MULTI-AGENT SYSTEM APPROACH FOR CONGESTION CONTROL IN ATM NETWORKS

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Abstract **- The Broadband Integrated Services Digital Network (B-ISDN) supports transmission of different types of data such text, audio, images, video and combination of these types of data at higher transmission rates. The Asynchronous Transfer Mode (ATM) has been widely accepted as transfer mode for B-ISDN. Traffic management and congestion control are main issues in ATM networks.**

In this paper, we describe existing multi-agent system architecture for management of ATM networks. We developed a software module using java to automate the activities of agents in multi-agent system architecture for monitoring the traffic and controlling congestion in ATM networks. We described the steps followed in developed software module for controlling congestion and compared the advantages of usage of multi-agent system architecture over conventional approach for controlling congestion in ATM networks

Keywords: ATM networks, Bandwidth Management, Multi-agent System, Virtual Paths.

I. INTRODUCTION

Asynchronous Transfer Mode (ATM)[1] have been proposed as the underlying transport and switching technique for Broadband Integrated Services Digital Network (B-ISDN). These networks supports a variety of services with diverse characteristics, e.g. voice, video, data, etc. ATM is connection oriented packet switched data transport system, handling fixed size cells are asynchronously multiplexed within the network and transmitted over a virtual circuit while preserving the cell sequence integrity.

Congestion control [2][8][9][10] and resource management have become crucial role in protecting the network from becoming congested, in achieving the network performance objectives and optimizing the use of network resources. The key resource in network management is physical link bandwidth. When current traffic is more than available link bandwidth, congestion problem may arise in the network.

The multi-agent system architecture proposed by Pere Vila is described in this paper. We developed a software module to automate the activities of agents in multi-agent system to monitor the physical link bandwidth and control congestion if any arise, in ATM network. This paper is organized as follows: Virtual paths and bandwidth management functions in ATM networks were described in section II. The multi-agent system architecture for ATM networks is described in section III. The congestion control using multi-agent approach is described in section IV. The advantages and drawback of multi-agent approach over conventional approach were discussed in section V. Finally the paper is concluded in section VI.

II. VIRTUAL PATHS AND BANDWIDTH MANAGEMENT IN ATM NETWORKS

ATM networks have mainly three layers of hierarchy : Physical layer, ATM layer, and ATM Adoption layer. The physical layer deals with physical media. The ATM layer deals with cells and cells transport. Routing and congestion control is performed at this layer. The ATM Adoption Layer will split the message into cells at sender and reassemble to get back the original message at the receiver.

In the ATM layer, there are two levels of hierarchy: Virtual Path (VP) and Virtual Channel (VC) levels. The highest is VC level: users can establish and release the connections i.e. virtual channels, through pre-established virtual paths (VPs). In this paper, we use the term Logical Path (LP) to refer to any kind of logical path (e.g. Virtual Path (VP), Label Switch Path (LSP)).

The Virtual path management [3][4][6]considered is the establishment and release of VPs between two nodes in network. Initially bandwidth will be assigned to the established virtual paths in the networks. Bandwidth management attempts to manage the capacities assigned to the different VPs that flows through the physical link. There are two actions normally taken by bandwidth

management functions: bandwidth re-allocation and VP-rerouting.
If there are congested VPs and underused VPs in the same link, the bandwidth assigned to each VP can be reconfigured. This method is known as bandwidth re-allocation. (fig. 1)

If almost all the VPs in the link are congested or near congestion and there is insufficient unutilized bandwidth capacities for swapping between VPs, routes as well as capacities are altered to minimize the traffic carried in the network. This means that a change in VP network topology is required. This is called VP re-routing.

