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Resource Allocation Algorithms in Cloud Computing for Agent Based Traffic Management

Heena Kousar
Associate Professor, Dept of CSE,
East Point College of Engineering & Technology,
Bangalore, India

Dr. B. R. Prasad Babu
Prof & Head of Dept, CSE,
SEA College of Engineering & Technology,
Bangalore, India

Abstract— Agent based computing is useful for handling of large scale distributed systems and uncertainty in dynamic environment. Urban Traffic and Transport management is ideal application suited for agent based solution because of the large distributed nature and dynamic busy idle nature. An important feature of an Agent is it can work without direct intervention of humans or others which helps to implement automated traffic and transport management. Previously many agent based solutions have been proposed for different aspects of traffic management. Many of the solutions face resource problems when taken for implementation. Here, we address the problems in the agent based deployment by using cloud computing platform and proposing resource allocation algorithms for efficient use of cloud resources for deploying agent based traffic management solutions.

Keywords— Multiagent System, SH routing, ARIMA model, Agent Scheduler, Sensor data Routing Engine.

I. INTRODUCTION

Increased traffic congestion and pollution are challenging the current traffic management solutions and necessities new techniques for solving the urban traffic problems. Agent technology was the new technology introduced in the early 1992 in traffic management systems, later multi agent traffic management systems was
proposed. For coordination and optimization all these systems focus on collaboration and negotiation between static agents. The introduction of mobile agent technology in 2004 lead to improve the development in the transportation field. The main characteristics of mobile agents are mobility, adaptive and autonomous, which is suitable to handle the inconstant and uncertainties states in a dynamic environment.

The transport domain deals mainly with people moving from one place to another in an urban environment. This domain is commonly seen as dynamic because of all the players and their interactions involved in it, for instance private cars, buses, trains and underground among others. Additionally, there is the infrastructure to consider, streets and sensors underneath, traffic lights, and (electronic) signs. Typically, the need for transport is called demand and involves the flow of vehicles, pedestrians and freight, and the transport offer is called supply which involves the infrastructure and services. The fluctuations in the transport demand during a period of time, unexpected accidents and faults, delays, energy consumption, and a limited transport supply make this domain increasingly complex and calls for the need of approaches to distribute the demand within the infrastructure and optimize its usage.

Software agents and multi-agent systems [2] are increasingly being used to solve overarching issues in the domain of traffic and transportation systems, namely traffic congestions, vehicle emissions, and transportation coordination. The applications of agent computing paradigm ranged from modelling and simulating traffic, managing congestion, and dynamic routing and recommendations [3]. Urban traffic control strategies to reduce traffic jams include intersection signal control [4], bus fleet management [5], integration of urban traffic control and route guidance [6], and intelligent route guidance [7].

In the traffic environment there are many states, an urban traffic management system must provide an appropriate traffic strategy agents. The requirements for the complete traffic management system are guidance, monitoring, emergency subsystems and traffic control. Hence to handle all this, new performance improvement traffic strategy environment, and addition of new subsystem, new traffic strategies is introduced continuously. Recent technology used by the urban traffic management systems to communicate with the traffic managers is decision support system and also uses large number of mobile agents to generate, store, manage, test, optimize.

An inevitable trend in the development of urban traffic management system with a friendly human –computer interface is the powerful decision support system. Thus, future systems must have the following capabilities.

1. Storage
2. Computing Power
3. Network Bandwidth

Using Cloud computing technologies for addressing the challenges in agent based urban traffic management is cost efficient and effective method. But managing the resources in cloud for the specific requirements of urban traffic management is not addressed in previous work

II. LITERATURE SURVEY

In the survey work, we explore the different agent based solutions and the problems in the solutions. Through this we arrive at the requirements for the resource management in cloud computing platform.

Cartesius was proposed by the F. Logi and S. G. Ritchie [8], a multi-agent innovative architecture for decision support real time system to Traffic Operations Center personnel for inter-jurisdictional traffic congestion management on freeway, coordinated, and surface street (arterial) networks. An agent can interact in between to produce consistent solutions accurately by cooperative paradigm, a distributed problem solving approach. Without requiring an agents to have shared access to all the globally available information, a lot of computing power is required for the distributed problem solving.

