Bandwidth Demand Prediction in ATM Networks

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Abstract - *The coexistence of a wide range of services with different quality of service (QoS) requirements in today's networks makes the efficient use of resources a major issue. It is desirable to improve network efficiency by adaptively assigning resources to services that have different bandwidth demands. The Asynchronous Transfer Mode (ATM) technology provides this flexibility by virtualizing network resources through the use of the virtual path (VP) concept. ATM is used widely in telecommunication systems to send data, video and voice at a very high speed. ATM promises to support all these different requirements with a common network. Within such a network all connections may impact on each other, ATM must manage traffic fairly and provide effective allocation of bandwidth for these different applications. For an effective allocation of bandwidth effective prediction of bandwidth demand is needed. Existing bandwidth demand prediction techniques involve complex operations and are very expensive. In this paper we present a novel bandwidth prediction technique for ATM networks. The proposed method is based on the previous bandwidth utilization information. The proposed technique uses simple data structure to store all the information and involves only simple mathematical calculations.*

Key Words: *ATM Networks; Bandwidth demand Prediction;*

1.INTRODUCTION

ATM is a packet switched, connection oriented transfer mode based on asynchronous time division multiplexing. ATM is considered to reduce the complexity of the network and improve the flexibility of traffic performance [1]. In ATM, information is sent out in fixed-size cells. Each cell in ATM consists of 53 bytes. Out of these 53 bytes, 5 bytes are reserved for the header field and 48 bytes are reserved for data field. ATM is Asynchronous as the recurrence of cells sent by an individual user may not necessarily be periodic. ATM integrates the multiplexing and switching functions and allows communication between devices that operate at different speeds [2]. Different traffic types with varied traffic characteristics and different QoS requirements can co-exist with Virtual Path (VP) sub networks within ATM network [3].

ATM network management involves many complex tasks like Bandwidth Management, Configuration Management, Failure Management and so on. Bandwidth Management attempts to manage the bandwidth assigned to virtual paths. The main objective of Bandwidth management is effective utilization of bandwidth. The concept of Virtual Paths (VP) is a powerful technique to improve the transmission efficiency in ATM networks. VP is basically a logical link between two nodes carrying the same type of traffic. VP networks [4] [5] is one of the best ways of utilizing the ATM networks. Intelligent controllers, which predict bandwidth-demand patterns to enable better VP management, have the potential to revolutionize ATM networks. In fact transmission efficiency can be improved by dynamically changing bandwidths of VP's based on demand. The VP bandwidth is dynamically altered in accordance to the traffic demand. For efficient management of VP bandwidth, an accurate estimate of bandwidth-demand of the traffic flowing through the VPs is required. In order to make an accurate estimate of the bandwidth demand, a proper understanding of the behavior of the traffic is required. The behavior of the traffic is usually expressed in terms of its past statically properties.

In this paper we propose a novel Bandwidth Prediction algorithm which is based on the previous bandwidth utilization information of a VP in the ATM network.

This paper is organized into four sections, in the first section Introduction to ATM networks and bandwidth demand prediction is discussed, in section II existing bandwidth demand prediction is presented, in section III Proposed Method is discussed and section IV gives a conclusion to the proposed work.

2. Existing methods

A. Bandwidth demand prediction using genetic algorithm

A genetic algorithm is a heuristic approach that applies the natural genetic ideas of natural selection, mutation and survival of the fittest. A rigorous mathematical formalism was introduced by Holland and his collaborators, and is till date the basis of genetic algorithms.
The algorithm uses a set of offered solutions called a "population"[6]. Each solution called an "individual" can be

any solution in the solution space represented by a string called "chromosome". The solution space is explored in order to find an optimal solution that satisfies the constraints posed by the problem.
The bandwidth-demand sampled after regular time intervals can be mapped to a string of symbols that characterizes the bandwidth-demand pattern for the sum of those intervals of time. We call such a string a loadgene. The bandwidth-demand pattern prediction problem then boils down to predicting the next loadgene given the previous few loadgenes. The methodology adopted is to generate a population of sample loadgenes, each obeying the distribution of symbols in the previous loadgene. The next loadgene is then predicted by evolving this population using a suitable fitness criterion.

B. Bandwidth demand prediction using fuzzy logic
Fuzzy logic is a set of mathematical principles for knowledge representation based on degree of membership rather than crisp membership of classical binary logic. Fuzzy logic is based on the theory of fuzzy sets, where an object's membership of a set is gradual rather than just a member or not a member of the set. Bandwidth predicting and policing in using fuzzy logic [7]. A token bucket fuzzy logic bandwidth predictor for real time variable bit rate traffic class is proposed. The fuzzy logic bandwidth predictor facilitates bandwidth predicting and dynamic policing based on the class based packet aggregates. A fuzzy logic based predictor component is proposed for real time variable bit rate traffic. The predictor predicts the actual bandwidth required by the traffic aggregates instead of allocating peak rate bandwidth to it. Once the bandwidth is predicted, the bandwidth value can be used to tune the traffic class token bucket rate and thus the token bucket policer is able to service actual bandwidth requirements of the AF traffic class in the network. The bandwidth value can also be made available to the admission control component to be used in gauging the actual available traffic class bandwidth.