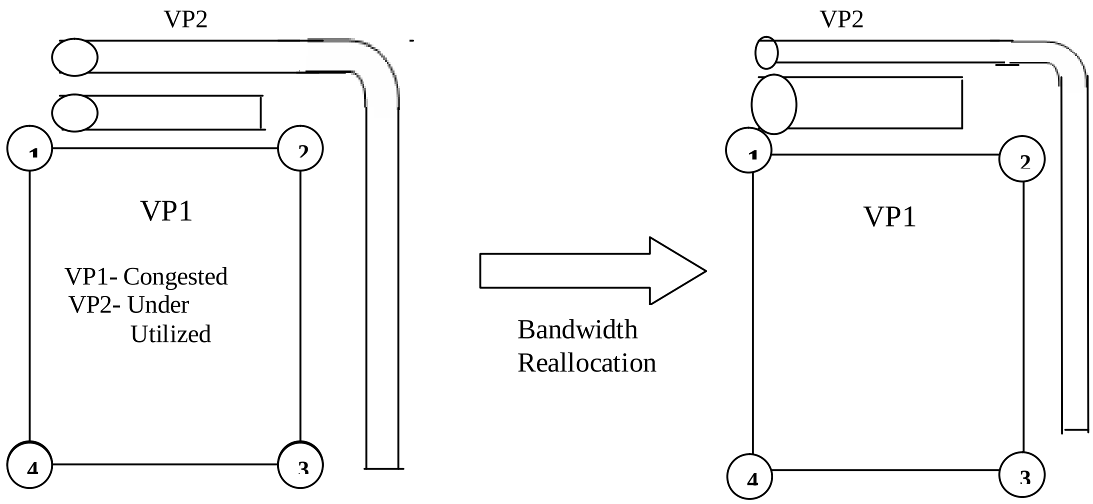

Fig.1. Virtual path bandwidth reallocation

III. MULTI-AGENT SYSTEM ARCHITECTURE

Pere Vila et al, proposed Multi-agent system architecture [5][7] for management of ATM networks using intelligent agents. The
main objectives of this architecture are the following.

- Maximize integration with conventional ATM management mechanisms.
- Robustness
- Scalability
- Simplicity of agents

Two types of agents are used in this architecture: Network monitoring agents (NM-agents) and Network Planning (NP-agents).

A. Network monitoring agents

The function of NM-agent is to monitor and control the bandwidth assigned to one virtual path. i.e. Each NM-agent is responsible for one resource, one virtual path or one physical link. If there are several unidirectional links or virtual paths commence from one node, several NM-agents exists at that node and each NM agent monitor the bandwidth of virtual path. NM-agents are supposed to be very simple reactive type of agents whose main task is reacts fast when an event (connection release, bandwidth requests, faults, etc) occurs.

B. Network planning agents

There is one NP-agent per node and each one responsible for all logical paths or virtual paths that begin in its node. The planning agents are more deliberative and have the assignment of planning virtual path topology and bandwidth allocation to achieve good network performance. The mission of these agents is to monitor and control the network by monitoring NM-agents and contacting neighbour NP-agents. The NP-agents can manage NM-agents (creation, deletion, modify, consult, etc.). No NP-agent has a complete overall view of the network, but NP-agents maintains some kind of distributed view by means of co-operation between neighbors, by which each agent has limited domain view and possesses limited information. However, by polling their abilities, agents are able to solve the problems beyond the capacity of any one single agent.

C. Example Environment for Multi-agent System architecture

We consider a network configuration shown in fig 2. It consist of four nodes labeled with numbers 1, 2, 3, and 4. There are a total number of 10 unidirectional logical paths in the network. Each path is labeled with alphabet (i.e. A to J) and each logical path is monitored by one NM-agent. There will be one NP-agent per node and one NM-agent per logical path. So there will be four NP-agents and ten NM-agents for the network shown in fig 2.

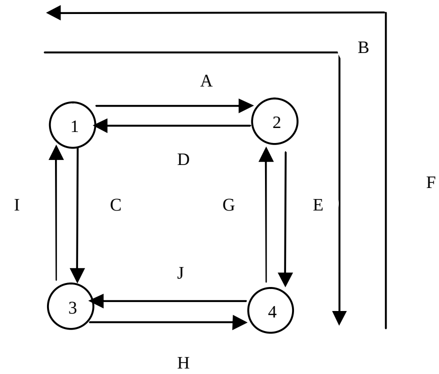

Fig.2 Network configuration

The NM-agents and NP-agents for the above network configuration are mentioned in table 1 and table 2 respectively.