Min Chee Choy[9] proposed a new synergistic, hybrid approach in applying intelligence computational concepts to implement a hierarchical, multiagent system which is cooperative complex traffic network for real-time traffic signal. The various subproblems are divided from the large-scale traffic signal control problem, and is handled by an intelligent agent with a fuzzy neural decision-making module. The lower-level agents make the decisions and are transferred to their respective higher-level agents. An agent can be control by adopting a cooperative distributed problem solving approach and coordinating an agent.

A multistage online process, problem domain which is changing dynamically in implemented in the multiagent architecture which involve reinforcement learning, weight adjustments and dynamically update the relations of fuzzy using an algorithm of evolutionary. If the cloud is realized a multi cloud system, the approach proposed by Min Chee Choy will be able to scale well for a bigger networks.

He-Sheng Zhang [10] proposed a spatial-temporal traffic data analysis method using multi agent systems for traffic data management. They used CORBA for agent management. The network traffic between the agents is very high in this approach and using cloud computing for this work requires efficient bandwidth allocation algorithms in cloud.

F.Y. Wang [11] proposed host mechanism and three-level hierarchical architecture and applied concepts of agent-based control to networked traffic and transportation systems. The architecture enables the development of "local simple, remote complex" network-based design for low-cost, high performance traffic systems. By adopting cloud computing based hierarchical multi cloud provisioning, the cost can be still reduced.

G. Li [12] presented a new solution for the Air Traffic Flow Management (ATFM) problem. Its main objective is to improve computational efficiency for ATFM by combing grid computing with multi-agent coordination techniques. ATFM in Grid Computing (ATFMGC) was proposed to balance the communication among Multi-Agents, in ATFM for grid computing environments, in order to deal with synchronization problems. The function of the agents, their knowledge representation and inference processes were discussed, as well as the grid architecture, in which the agents execute it, was described to demonstrate the developed model. Also, a metric criterion called Standard of Balancing among Agents (SBA) was used as a basic index to measure the effectiveness of reducing the amount of communication among agents, and the delay of flights. When we move traffic management to cloud computing using agents, we need measures similar to SBA to measure the effectives of agents in cloud.

III. PROPOSED SOLUTIONS

Our proposed solution for agent resource management for cloud computing is based on distributed cloud service. The architecture of our solution is given Fig.1

Our solution consist of following components

1. Sensor Data Routing Engine
2. Agent scheduler
3. Multiple cloud interfaces
4. Physical traffic sensors.

Physical traffic sensors capture traffic data using their functional components and send data to the data routing engine on the wireless link interfaces, which is essentially a proxy forwarding the sensor feed to the cloud VM for processing by the traffic agents and to Sensor Data routing engine is a lightweight component send the senor feed statistics to the Agent scheduler which runs in cloud to decide on agent scheduling and routing of sensor feed.

