International Journal of Advanced Computer Technology (IJACT)

ISSN:2319-7900

OPTIMAL ROUTING MULTI-AGENT SYSTEM APPROACH FOR CONGESTION CONTROL IN HIGH SPEED NETWORKS

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Abstract: Traffic Management and Congestion Control are major issues in high speed networks. Congestion represents an overloaded condition in a network. In this paper, we described existing Multi-Agent architecture for management of ATM networks. We developed a software module using Java, by using Optimal Routing for controlling congestion in high speed networks. We described the steps to be followed in developed software module and finally presented advantages over conventional approaches.

Keywords: ATM Networks, Bandwidth Management, Multi-agent System, Optimal Routing, Virtual Paths.

1. Introduction

Asynchronous Transfer Mode (ATM) [2] networks are high speed networks that endure a variety of services with various features, e.g. Voice, video, data, etc. ATM is connection oriented packet switched data transfer system, handling fixed size cells that are asynchronously multiplexed within the network and broadcast over a virtual circuit while preserving the cell sequence integrity. Asynchronous Transfer Mode provides the prospect for both terminal users and communications carriers to hold virtually any type of information using a common format.

Congestion control [3] [9] [10] [11], resource management and traffic management have become crucial role in protecting the network from becoming congested, in achieving the network performance objectives and optimizing the use of net 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 and Optimal Routing is described in this paper. A software module has been arisen, to automate the activities of agents in a multi - agent system to monitor the physical link bandwidth, Optimal routing between the two nodes and control congestion if any arise, in ATM network. This paper is organized as follows: Bandwidth management functions in High speed networks were described in

section 2. The multi-agent system architecture for High speed networks is described in section 3. The Optimal routing multi-agent system for congestion control and for reducing the number of messages between the NP agents is described in section 4. The Experiments and results conducted are described in section 5. The advantages of Optimal routing multi-agent approach over Multi-Agent System are discussed in section 6. Finally the paper is concluded in section 7.

2. Bandwidth Management in High Speed 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 cellular phones and cells transport. Routing and congestion control is done at this stage. The ATM Adoption Layer will split the message into cells at sender and reassemble to get back the original message at the recipient.

In the ATM layer, there are two layers of hierarchy: Virtual Path Connection (VPC) and Virtual Channel Connection (VCC) levels. A virtual path connection (VPC) is a labeled path which can be used to carry a pile of virtual channel connections (VCCs) and to manage the resources used by these connections. The virtual network is organized as a collection of VPCs which form a VPC, or logical, overlay network. The higher is VC level: users can establish and release the connections, i.e. Virtual channels, through pre-established virtual paths (VPs). The Virtual path management [4] [5] [7] considered is the establishment and release of VPs between two nodes in a network. Initially bandwidth will be administered to the established virtual paths in the network. Bandwidth management attempts to handle the capacities assigned to

ISSN:2319-7900

the different VPs that flow through the physical link. There are two actions normally taken by bandwidth management functions in Multi-Agent System architecture, namely bandwidth re-allocation and VP-rerouting.

If there are congested VPs and underused VPs in the same connection, the bandwidth assigned to each VP can be reconfigured. This method is known as bandwidth re-allocation shown in Fig. 1.

If nearly all the VPs in the link are congested or near to congestion and there is an insufficient unutilized bandwidth capacity for swapping between VPs, routes as well as capacities are modified to minimize the traffic had a roll in the oven in the mesh. This means that a change in VP network topology is required. This is called VP re-routing.

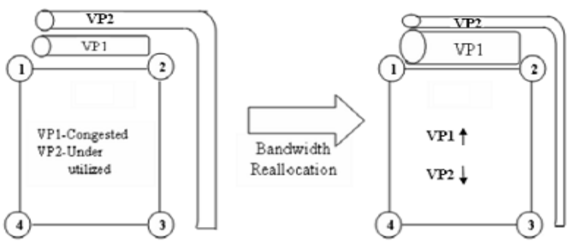

Fig. 1 Virtual path bandwidth reallocation.

S.No.	Node	NP-agent	Managing NM-agents and their corresponding virtual paths
1	a	P_a	$M_{a,b}$-1, $M_{a,c}$, -2 ,$M_{a,d}$ -3
2	b	P_b	$M_{b,a}$ -4, $M_{b,d}$ -5
3	c	P_c	$M_{c,a}$ -6, $M_{c,d}$ -7
4	d	P_d	$M_{d,a}$ -8,$M_{d,b}$ -9,$M_{d,c}$ -10

Table. 1 NP-agents and their managed NM-agents.

3. Multi-Agent System Architecture

Pere Vila et al, proposed Multi-agent system architecture [1], [6], [8] for management of ATM networks using intelligent agents. The primary aims 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 agents (NP-agents).

