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Congestion Analysis through a Game Theoretic Approach in ABR of High speed Network

KEYWORDS: Available bit rate, Constant bit rate, Variable bit rate, Game theory, Nash equilibrium, Von Neumann Morgenstern (vNM) and Iterated elimination of strictly dominated action.

Annapurna V. K.	Dr. C. Vidya Raj
Associate Professor, Dept of Computer Science & Engg., The National Institute of Engg., Mysore –INDIA	Professor & Head, Dept of Information Science & Engg The National Institute of Eng Mysore –INDIA

ABSTRACT *High speed networks dominate both the wide-area network (WAN) and local area network (LAN). Audio conferencing & video conferencing demand for greater bandwidth, high speed and reliable transfer of data. For this an efficient and flexible multicast capability is required. Existing and available methods does not address all demands. Because of high speed and small cell size, ATM network present difficulties in effectively controlling congestion. A study was conducted on congestion occurrence in ABR traffic. A game theoretical approach called Iterated elimination of strictly dominated action is used to study the congestion in network. A node's action which is strictly dominated is never best response. A node's action which is strictly dominating results in congestion. An action profile is rationalizable if and only if it survives iterated elimination of strictly dominated actions.*

I. INTRODUCTION

Demand for increasing use of still images and video data in applications and popularity of these in World Wide Web had forced rapid introduction of High speed network [1].

Many multimedia applications such as audio and videoconferencing, distance learning etc. are multicast. They demand for greater bandwidth, high speed and reliable transfer of data. For this an efficient and flexible multicast capability is required. Existing and available methods does not address all demands mentioned above. Hence, there is need for developing an efficient technique to address this issue related to ATM Multipoint/Multicast transmission.

Traffic management for multipoint connections is a complex problem, due to presence of multiple senders with different traffic characteristics, multiple receivers with different QoS requirements, and different bottlenecks along multipoint connection path.

In this paper we study the congestion problem in available bit rate (ABR) service in ATM network with many senders and many receivers. Based on the network bandwidth available, ABR sources increases the data rate or reduces the data rate. According to the traffic management specification [4], Resources management [RM] cells are generated periodically and circulated from the source to the destination and back to the source.

Rate control parameters of the RM cell can be modified by the destination or switching nodes along the path subject to local traffic conditions. The source adjusts its data rate based on the field in backward resource management cells. A positive feedback from nearest node indicating no congestion to the source will make source node to increase its data rate without knowing the status of the other branch which is congested. Hence node will be misled to increase its cell rate [5]. Nodes thus make selfish decisions based on the behavior of other nodes, resulting in a non-cooperative game. Naturally this scenarios call for a game–theoretic approach for studying both the behavior of such non-cooperative nodes, as well as their impact on the network performance.

Game Theory has been applied to a number of areas in computer networks such as congestion control, flow control and multicasting.

Game theory is the science concerning the strategic interdependence among different individuals. As the most important characteristic, each individual is in pursuit of maximal profit and benefits not only from its own action, but also from others.

This approach looks at the network as a game whose players (or users) are the sources, routers and destinations and each player tries to maximize its payoff through its strategy (actions) set. Unlike the traditional approach where each user is assumed to be following a mandated protocol, the game theoretic approach makes no such assumption. In fact, this approach goes to the other extreme and considers all users to be selfish and acting only in their self-interest. The challenge in the game theoretic approach is to analyze selfish motives and actions by individual nodes and translate into desired results for the whole system.

A technique called Iterated elimination of strictly dominated actions (Never-best response) is used for studying the congestion in ABR of High speed Network.

The rest of the paper is organized as follows. In the following section we introduce concept of multipoint-to-multipoint multicasting and different service categories of ATM. In section III we describe the basic definitions of Game theory and iterated elimination of strictly dominated action. Our proposal is presented in the IV section. Finally, we conclude the paper in last section.