S.No.	Node	NM-agents	Virtual Path (VP)
1	1	$M_{1,2}$	A
2	1	$M_{1,3}$	B
3	1	$M_{1,4}$	C
4	2	$M_{2,1}$	D
5	2	$M_{2,3}$	E
6	3	$M_{3,1}$	F
7	3	$M_{3,2}$	G
8	3	$M_{3,3}$	H
9	4	$M_{4,1}$	I
10	4	$M_{4,3}$	J

Table.1 NM-agents and their managed paths

S.No.	Node	NP-agent	Managing NM-agents
1	1	P_1	$M_{1,2}$, $M_{1,3}$, $M_{1,4}$
2	2	P_2	$M_{2,1}$, $M_{2,3}$
3	3	P_3	$M_{3,1}$, $M_{3,2}$, $M_{3,3}$
4	4	P_4	$M_{4,1}$, $M_{4,3}$

Table.2 NP-agents and their managed NM-agents

IV. VIRTUAL PATH BANDWIDTH MANAGEMENT AND CONGESTION CONTROL

We implemented Multi-agent system using Java. Each NP-agent implemented is an independent process and NM-agents are threads inside each NP-agent process. The developed a software module can be used for monitoring the logical path bandwidth management and controlling congestion in ATM network. The steps used in developed software module for monitoring logical paths and controlling congestion is described below:

Step 1: Initially the network will be configured by specifying the number of nodes, number of logical paths, and maximum bandwidth capacity of each LP. NP-agents and NM-agents will be created based on number of nodes and LPs in the network.

Step 2: When the source node wants to transmit data to destination node, we have to identify the primary logical path (P_LP) and invoke NM-agent process, monitoring that LP. The user specifies the bandwidth requested for that P_LP for transmission of data from source to destination node. The NM-agent process, checks to see if there is enough bandwidth available from the P_LP. If so, the user request will be granted and data will be transmitted over P_LP. The NM-agent records the available bandwidth of P_LP. After certain time interval, if the user requests for some more bandwidth, NM-agent process checks again the available bandwidth of LP. The required bandwidth is not available, then it consults NP-agent process at that node.

Step 3: The NP-agent process checks to see if backup LP exists from that node. Then NP-agent consults NM-agent which is currently monitoring backup LP. The NM-agent of backup LP, checks the available bandwidth capacity. If it finds the enough bandwidth capacity, it informs the NP-agent process and records the remaining available bandwidth. The NP-agent process informs the NM-agent process to utilize the backup LP bandwidth and this process is known as bandwidth re-allocation.

Step 4: When NP-agent process finds no backup LP exists or backup LP bandwidth have completely utilized, then it checks for alternate path which exists from source to destination node. If such alternate path exists, then it consults NM-agent process, which is monitoring that alternate path. The NM-agent of alternate LP, checks the available bandwidth capacity. If it finds the enough bandwidth capacity, it informs the same to the NP-agent process and records the remaining available bandwidth after giving permission to utilize the requested bandwidth. The NP-agent process informs the original NM-agent process to utilize the alternate LP bandwidth and this process is known as bandwidth re-routing.

Step 5: When NP-agent process finds no backup LP or backup without available bandwidth and no alternate path or alternate path without sufficient bandwidth, then congestion state is announced by the NP-agent process.

The above steps can be described by using example interaction between NM-agents and NP-agents at Node1 in the network configuration shown in fig 2. Here node1 wants to transmit data at regular intervals to node2 by requesting more bandwidth from node1. The communication taken place between NM-agents and NP-agents for managing logical paths bandwidth and controlling congestion is described in fig 3.

