Lagrangian function defined as

$L(w, w_{io}, \lambda) = \frac{1}{2} wTw + \sum_{i=1}^{N} \lambda_i [Yi (wTiyi + wio) - 1]$ Combining the equations, we get

$$W = \sum_{i=1}^{N} \lambda_i Y_i y_i \quad \text{and} \quad \sum_{i=1}^{N} \lambda_i Y_i = 0$$

Finally, SVM is to optimize the separating hyper planes in a high dimensional feature space.Congestion in ATM network environment, which work on different quality of service (QoS) for the throughput. The support vector machine, which has given high performance for congestion control.

IV. Proposed Method

The planned congestion control technique features parameterized call recognition. Presented bandwidth and highest node delay are two crucial parameters used for setting up links. Bandwidth is pre-allocated for real-time traffic based on position mean bit rates. Available buffers are the control parameter for admitting non-real-time cell transfers on a link-by-link basis. Details are shown below.

Two types of traffic are defined in the form: a) Real-time Traffic (RT): Cells of this type are delay-sensitive. They must be delivered to the destination within a predefined time frame. b) Data Traffic (DT): Cells of this kind are delay-insensitive, but they are loss-sensitive. All cells should be delivered.

EB (Effective Band width) is the criterion used for call acceptance. There exists a divide EB for each type of traffic and for every node. EB is a two-element vector with the format of EB = (x, y).

The EB of a node is defined as follows:

$EB_k = (C\ AVAIL_k , M_k)$

Where EB_k = the EB of node k

$C\ AVAIL_k$ = the available (unallocated) channel capacity at node k

M_k = the maximum node delay at node k

For ease, all definitions in this model are time-implicit. The time feature is syntactically absent but intuitively understands. For example, EB_k is short for EB_k (t), denoting the EB of node k at time t (the time node k is inquired).

The EB of RT traffic is defined as:

$EB\ RT_{k,l} = (B\ RT_k , D\ RT_{k,l})$

Where $EB\ RT_{k,l}$ = the EB of the k th RT traffic at node l

$B\ RT_k$ = the prespecified mean bit rate of the k^{th} RT traffic

$D\ RT_{k,l}$ = the allowable maximum node delay of the i^{th} RT traffic at node j , and

$D\ RT_{k,l} = D\ RT_k, pred(k,l) - M\ pred(k,l)$

Where pred(k,l) = the predecessor of the lth node of the kth traffic

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The EB of DT traffic is defined as:

$EB\ DT_{k,l} = (0\ DT_k\ ,\ D + DT_{k,l})$

Where $EB\ DT_{k,l}$ = the EB of the k^{th} DT traffic at node l

$0\ DT_k$ = the prescribed mean bit rate of the k^{th} RT traffic is zero (at the connection setup time)

$D + DT^{k,l}$ = a quantity that is larger than the allowable maximum node delay for the

k^{th} RT traffic at node l
$EB_1 = (x_1, y_1)$ and $EB_2 = (x_2, y_2)$

A RT link request is granted only if its EB can be fulfilled by all intermediary nodes on the route; i.e., RT_k can be granted its connection request only if $O(EB_l\ ,\ EB\ RT_{k,l}) = 1$ is true for all l 's on the routes. DT traffic is also connection-oriented. However, a DT link request is always granted. From the EB definition for DT traffic we know that acceptance is instantaneous. A route can be chosen randomly by the entrance node. EF (EF actives buffers) is the key measure used to grant cell transfer requests for DT traffic from node to node. There exists a separate EF for each DT cell transfer demand and for each node. EF is a scalar quantity.

V. Results and Discussion

With the increase in data transmission the number of challenges and issue comes into play, one of the major issue due to heavy traffic is the congestion. To control the congestion various techniques and methods have been evolved time and again. Designing the perfect technique for controlling the congestion in a network is very difficult. To predict and control short-term congestion in ATM networks, a control method using support vector machine techniques has been introduced in this paper. The performance of the proposed congestion control technique is evaluated by using simulations. We suppose the following for all our simulations: a) Channel capability allocation is based on the prescribed mean arrival rate for each input source. b) RT traffic is shaped by employing a leaky bucket method based on the channel capacity allocated. In our simulations, the leaking rate of a leaky bucket queue coincides with the service rate for that line. c) Each DT input resource is allocated a huge buffer (a fat bucket policy) to provide accommodation sudden bursts of cells without risking any loss. d) The system is in equilibrium and running at full speed (all channel capacity allocated) when it is analyzed.

The control methods not only minimize the cell loss rate but also guarantee the quality of information (such as voice sources) fed into the multiplexer buffer, which utilizes the ATM networks at as high a rate as possible. The ultimate goal of the congestion control is to make optimal utilization of network resources. Therefore congestion must be avoided as it leads to degrade in the performance of the network.

VI. Conclusion

To improve network utilization and robustness for ATM networks there is increasing evidence that reactive congestion controls are necessary. This paper presents a new approach to the problem of congestion control arising to the user-to-network interface (UNI) of the ATM-based broadband integrated services digital networks (B-ISDNs). Our approach employs an adaptive rate based feedback control algorithm using Support Vector Machine (SVM). The reinforcement learning NN controller provides an adaptive optimal control solution. This is achieved via the formulation of cost function and it is defined in terms of two main objectives: (1) to minimize the cell loss rate (CLR), i.e., control congestion and (2) to preserve the quality of the voice/video traffic via maintaining the original coding rate of the multimedia sources. The results show that the NN control system is applicable to any type of multimedia traffic and it maximizes the performance of the system. Hence, our novel approach is very effective in controlling the congestion of multimedia traffic in ATM networks.

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Vol. 4, Issue 12, December 2016

ACKNOWLEDGEMENT

Authors are thankful to Subhani Shaik, Assoc. Professor and Shaik Subhani, Asst. Professor, Dept. of computer science & engineering, for giving continues support and encouragement to carry out this work. Authors are also thankful to the reviewer for critically going through the manuscript and giving valuable suggestions for the improvement of manuscript.

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