II. MULTICASTING AND DIFFERENT SERVICE CATEGORIES OF ATM

Multicast communication is a technique in which a single data source transmits user data to more than one receiver. There are four categories of multicasting in ATM, Point-to-Point, Point-to-Multipoint, Multipoint-to-Point, Multipoint-to-Multipoint (Multipeer). Multipeer communication takes place when several senders are able to send user data to the same set of receivers. This corresponds to an m : n type of communication and is frequently referred to as multipoint communication [2].

ATM networks support different service categories, namely constant bit rate(CBR), real-time variable bit rate(rt-VBR), non-real time variable bit rate (nrt-VBR), available bit rate(ABR) and unspecified bit rate(UBR).Each one of these service categories has different quality of service requirement [1].

The CBR service is perhaps the simplest service to define.

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It is used by applications that require a fixed data rate that is continuously available during connection life time and a relatively tight upper bound on transfer delay. Data is sent in a steady stream with low cell loss. This is an expensive service because the granted bandwidth must be allocated, whether or not it is actually used.

VBR Specifies a throughput capacity over time, but data is not sent at a constant rate. This also specifies low cell loss. It is available in two varieties, real-time VBR for isochronous applications and non-real-time VBR for all others. The rt-VBR category is intended for time sensitive application; that is, those requiring tightly constrained delay and delay variation.

The UBR service category needs no guaranteed service requirement in terms of throughput, delay and delay variation. Cells can be dropped.

ABR provides guaranteed minimum cell rate (MCR) and is designed to provide low cell loss for well behaving sources. It uses closed-loop feedback control to indicate network congestion information to the sources. The sources adjust their allowed cell rate (ACR) based on the network feedback. Feedback is indicated in resource management cell (RM) cells, which are periodically sent by the source and turned around by destination. The switches along the path indicate the maximum rate they can currently support in the RM cell. The RM cells in the forward direction are called forward RM (FRM) cells, and those in the backward direction backward RM (BRM) cells [4].

III. GAME THEORY MODEL

Game theory is related to the actions of decision makers who are conscious that their actions affect each other. The essential elements of a game are players, actions, payoffs and information. The latter are collectively known as the rules of the game, based on which the modeler intents to describe a situation so as to explain what will happen in it. Players are the individuals who make decisions. Each player's goal is to maximize his utility by a choice of actions.

Trying to maximize their payoffs, the players devise plans known as strategies that pick actions depending on the information available at each moment. The combination of strategies chosen by each player is known as the equilibrium. The outcome of the game is a set of interesting elements that the modeler picks from the values of actions, payoffs, and other variables after the game is played out.

There are two types of strategies; pure and mixed. A pure strategies, is one in which each player choose a specific action deterministically. In mixed strategy, each player chooses action probabilistically.

The action profile a* in a strategic game with ordinal preferences is a Nash equilibrium if, for every player i and every action a_i of player i, a* is at least as good according to player i's preferences as the action profile (a_i , a_{-i}^*)

Games can also be distinguished as cooperative games and non cooperative games. In a cooperative game, the players cooperatively try to come to an agreement, and the players have a choice to bargain with each other so that they can gain maximum benefit, which is higher than what they could have obtained by playing the game without cooperation. On the contrary, in a noncooperative game, a player is unable to bind and enforce agreements with other players. Every action used with positive probability in some mixed strategy Nash equilibrium is rationalizable.

Iterated elimination of strictly dominated actions: (Never-best response in strategic game) The action a_i' of player i in a strategic game with vNM (von Neumann and Morgenstern) preferences is a never-best response if for every belief μ_i of player i about the other players' actions there exists a mixed strategy α_i of player i such that player i's expected payoff to α_i exceeds her expected payoff to a_i' :

$$\sum_{a_{-i} \in A_{-i}} \mu_i(a_{-i}) U_i(\alpha_i, a_{-i}) > \sum_{a_{-i} \in A_{-i}} \mu_i(a_{-i}) u_i(\alpha'_i, a_{-i})$$

where $U_i(\alpha_i, a_{-i})$ is player i's expected payoff when she uses the mixed strategy α_i and the other players' actions are a_{-i}, u_i is her Bernoulli payoff function, and A_{-i} is the set of lists of the other players' actions.