C. Existing methods suffer from the following drawbacks

Repeated fitness function evaluation for complex problems are often the most prohibitive and limiting segment of artificial evolutionary algorithms. Finding the optimal solution to complex high-dimensional, multimodal problems often requires very expensive fitness function evaluations.

Genetic algorithms do not scale well with complexity. That is, where the number of elements which are exposed to mutation is large there is often an exponential increase in search space size.

Operating on dynamic data sets is difficult, as genomes begin to converge early on towards solutions which may no longer be valid for later data.

In this paper we propose a novel Bandwidth Prediction algorithm which is based on the previous bandwidth utilization information of a VP in the ATM network. The proposed techniques use simple mathematical operations to predict the bandwidth and uses simple data structure to store the bandwidth information of a VP. Even though the network is complex the proposed technique predicts the bandwidth with simple operations without any extra complexity.

3. POPOSEDMETHOD

In the Proposed technique bandwidth demand is predicted based on the previous utilization values of a VP. Three values are considered namely PBU (Peak Bandwidth Utilization), LBU (Least Bandwidth Utilization) and ABU (Average Bandwidth Utilization) for different time slots. Based on these values the bandwidth demand is predicted. The proposed technique involves the following four phases.

1. Input Phase
2. Clustering Phase
3. Comparison Phase
4. Update Phase

Algorithm: Novel Bandwidth Prediction Algorithm

1. Identify the link or virtual path for which bandwidth is to be predicted.

2.Calculate the PBU, LBU and ABU for the first hour slot (i.e. may be 12 hour or 6 hour or 4 hour slot).

$$PBU = MAX(B1, B2, \ldots Bn)$$

$$LBU = MIN(B1, B2, \ldots Bn)$$

$$ABU = \frac{\sum_{i=1}^{n} B_i}{n}$$

Where n is the number of bandwidth values
3. Calculate Pbi1 for the selected Virtual path.

$$Pb_{i1} = \frac{PBU + LBU + ABU}{3}$$

4. .Calculate the PBU, LBU and ABU for the next hour slot (i.e. may be 12 hour or 6 hour or 4 hour slot).

5.Calculate Pbi2 for the selected Virtual path.

6.Group bandwidth predictions Pb1, Pb2, Pb3,...... into different clusters based on a threshold value.

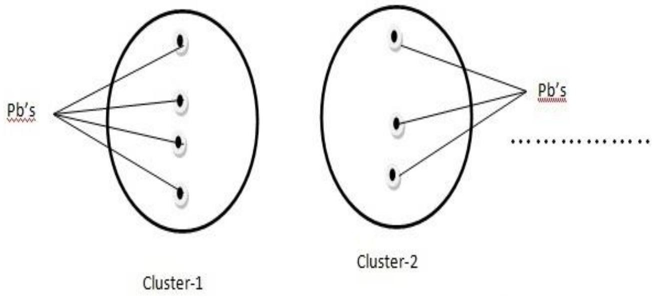

Fig-1: Clustering of Pbs

7.Select the cluster which contains the maximum no of Pb's(bandwidth predictions) as shown in Fig-1

8.Calculate the cluster value for the selected cluster.

9.The calculated PB is the final bandwidth predicted.

$$PB = \frac{\sum_{i=1}^{n} Pb_i}{n}$$

Input Phase: In this phase for a particular link the input values will be generated for bandwidth prediction. A new model called service Provisional Model (SPM) and resource model of a bandwidth allocation time table (BATT) [8]. The minimum period of reservation service is limited to an hour for the purpose of simplifying the procedure. The minimum BATT is one day. When a user subscribes to the reservation service, the NMS determines whether the subscription can be accommodated by consulting the BATT.

In this paper we use a similar table called bandwidth utilized time table (BUTT) is used, to generate the input values as shown in Fig-3. The BUTT contains the previous utilized bandwidth values for each virtual path.

For estimate of traffic behavior the statistical properties are assumed to vary slowly and hence daily, weekly and seasonal cycles are not considered, but short term estimates (hourly) are considered.

