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Enhancing Security In ATM Networks Through Congestion Control Technique

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***Abstract*— In ATM networks, the information is transmitted using short fixed-length cells, which reduces the delay variance, making it suitable for integrated traffic consisting of voice, video and data. By proper traffic management, ATM can also ensure efficient operation to meet different quality of service (QoS) desired by different types of traffic. In ATM networks, traffic control and congestion control can be done by a set of QoS parameters and classes for all ATM services that is to minimize network, end-system complexity while maximizing network utilization. The future telecommunication should have such characteristics: broadband, multimedia, economical implementation for diversity of services Broadband integrated services digital networks (B-ISDN) provides what we need. Asynchronous Transfer Mode (ATM) is a target technology for meeting these requirements.**

***Index Terms* — ATM, B-ISDN, QoS**

I. INTRODUCTION

ATM network uses fixed-length cells to transmit information. The cell consists of 48 bytes of payload and 5 bytes of header. 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 virtual channel connection (VCC) going through one or more virtual paths (VP) and virtual channels (VC) before transmitting information. The cells is switched according to the VP or VC identifier (VPI/VCI) value in the cell head, which is originally set at the connection setup and is translated into new 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 something to transmit. So the network uses statistical multiplexing to improve the effective throughput.

Recent advances in high-speed multiplexing, switching, and optical transmission systems coupled with potential opportunities to provide new services have stimulated a great deal of interest in Integrated Services Digital Networks (ISDN) with Broadband ISDN (BISDN) capabilities. The Asynchronous Transfer Mode (ATM) technique provides the required flexibility for supporting heterogeneous services in a BISDN environment.

Due to the flexible and dynamic nature of ATM and the heterogeneity of services in a BISDN environment, the definition of an effective overall congestion control strategy will play a critical role in the ultimate success of BISDN. Our paper summarize the main overall congestion control strategies that have been proposed in literature and standard forums discuss the basic techniques that could be used in implementing the overall congestion control in ATM networks.

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II. SELECTION CRITERIA

To design congestion control scheme is appropriate for ATM network and non-ATM networks as well, the following guidance are of general interest.

- **Scalability**

The scheme should not be limited to a particular range of speed, distance, number of switches, or number of VCs. The scheme should be applicable for both local area networks (LAN) and wide area networks (WAN).

- **Fairness**

In a shared environment, the throughput for a source depends upon the demands by other sources. There are several proposed criterion for what is the correct share of bandwidth for a source in a network environment. And there are ways to evaluate a bandwidth allocation scheme by comparing its results with a optimal result.

- **Fairness Criteria**

1. Max-Min
   The available bandwidth is equally shared among connections.
2. MCR plus Equal Share
   The bandwidth allocation for a connection is its MCR plus equal share of the available bandwidth with used MCR removed.
3. Maximum of MCR or Max-Min Share
   The bandwidth allocation for a connection is its MCR or Max-Min share, which ever is larger.
4. Allocation proportional to MCR
   The bandwidth allocation for a connection is weighted proportional to its MCR.
5. Weighted allocation
   The bandwidth allocation for a connection is proportional to its pre-determined weight.

- **Fairness Index**
  The share of bandwidth for each source should be equal to or converge to the optimal value according to some optimality criterion. We can estimate the fairness of a certain scheme numerically as follows.
- **Robustness**
  The scheme should be insensitive to minor deviations such as slight mistuning of parameters or loss of control

messages. It should also isolate misbehaving users and protect other users from them.

- **Impement ability**
  The scheme should not dictate particular switch architecture. It also should not be too complex both in term of time or space it uses.

To make it easier to manage, the traffic in ATM is divided into five service classes:

- **CBR: Constant Bit Rate**

Quality requirements: constant cell rate, i.e. CTD and CDV are tightly constrained; low CLR.
Example applications: interactive video and audio.

- **rt-VBR: Real-Time Variable Bit Rate**

Quality requirements: variable cell rate, with CTD and CDV are tightly constrained; a small nonzero random cell loss is possible as the result of using statistical multiplexing.
Example applications: interactive compressed video.