An action a_i' of player i in a strategic game with vNM preferences is strictly dominated if player i has mixed strategy that yields her a higher payoff than does a_i regardless of the other players' actions. A strictly dominated action is a never-best response. If a_i' is strictly dominated by the mixed strategy α_i, then $U_i(\alpha_i, a_{-i}) > u_i(a_i', a_{-i})$ for all a_{-i}, so that equation 1 is satisfied for any belief μ_i of player i about the other players' actions, and hence a_i' is a never-best response.

A player's action in a strategic game with vNM preferences in which each player has finitely many actions is a never-best response if and only if it is strictly dominated.

An action profile is rationalizable if and only if it survives iterated elimination of strictly dominated actions.

(Iterated elimination of strictly dominated actions) Suppose that for each player i in strategic game and each t = 1 , … . , T there is a set X_i^t of actions of players i (the set of actions remaining at the start of round t of elimination) such that

$X_i^1 = A_i$ (the set of all possible actions)

X_i^{t+1} is a subset of X_i^t for each t = 1,…..,T-1 (at each stage we may eliminate actions)

For each t = 1 , . . . ,T-1, every action of player i in X_i^t but not in X_i^{t+1} is strictly dominated in the game in which the set of actions of each players j is X_j^t (we eliminate only strictly dominated action)

No action in X_i^T is strictly dominated in the game in which the set of actions of each players j is X_j^T (at the end of the process no action of any players is strictly dominated).

Then the set of action profiles a such that $a_i \in X_i^T$ for every player i survives iterated eliminated of strictly dominated actions [3].

IV. ANALYZING CONGESTION THROUGH GAME THEORY

Congestion in ATM:

Because of high speed and small cell size, ATM networks present difficulties in effectively controlling congestion not found in others types of networks, including frame relay and packet-switching networks. The complexity of the problem is compounded by the limited number of overheads bits available for exerting control over the flow of user cells. This area is currently the subject of intense research, and approaches to traffic and congestion control are still evolving.

The following reasons explain why tools are inadequate for ATM networks when number of tools exists for control of congestion in packet switched and frame relay networks.

1. The majority of traffic is not amenable to flow control. For example, voice and video traffic sources cannot stop generating cells even when network is congested
2. Drastically reduced cell transmission time compared to propagation delays across the network results in slow feedback.
3. ATM networks typically support a wide range of applications requiring capacity ranging from a few kbps to sev-

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eral hundred MBps. Relatively simple minded congestion control schemes generally end up penalizing one end or other of that spectrum.

4. It is difficult for conventional congestion control techniques to handle fairly different traffic patterns (CBR vs. VBR sources) generated by Applications on ATM networks

Different applications on ATM networks require different networks services (delay sensitive service for voice and video, and loss-sensitive service for data). The very high speed in switching and transmission make ATM networks more volatile in terms of congestion and traffic control. A scheme that relies heavily on reacting to changing conditions will produce extreme and wasteful fluctuations in routing policy and flow control.

Suppose A is performing a long life transfer to destination B and that implicit congestion control is being used (i.e., there are no explicit congestion notifications; the source deduces the presences of congestion by the loss of data). If the network drops a cell due to congestion, B can return a reject message to A, which must then retransmit the dropped cell and possibly all subsequent cells. But by the time the notification gets back to A., it has transmitted an additional N cells, where

$$N = \frac{48 \text{ X } 10^{-3} \text{ seconds}}{2.8 \text{ X } 10^{-6} \text{ seconds/cell}}$$

$$= 1.7 \text{ X } 10^{4} \text{ cells}$$

$$= 7.2 \text{ X } 10^{6} \text{ bits}$$

Over 7 megabits of data have been transmitted before A can react to the congestion indication. This calculation helps to explain why the techniques that are satisfactory for more traditional networks break down when dealing with ATM WANs [2].

