ATM Traffic Management and Congestion Control Techniques - 29.03.2006

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I. Introduction

A variety of traffic control functions have been defined to maintain the QOS of ATM connections.These include:

1. Resource management using virtual paths
2. Connection admission control
3. Usage parameter control
4. Selective cell discard
5. Traffic Shaping

II. Resource management using virtual paths

The essential concept behind network resource management is to allocate network resources in such a way as to separate traffic flows according to service characteristics.

The network provides aggregate capacity and performance characteristics on the virtual path (VPC), and these are shared by the virtual connection(s) (VCC). There are three cases to consider:

1. User-to-user application
2. User-to-network application
3. Usage parameter

The QOS parameters that are of primary concern for network resource management are cell loss ratio, cell transfer delay, and cell delay variation, all of which are affected by the number of resources devoted to the VPC by the network.

Anyhow, with multiple VCCs within the same VPC, the network has two general options for allocating capacity to the VPC:

1. Aggregate Peak Demand
2. Statistical Multiplexing

A. Aggregate Peak Demand

Sets the capacity of the VPC to the total of the peak data rates of all of the VCCs within it.

B. Statistical Multiplexing

If the network sets the capacity of the VPC to be greater than or equal to the average data rates of all the VCCs but less than the aggregate peak demand, then a statistical multiplexing service is supplied.

III. Connection Admission Control

Connection admission control is the first line of defense for the network in protecting itself from excessive loads. In essence, when a user requests a new VPC or VCC, the user must specify (implicitly or explicitly) the traffic characteristics in both directions for that connection. The user selects traffic characteristics by selecting a QoS from among the QoS classes that the network provides. The network accepts the connection only if it can commit the resources necessary to support that traffic level while at the same time maintaining the agreed-upon QoS of existing connections. By accepting the connection, the network forms a 'traffic contract' with the user. Once the connection is accepted, the network continues to provide the agreed QoS as long as the user complies with the traffic contract.

For the current specification, the traffic contract consists of the four parameters cell rate (SCR), and burst tolerance. Only the first two parameters are relevant for a constant bit rate (CBR) source; all four parameters may be used for variable bit rate (VBR) sources.

TABLE I

Traffic Parameters Used in Defining QoS

PARAMETER	DESCRIPTION	TRAFFIC TYPE
Peak Cell Rate (PCR)	Upper bound on traffic possible.	CBR, VBR
Cell Delay Variation (CDV)	Upper bound on the variability in the cell arrivals at a point with reference to the PCR.	CBR, VBR
Sustainable Cell Rate (SCR)	Upper bound on the average rate of an ATM connection.	VBR
Burst Tolerance	Upper bound on the variability in the cell arrivals at a point with reference to the SCR.	VBR

Another aspect of quality of service that may be requested or assigned for a connection is cell-loss priority. A user may request two levels of cell-loss priority for an ATM connection; the priority of an individual cell is indicated by the user through the CLP bit in the ATM cell header. When two priority levels are used, the traffic parameters for both cell flows must be specified; typically, this is done by specifying a set of traffic parameters for high-priority traffic (CLP = 0) and a set of traffic parameters for all traffic (CLP = 0 or 1). Based on this breakdown, the network may be able to allocate resources more efficiently.

IV. Usage Parameter Control

Once a connection has been accepted by the Connection Admission Control function, the Usage Parameter Control (UPC) function of the network monitors the connection to determine whether the traffic conforms to the traffic contract. The main purpose of Usage Parameter Control is to protect network resources from an overload on one connection that would adversely affect the QOS on other connections by detecting violations of assigned parameters and taking appropriate actions. Usage parameter control can be done at both the virtual path and virtual channel levels.

The following actions may be taken for cells depending on the loss priority (CLP bit):

1. A cell with CLP = 0 that conforms to the traffic contract for CLP = 0 passes.
2. A cell with CLP = 0 that is noncompliant for (CLP = 0) traffic but compliant for (CLP 0 or 1) traffic is tagged and passed.
3. A cell with CLP = 0 that is noncompliant for (CLP = 0) traffic and noncompliant for (CLP 0 or 1) traffic is discarded.
4. A cell with CLP = 1 that is compliant for (CLP = 1) traffic is passed.
5. A cell with CLP = 1 that is noncompliant for (CLP 0 or 1) traffic is discarded.

V. Selective Cell Discard

Comes into play when the network, at some point beyond the UPC function, discards (CLP = 1) cells. The objective is to discard lower priority cells in order to protect the performance for higher-priority cells.

Note that the network has no way to discriminate between cells that were labeled as lower-priority by the source and cells that were tagged by the UPC function.

VI. Traffic Shaping

The UPC algorithm is referred to as a form of 'traffic policing'. Traffic policing occurs when the flow of data (cells) is regulated so that cells that violate the contract are discarded or tagged. Traffic policing is complemented by 'traffic shaping' wherein cell traffic is smoothened out to reduce cell clumping. Thsi reduces average delay time and leads to a fairer resource allocation scheme. A simple traffic shaping scheme is the 'token bucket'. The following fihure illustrates this scheme wherein a token generator produces tokens at a constant rate into a token buffer of size 'T'. Arriving cells are stored in a buffer of size 'R'. To transmit a cell through the server, one token must be removed from the token buffer. The result of the scheme is a smoothing out of cell traffic.

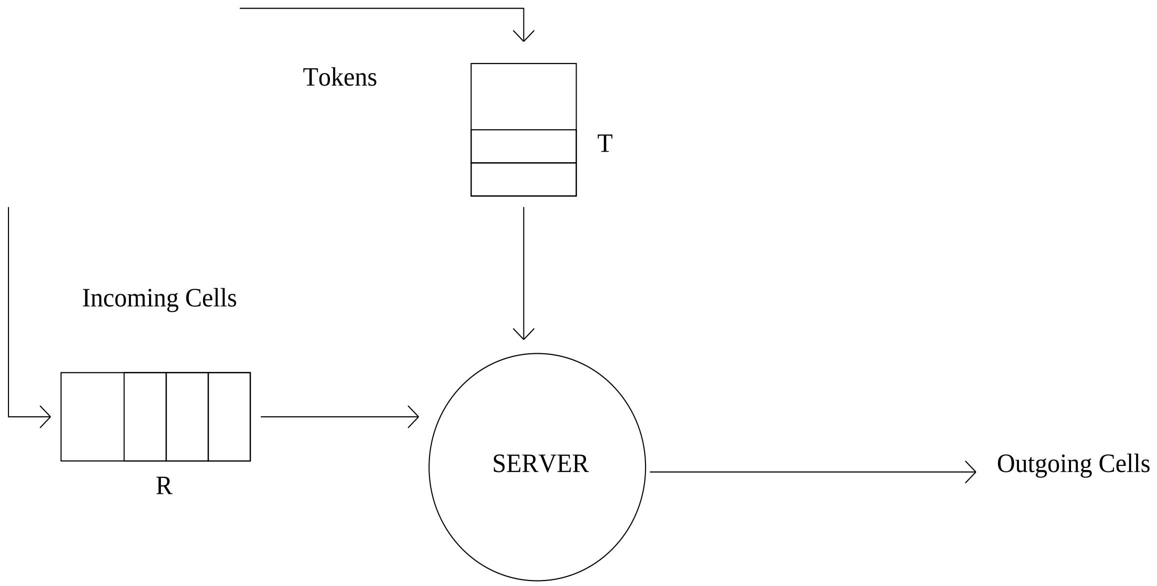

Fig. 1. Token Bucket Traffic Shaping