- **nrt-VBR: Non-Real-Time Variable Bit Rate**

Quality requirements: variable cell rate, with only CTD are tightly constrained; a small nonzero random cell loss is possible as the result of using statistical multiplexing. Example applications: response time critical transaction processing.

- **UBR: Unspecified Bit Rate**

Quality requirements: using any left-over capacity, no CTD or CDV or CLR constrained.
Example applications: email and news feed.

- **ABR: Available Bit Rate**

Quality requirements: using the capacity of the network when available and controlling the source rate by feedback to minimize CTD , CDV and CLR.
Example applications: critical data transfer, remote procedure call and distributed file service.

III. TRAFFIC DESCRIPTOR

Quality of Service

A set of parameters are negotiated when a connection is set up on ATM networks. These parameters are used to measure the Quality of Service (QoS) of a connection and quantify end-to-end network performance at ATM layer. The network should guarantee the QoS by meet certain values of these parameters.

- **Cell Transfer Delay (CTD)}:** The delay experienced by a cell between the first bit of the cell is transmitted by the source and the last bit of the cell is received by the destination. Maximum Cell Transfer Delay (Max CTD) and Mean Cell Transfer Delay (Mean CTD) are used.
- **Peak-to-peak Cell Delay Variation (CDV)}:** The difference of the maximum and minimum CTD experienced during the connection. Peak-to-peak CDV and Instantaneous CDV are used.
- **Cell Loss Ratio (CLR)}:** The percentage of cells that are lost in the network due to error or congestion and are not received by the destination.

Usage Parameters

Another set of parameters are also negotiated when a connection is set up. These parameters discipline the behavior of the user. The network only provides the QoS for the cells that do not violate these specifications.

- **Peak Cell Rate (PCR):**
  The maximum instantaneous rate at which the user will transmit.
- **Sustained Cell Rate (SCR):**
  The average rate as measured over a long interval.
- **Burst Tolerance (BT):**
  The maximum burst size that can be sent at the peak rate.
- **Maximum Burst Size (MBS):**
  The maximum number of back-to-back cells that can be sent at the peak cell rate.
- **Minimum Cell Rate (MCR):**
  The minimum cell rate desired by a user.

The traffic descriptor of a Virtual Channel (VC) and/or Virtual Path (VP) is the set of necessary and sufficient parameters that characterize the traffic of the VC/VP. The traffic descriptor plays a key role in the service provisioning, admission control, and Usage Parameter Control (UPC) of the network, because it: Constitutes the basis of the service contract between the user and the network

IV. PARA METER CONTROL. OVERALL CONGESTION CONTROL STRATEGIES

The network should perform the following functions: Control the access of the subscribers to the network resources. The admission control scheme keeps the excess traffic load out of the network and ensures that the average demand of the accepted subscribers does not exceed the network resources. In addition to call acceptance, an admission control mechanism may either permit the in call renegotiation of the traffic descriptor of a VC/VP [9]. and/or support short hold mode service [1] (i.e., burst admission control [11] for certain bursty services- of an ATM network. Protect the users' QOS against the stochastic fluctuations of the subscribers' loads and enable the network to instruct the subscribers to adjust their rate, i.e., the congestion control scheme should include flow/reactive control mechanisms. Upon the onset of congestion at a node on the end-to-end path of a VC within the network, the network should be able to inform the source, destination, or both and instruct them to take the necessary actions.

Admission Control

Admission control can be defined as the acceptance or rejection of requests for setting up new connections (i.e., VCs/VPs) in accordance with an admission policy [12]. The objectives of an admission control policy are to establish fair blocking among various service types (each of which may have significantly different bandwidth needs and QOS requirements) and assure that sufficient network resources are available for each admitted connection.

Class Related Rule

First, let us consider homogeneous conditions. Suppose that *n* is the number of VCs in a class. We can determine a VP bandwidth (Br.p) that accommodates the VCs and satisfies the QOS requirements in a simulation assuming the burst level activity of a VC conforms to the two-state
Under heterogeneous conditions, the statistical multiplexing gain is a complex function of the numbers of VCs in individual traffic classes and it is difficult to determine

QOS Evaluation Method

When a new VC requires connection, the QOS evaluation method estimates how QOS performance will be affected after the acceptance of the VC. This estimation is usually based on bounds or approximations that can be easily obtained. For example. under the assumption that the average and maximum number of cells arriving during a fixed intervals are specified, an upper bound of cell loss probability could be used [12-17].VC completes the service and leaves the system. This method can be applied under heterogeneous conditions.