The ATM switches are capable of computing explicit rates (ER) for the ABR connections that can be supported. When the BRM cell travels back to the source, each of the switching nodes will compute an explicit rate of the virtual connection (VC) concerned. The ER field of the BRM cell will record the minimum of the ER values along the path. On receipt of a BRM cell, the source will adjust its data rate according to the most up-to-date ER value.

Consider the figure1 in the last page, FRM cells from M_a are multicast to M_b and other members. BRM cells from M_b will reach the branch point earlier than the BRM cell from other far distance nodes because of shorter propagation delay. Assume if congestion is occurring at switch 2. Positive feedback from M_b indicating no congestion will be sent to M_a. M_a without knowing the status of other will be misled to increase its cell rate.

RM cell periodicity is still not addressed completely for Multipoint networks. RM cells are sent in order to be robust to cell losses due to dynamic behavior of nodes. If this period is too large, the user access time to the multicast network may increase significantly with the number of cell losses. However if the period is to small, RM cells are sent too often and may create the congestion in the network.

Adjusting the periodicity of RM cells of different sources is very important for efficient utilization of network resources. Game theoretical approach is used to study the selfishness of different sources.

An action profile (set of actions taken by a node) is rationalizable if and only if it survives iterated elimination of strictly dominated actions. A node or source should not choose an action that is strictly dominated in the transmission of cells that results when we eliminate all other nodes' strictly dominated actions. That is, node will assume that opponent nodes actions are not strictly dominated in the transmission that results when all of current nodes strictly dominated actions are eliminated. Thus the node will choose an action that is not strictly dominated in the transmission (game) that results when, first, all of current node's strictly dominated actions are eliminated, and then all of other opponent node's strictly dominated actions are eliminated.

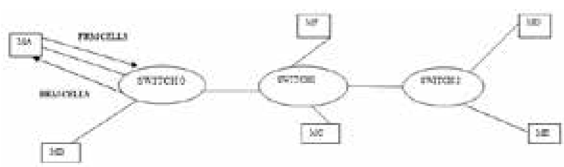
So to summarize each step in the argument for rationalizability is equivalent to an additional round of elimination of strictly dominated strategies, so that the rationalizable actions are those that remain no matter how many rounds of elimination is performed. That is, an action profile is rationalizable if and only if it survives iterated elimination of strictly dominated actions. This is required to achieve Nash equilibrium [3].

According to game theory approach, the source node should be rational (maximum rate) by choosing an action that is selfish and strictly dominates transmission of cells with out analyzing all the BRM cells from all the nodes. By eliminating dominated actions through many iterations, finally left out is dominating actions (selfish node) using which congestion creating nodes are identified. By proper buffer management and scheduling, congestion can be avoided.

CONCLUSION

In this paper, we studied the problem of congestion in High speed network where the goal of each node is to maximize its transmission and hence leading to congestion. We have mentioned about RM cell periodicity and how this leads to congestion. A node which reacts to BRM cells from nearest node dominate strictly by sending data at high rate with out bothering about other nodes. This leads to congestion and was compared to dominating action in game theory. That is, an action profile (set of actions) of a node is rationalizable if and only if it survives iterated elimination of strictly dominated actions.

Figure1



REFERENCE [1]. William Stalling, "High Speed Networks and Internets, Performance and Quality of Service", II Edition, Pearson Education 2011. | [2]. Ralph Wittman, Martina Zitterbert , "Multicast Communication, Protocols and Applications", Elsevier publication, 2008 | [3]. Martin J.Osborne," An Introduction to Game theory", Oxford university press, 2009. | [4]. ATM Forum Technical Committee, Traffic Management Specification Version 4.0, 1996 | [5]. Derek C. W. Pao, "A Congestion Control Algorithm for Multipoint-to-Multipoint ABR Service in ATM Networks"