3.1 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 course or single physical connection. If there are several unidirectional links or virtual paths commencement from one client, several NM-agents exist on that guest and each NM agent monitors the bandwidth of virtual path. NM-agents are thought to be a very simple reactive type of brokers whose main task is, reacts fast when an event (connection release, bandwidth requests, defects, etc.) takes place.

3.2 Network Planning Agents

At that spot is one NP-agent per node and each one responsible for all logical paths or virtual paths that go turned in its nose. The planning factors are more deliberate and have the assignment of planning virtual path topology and bandwidth allocation to achieve better network performance. The commission of these agents is to monitor and control the network by monitoring NM-agents and contacting neighbors NP-agents. The NP-agents can manage NM-agents (creation, deletion, modify, consult, etc.). No NP-agent delivers a complete overall view of the web, but NP-agents maintains some sort of distributed view by way of cooperation between neighbors, by which each agent holds a limited domain view and possesses limited information. Nevertheless, by polling their abilities, agents are able to resolve the problems beyond the capability of any one single factor.

3.3 Example Environment for Multi-Agent System Architecture

We consider a network configuration shown in Fig. 2. It consist of four nodes labeled with names a, b, c and d. There are a total number of 10 unidirectional logical paths in the network. Each path is labeled with numbers (i.e. 1 to 10) and each logical path is monitored by one NM-agent. There will be one NP-agent per node and one NM-agent per logical track. Then there will be four NP-agents and ten NM-agents in the mesh depicted in Fig. 2.

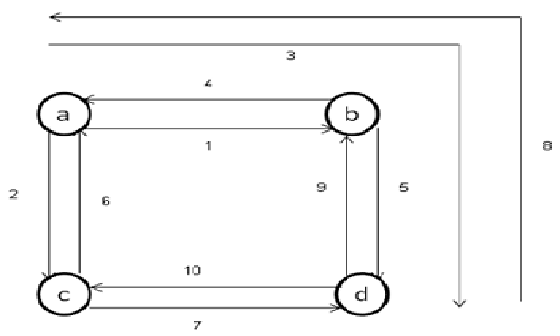

Fig. 2 Network configuration.

The NM-agents and NP-agents for the above network configuration are mentioned in Table1.

4. Optimal Routing for Multi-Agent System and Congestion Control

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The steps used in the maturation of the software for optimized Multi-Agent System and to control congestion is as follows:

Step 1:Initially the network will be configured by setting the number of guests, number of logical paths, and maximum bandwidth capacity of each LP. NP-agents and NM-agents will be created based on the number of nodes and LPs in the mesh, respectively. For each LP a cost parameter is assigned based on the bandwidths given to them. The highest bandwidth LP in the entire network is assigned with least cost and the next highest bandwidth LP is set apart with the second least cost and so along. The example network topology along with bandwidth and cost assigned to LP's is shown in Fig. 3.

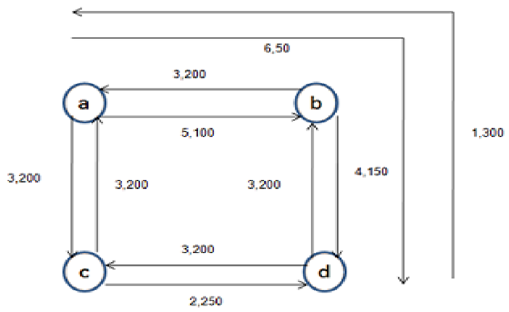

Fig. 3 Example Network Topology that represents bandwidth and cost of LP.

Step 2: When the source node wants to send information to a destination node, the primary logical path (P_LP) is identified and invokes NM-agent process, monitoring that LP. The user determines the bandwidth needed for transmission of information from origin to destination node. The NM-agent process of P_LP, checks to see if there is enough bandwidth available from the P_LP. If then, the user request will be granted and data will be transmitted over P_LP. The NM-agent records the available bandwidth of P_LP. If the user requests for some more bandwidth; NM-agent process of P_LP checks again the available bandwidth of the LP. If no bandwidth is available, then it consults NP-agent process of that node.

Step 3: The NP-agent process checks to see if backup LP exists for that client. If any, 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, NM-agent informs the NP-agent process and records the remaining available bandwidth. The NP-agent process informs the NM-agent process to use the backup LP bandwidth and this process is known as bandwidth re-apportionment.

Step 4: When NP-agent process finds no backup LP exists or backup LP bandwidth have completely utilized, then it goes over for alternate way of life which exists from source to destination node. Here the NP-agent can find many alternative routes between source and goal nodes. But among the many alternative paths the NP-agent chooses the least cost alternative path.