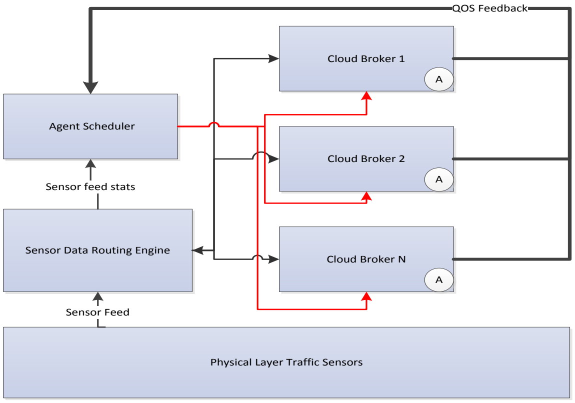

Fig 1. Architecture of Agent Resource Management System

Agent Scheduler is the important component in our architecture which takes care of scheduling the agents in terms of number of agents and agent location depending on the QOS feedback collected from the cloud brokers and the sensor feed stats. Agent Scheduler will decide the scheduling logic based on the demand supply collected from sensor feed stats and the QOS feedback.
Cloud Broker is the resource management platform for the cloud, most commercial vendor provide web service API for controlling the resource management and for collecting statistics. Agent Scheduler will use the web service API to control the resource management and for agent code provisioning on the cloud.
Agent Scheduler is the core component of our proposed solution. We use geographic dynamic prediction based load balancing algorithm for agent scheduling. The working of the algorithm is given below.
i. Initially the agent is moved to geographical close data center for processing by the scheduler. Agents are moved to the geographical data center and the routing rules are set at the sensor data routing engine to route the sensor data to the processing agents.
ii. Agents will process the sensor feed data and gives the response action to the sensor data routing engine component in the agent to deliver action to the physical sensors.
iii. Agent scheduler collects the QOS feedback for the agents in terms of response time and also sensor data statistics to predict the load at any particular region and based on it will decide to spawn further agents. The number of agents spawned or deleted is decided by the agent scheduler.
iv. The load prediction is done based on constructing linear regression model using the past history of load and predicts the load at later point of time. ARIMA model will be used for model construction
Two ways of load balancing will be implemented in our solution short term and long term. Based on the response time of the agents, short term load balancing will be done to increase the agents to handle the traffic data from a particular region. Long term load balancing is based on prediction of traffic data load from the sensors,. By using this proposed scheduling method the response time is always under control and the resource is consumed according to demand without causing wastage. Wastage is also a important factor because many cloud providers charge the users in terms of number of VM used and by reducing the wastage, cost saving is achieved.
The algorithm flow chart is given in Fig 2.

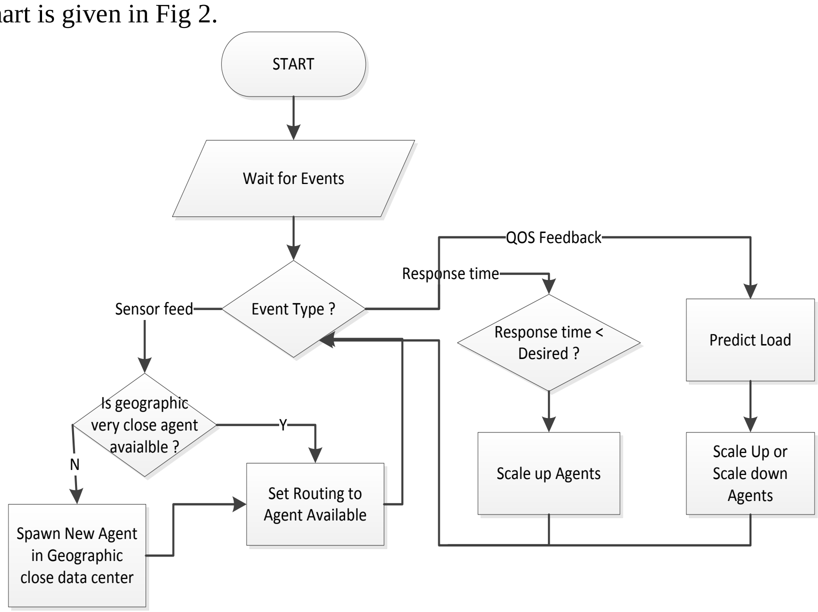

Fig 2.. Algorithm flowchart for Agent Scheduler.

The data travel path from sensor node to the agent node must be optimized to reduce the delay, so that agent decisions are in real time. To reduce the delay path must be free from congestion. Also the path construction must be free from control message overhead which causes congestion in the network. For this we propose congestion controlled routing mechanism to calculate at the cloud and provisioned to agent, so that agent will advertise the path to the sensor nodes once it reaches the targeted location. Once an agent moves to a node, it advertises its ROUTE_TO request which carries the route from itself to the sensor nodes in its configurable coverage area. For route computation at the cloud for the particular agent, sensor data routing engine will implement a congestion controlled path computation from sensor node to the agent with a constraint on maximum load on each link, so that there is no congestion on any path. Once the paths are computed, they are copied to agent's memory and carried to the target node in the network. From the target location agent carries the path to the sensor nodes. Sensor nodes use the path to route data packets to the agent.

IV. PERFORMANCE ANALYSIS.

We simulated the proposed solution in simulation bed with Microsoft Azure cloud service for agent provisioning and resource allocation. Agent scheduler was also run on separate VM in the Azure cloud. For sensor and agent simulation we customized the J-Prowler simulator.
The sensors network was simulated with following parameters

Table 1. Simulation of Sensor Network.