Consider the below network with four links, the BUTT for this network is shown in Fig.-2

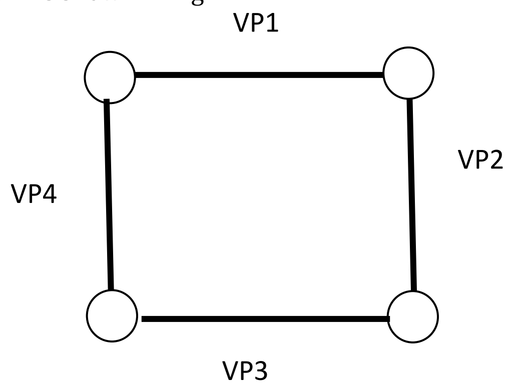

Fig-2: A network with 4 nodes

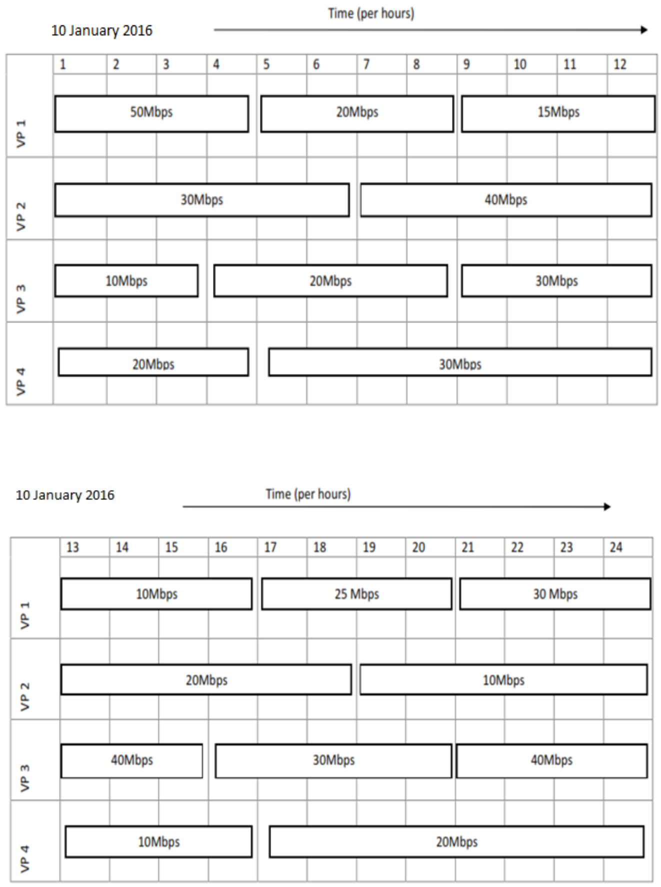

Fig-3: Bandwidth Utilized Time table (BUTT)

The input values generated include PBU, LBU and ABU for a particular link or virtual path.

For estimate of traffic behavior the statistical properties are assumed to vary slowly hence short term estimates (hourly) are considered. Considering the network in Fig-2 , the first 12 hour slot estimate of bandwidth for VP1by using BUTT in Fig is as shown below.

PBU = MAX (50, 20, 15) i.e. PBU = 50

LBU = MIN (50, 20, 15) i.e. LBU = 15

ABU = (50+20+15)/3 =28

Pb11= (50+15+28)/3=31

The next 12 hour slot estimate of bandwidth for VP1 by using BUTT is as shown below.

PBU = MAX (10, 25, 30) i.e. PBU = 30

LBU = MIN (10, 25, 30) i.e. LBU = 10

ABU = (10, 25, 30)/3 =21

Pb12= (30+10+21)/3=20

Clustering Phase: The different input values generated in phase-1 are not taken directly as input. First they are grouped into clusters and then given as inputs. The clustering is based on similarity in the values. That is two input values are grouped into one cluster if the difference between them is less than a threshold value.

Comparison Phase: In this phase the clustered input values are compared and a solution is found considering the traffic parameters of ATM network as shown in Fig-4. From the generated clusters a single cluster is selected which contains maximum number of Pbs. If any two clusters contain same number of Pbs then a cluster that contains maximum Pb is selected. In the above example both cluster 1 and 2 contain same number of Pbs, so the cluster with the maximum Pb value is selected i.e cluster-1 is selected (since Pb1=31 and Pb1=20).

Updating Phase: In this phase the newly generated solution is stored in corresponding tables for future use. The selected PB is stored in corresponding tables for future use i.e these values can also be used to predict the bandwidth in the next cycle.

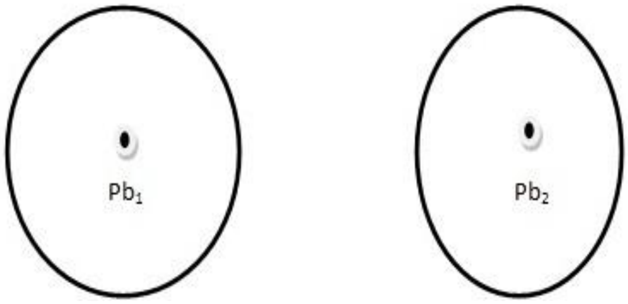

Fig-4: Comparing and selecting a cluster of Pbs

4. CONCLUSIONS

In this paper a novel Bandwidth Prediction algorithm is proposed, it involves four phases namely (1) Input phase, (2) clustering phase, (3) comparison phase, and (4) update phase. The Novel Bandwidth prediction suits well for high-dimensional complex problems, the Input phase and clustering phase spits the input samples into groups thereby reducing the complex problems sets into simplified clustered groups. The Novel bandwidth prediction does not require any extra expenses for dealing with complex problems.

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