Step 5: The NP-agent chooses the least cost alternative path with the help of the cost parameter assigned to the LP. For that the total cost of each alternative path that exists between source and destination nodes is computed by the sum of the costs of LP's that exists in the way of life. Then a comparison is constructed between the total monetary values of the alternative paths, among them the path having less total cost is chosen by the NP-agent.

Step 6: The NP-agent consults the NM-agent and NP-agents of the other nodes in the alternative paths, the NM-agent checks the status of the availability of bandwidth and if enough bandwidth is available, the same thing is informed to the NP-agent and records the remaining available bandwidth and giving permission to utilize the requested bandwidth. The NP-agent informs the original NM-agent to utilize the alternative LP bandwidth. This is called Re-routing. If the first minimum cost alternative path does not exist, i.e., bandwidth in that path is completely utilized then the NP-agent chooses the second minimum cost alternative path and so on.

Step 7: Since the least cost alternative path selection concept is used, the cost required for the transmittal of data will be less and the data is conducted rapidly. The number of messages between NP-agent and NP-agent of the nodes will be reduced because transmission of data is caused through the less cost paths; automatically the data is sent with the highest bandwidth. Even though the user calls for high bandwidth, transmission is done through highest bandwidth, hence there is no need to intercommunicate with the other NP-agents. Thus the number of messages will be brought down when compared with the normal multi-agent system. Since the number of messages between NP-agent and NM- agent does not possess any influence on the network traffics, that event is not counted here. So we can control congestion, shorten the cost required for the transmittal of data and can shorten the number of messages between NP-agent and NP-agent of the lymph glands.

5. Experiments and Results conducted for Optimal Routing, Multi-Agent System

The experiment has been carried on in the network configuration shown in Fig.3 by taking 'a' as source node and 'd' as destination node. A notice is made to know, the number of messages between NP and NM agents of same node, and between NP and NP agents of different nodes as

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the bandwidth capacity is increased. Initially source node 'a' requests bandwidth of 50 MBPS, later with incremental bandwidth of 50 MBPS over time. From the graph shown in Fig.4.

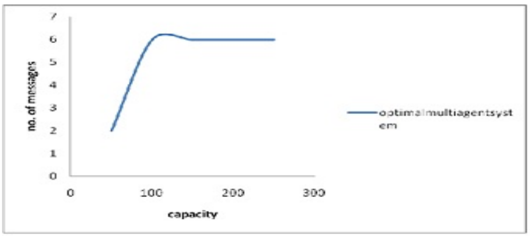

Fig. 4 Bandwidth vs no. of messages between NM and NP agents.

The ordinal number of messages exchanged between NM agents and NP agents in the same node is found to be 2,6,6,6,6 for the bandwidths 50,100,150,200,250 respectively. These messages are not being carried in the net, then there is no impact on net traffic.

From the graph shown in Fig.5, the number of messages exchanged between NP-agents among different nodes is found to be 0,2,2,2,2 for the bandwidths 50,100,150,200,250 respectively. On that point is minimal impact on the network traffic, since the number of messages is found to be very less. Hence, logical path's bandwidth management and congestion can be effectively manipulated by applying an optimal routing methodology.

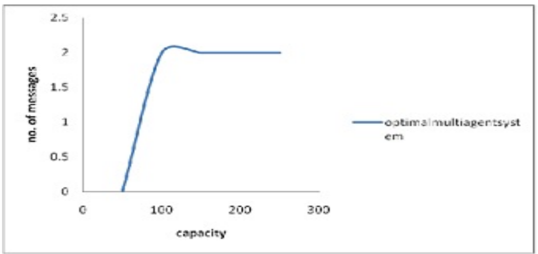

Fig. 5 Bandwidth vs no. of messages between NP-agents.

6. Advantages of Optimal Routing, Multi-Agent System Approach

6.1 Advantages

In multi-agent system, that holds up the agent's approach, if the number of clients in the network grows the messages that are transmitted between the planning agents of different nodes increases in addition to the actual data, when the optimal route is not utilized for the contagion of the data between the guests. This will precede to the traffic overhead and to congestion. Merely with the proposed system as the data is being shipped with high bandwidth first, the number of messages for communication between the planning agents of different nodes are less. And since the optimal routing algorithm is being applied, the data are beamed through the optimal route.

Another advantage of the multi agent approach is the system can be scalable. The functioning of the scheme does not degrade as the web develops.

7. Conclusion

We described an Optimal routing methodology for bandwidth management and congestion control in high speed networks, utilizing multi-agent approach. The functionalities of NM agents and NP-agents were identified. The developed methodology effectively manages logical paths bandwidth and controls congestion with minimum number of control messages exchanged between NP agents between different nodes in the mesh.

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