Fixed Boundary Method

The fixed boundary method introduces traffic classes and provides the number of *trunks* for each class [13]. A network provider determines the VP bandwidth such that all trunks of all classes can be accommodated and some degree of statistical multiplexing among classes is achieved when the VP bandwidth is dimensioned. The call acceptance rule is quite simple. The QOS evaluation method or the following approaches can be applied to the sizing of the VP bandwidth under heterogeneous conditions. One method is to determine the VP bandwidth from a certain specified percentile of the offered load assuming a Gaussian distribution, whose mean is equal to ABR and its variance is equal to the bit rate variance of each VC [12] [15]. Another method is to assume that the cell stream from each VC can be modeled as bursts and silence periods and determine the VP bandwidth such that the probability that the amount of bursts at an arbitrary instant is less than 100& of the VP bandwidth, is 1 - E or less, where 0 < d . The amount of bursts multiplexed can be directly evaluated from PBR and ABR without assuming the distributions of bursts and silence periods in the cell arrival process. Suppose that n VCs with PBR= *R* and ABR=a are multiplexed, and p(n,k). represents the probability that the number of bursts at an arbitrary instant is *k.* Then, p(n,k) is given by:

$$P(n,k) = \binom{n}{k} a(R)^k \left(1 - \frac{a}{R}\right)^{n-k}$$

and the VP bandwidth, ***B*,** is provided by

$$\Sigma\, p(n,k) < 1 - E \quad (8)$$

A similar equation can be obtained under heterogeneous conditions. Similar discussions can be found in Burgin *et al.* [17], in which the burst level is considered. However, this method does not require the bandwidth reservation that other methods need to avoid a severe degradation of blocking probability for new vcs. The fixed boundary method could result in an inefficient

Measurement Method

Bandwidth to each VC based on the specified traffic descriptor and is not concerned with the actual bandwidth required by the VC. However, if we know the actual bandwidth instead of the nominal one, more VCs are expected to be accepted and resource utilization can be improved. The measurement method [18] uses the following relationship between cell loss probability, PLO and the distribution of the number of cells arriving at a VP**.**

$$\frac{P_{Loss} \le \sum_{k=0}^{\infty}\left[k - \frac{sBvp}{L}\right] + p(k)}{\sum_{k=0}^{\infty} kp(k)}$$

The admission control scheme accepts a new VC whose average and maximum numbers of cells during the interval, s, are *a* and *R,* if an only if the right-hand side of the above said Equation , after the acceptance of the new VC, **is** less than the cell loss probability objectives of the network. After the acceptance of the VC, the probability that *k* cells arriving is assumed to be given by:

$$p(k)\left(1 - \frac{a}{R}\right) + p(k - R)\left(\frac{a}{R}\right) \quad k \ge R$$
$$p(k)\left(1 - \frac{a}{R}\right) \quad k < R$$

Here, ***p(k)*** is estimated from the measurement. If the right hand side of Equation 10 is too complex to be evaluated directly, the current load vector is employed.

Planar Approximation

In this approach [29], the network uses the traffic descriptor of a VC/VP and its QOS requirements to estimate the amount of capacity required (referred to as equivalent capacity) for the support of this VC/VP. The equivalent capacity of a VC/VP is defined as the amount of capacity required to satisfy the QOS requirements of the service of this VC/VP.

Sigma Rule

In this approach [12], the probability that the total bit rates of the accepted VCs on a VP exceed the permissible throughput of the VP **is** chosen such that the cell loss requirements of all VCs within the VP are satisfied. In the Sigma rule, all VCs that may be routed on a VP are segregated into two classes, class I and **11.** The decision to accept an incoming VC is based on the mean and peak rates of the incoming and existing VCs. There is no statistical multiplexing gain for VCs of class I, and the peak rate is allocated to a VC of class I.