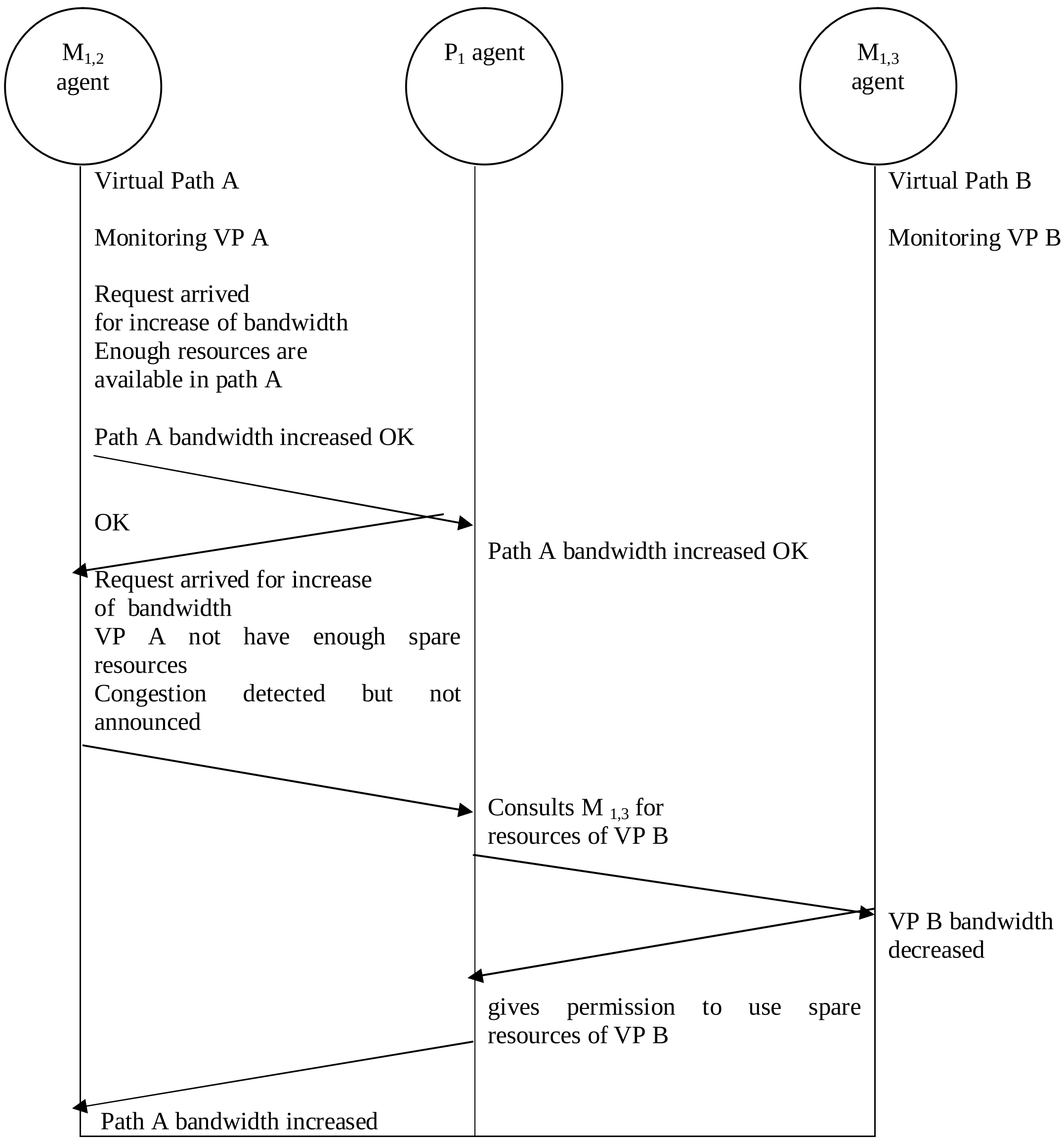

Fig 3. Example interaction between NM-agents and NP-agents

V. ADVANTAGES AND DRAWBACK OF MULTI-AGENT APPROACH OVER CONVENTIONAL APPROACH

A. Advantages

In conventional approach, there will be a single path or route exists between source and destination node. If at any instant amount of time, the current traffic is more than offered network capacity, congestion state arises. In such a case, the cell drop problem may occur and the source terminal has to change the transmission rate until it finds no congestion in the network.

In case of multi-agent systems, that supports agents approach, primary path bandwidth initially used for transporting cells. In addition to primary path, backup path, and alternate path may exists between source and destination nodes. If primary path is about to congested, then backup path bandwidth will be utilized. If backup path bandwidth is also fully utilized, then alternate path bandwidth will be utilized. If alternate path bandwidth is also fully utilized, then only congestion occurs in the system. So there is less chance of occurring congestion in the system.

Another advantage of multi agent approach is, the system can be scalable. The performance of the system does not degrade as network grows.

B. Drawback

As the number of nodes and paths increases, the number of NP-agent and NM-agent processes will be increases. So there will be more number of message exchanges or interaction in the networks in addition to the actual data to be transmitted. But this problem is negligible.

VI. CONCLUSION

We described multi-agent system architecture for ATM network management. The functionalities of NM-agents and NP-agents were described. We also present a developed system for virtual path bandwidth management for controlling congestion in ATM networks using NM-agents and NP-agents. The developed system has advantages such as less chances of occurring congestion in network and scalability over conventional approach.

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