Usage Parameter Control

The UPC (i.e., policing or traffic enforcement) is a mechanism that ensures a VC/VP does not violate its agreements with the network (i.e., it does not exceed its traffic descriptor). The UPC monitors the traffic of a VC/VP at the ingress of the network and takes necessary actions whenever the VC/VP violates its descriptor and transmits excessive traffic into the network.

V. PAYLOADLTYPE

In the event of congestion, the network discards the marked cells [18] **[16].** To ensure that a VC/VP conforms to its agreement with the network, the network should monitor and enforce the unmarked and marked cell streams of the VC/VP at the ingress of the network [8]. The strength of this scheme **is** that it encourages the users to utilize the network and may be useful for services that do not need a stringent QOS. When the network guarantees the QOS for a VC, this scheme may become ineffective, due to the fact that unless the network could purge (discard) the marked cells of different VCs fairly, the QOS of all VCs may not be satisfied.

Leaky Bucket Algorithm

A leaky bucket scheme [13] is a counter with three parameters, a threshold value *(S*), decrementing value (d), and decrementing time period (T) established at the VC/ VP set up. The scheme functions as follows: Each time an ATM cell of the VC/VP arrives, the count is either incremented or remains unchanged depending on its actual value. The count is incremented, if it **is** below the threshold value. and the ATM cell is permitted into the network. The count remains unchanged if it has already reached the threshold value *S,* and the cell **is** discarded.

Performance Metrics of UPC

Since different algorithms can be used for the UPC, it is essential to search for a set of performance metrics that could be used to verify the effectiveness of a UPC scheme, and compare its performance with other UPC schemes. An example set of metrics that could capture key characteristics of a UPC scheme are responsiveness and error margin [18]. These metrics are defined as follows:

Responsiveness

The responsiveness of a UPC scheme indicates how quickly a UPC can detect the excessive traffic of a VC.

Error Margin

In general, the error margin reflects the Sensitivity/accuracy of the UPC mechanism. For instance, it could consist of:

- Probability of false alarm-represents the probability that the UPC incorrectly identifies non excessive traffic as excessive.
- Probability *of* late alarm-represents the probability that the UPC incorrectly permits the excessive traffic of the user into the network.

VI. QOS CONTROL AND CELL LOSS PRIORITY

Cell delay and cell loss are the key causes of QOS deterioration in an ATM network. A relative system of cell delay and/or CLPs enables the network to reduce the impact of cell delay and cell loss in the network and exerts some control on the QOS of its services. Although the dominant portion of a cell delay in a ATM network is the propagation delay and the processing delay, the delay priority reduces the cell delay jitter and protects the real-time services against the instant bursts of other traffic in the network.

V. FLOW/REACTIVE CONTROL

Since coincident bursts and focused loads may result in instantaneous overloads in a node(s) of an ATM network, the congestion control scheme of the network should provide flow reactive control capabilities. Whenever a node within the network experiences congestion, it will invoke these capabilities to react to its instantaneous overload condition. These capabilities reduce the cell loss in the network and improve the QOS for the users. To provide these capabilities, the overall congestion control strategy should include BCN or FCI.

VII. SUMMARY AND CONCLUSIONS

This paper reviewed different strategies of congestion control in ATM networks. Towards this goal, we have described the problem, presented a summary of the overall congestion control strategies, and discussed the basic capabilities that could be used in the overall congestion control of a network. The set of mechanisms that constitute a general framework for congestion control consists of admission control, UPC, relative cell delay/loss priority, and flow/ reactive control mechanisms. Depending on their service scenarios, the overall congestion control schemes of different networks may consist of different combinations of these mechanisms. Furthermore, different networks may realize the same mechanism (e.g., admission control, UPC, etc.) through the use of different algorithms and implementations. Therefore, it may be neither desirable nor practical to expect that standard forums arrive at agreements on the structure and algorithm for each one of the mechanisms described in the general framework. The issues with solutions constituting the set of basic requirements for traffic/congestion control in ATM networks are [23]: the traffic descriptor and QOS parameters of a VC/VP, the specification of the CLP field, and the means of BCN and FCI. The function of a FCI mechanism is to convey the congestion control. For instance, the congestion management strategy [22] of this paper reviews different congestion control strategies

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