No of Nodes	100
Sensor Deployment area	100 sq.m
Communication range	10 m
Sensor Deployment model	Uniform
Data rate from sensors	5 packet per second

We measured the following parameters

1. QOS in terms of delay and packet loss from sensor to agent
2. Average response time for agents reply to sensor considering the entire network area.
3. The resource consumption rate at the cloud.
4. The bandwidth consumption between data centers and sensor network

For delay and packet loss comparison, we used the well known SH, Clustering routing scheme to compare against our scheme, we measured the delay and packet loss over a period of time and found that our mechanism is able to achieve reduced delay and packet loss compared to SH routing scheme shown in Fig 3..& Fig 4.

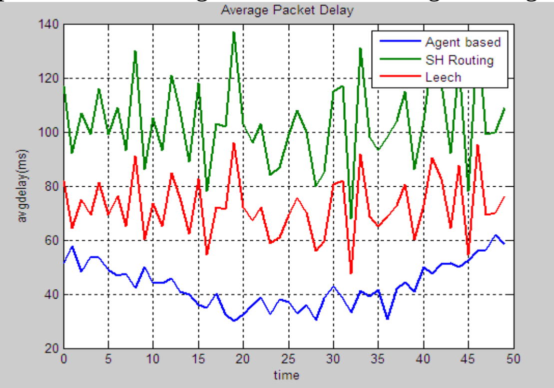

Fig 3. Delay and Packet loss comparison using SH routing scheme, Leech scheme with respect to Agent based routing scheme

Fig 4. Packet Delivery ratio comparison using SH routing scheme, Leech Scheme with respect to Agent based routing scheme.

The fig 5. shows the average response time for action to the sensor from the agent is compared against the response time from single sink to the sensor via SH routing and we found that our response time is short compared to the SH routing scheme

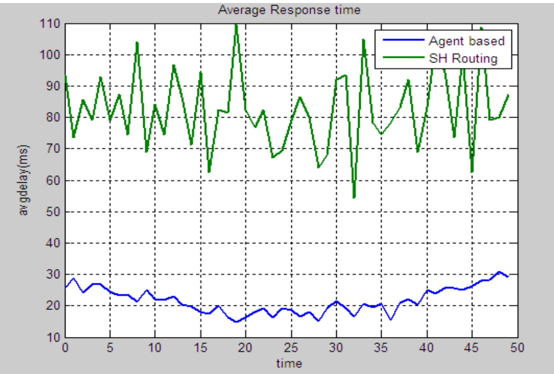

Fig 5. Average Response time comparison between SH Routing and Agent based Routing.

The resource consumption rate from the cloud is measured and plotted in Fig 6. From this plot, we find after a short transient, the resource consumption rate is reduced and uniform.

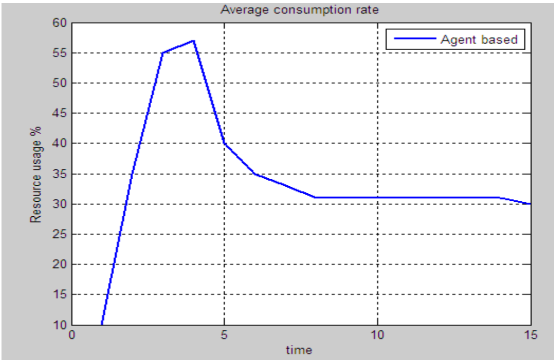

Fig 6. Resource consumption rate is reduced and uniform.

The bandwidth consumed between the cloud center and the sensor network is measured continuously and we find more bandwidth is needed only during the initial times and later bandwidth consumption is reduced and constant shown in Fig 7.

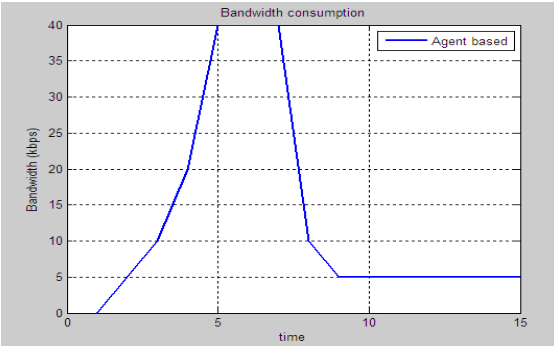

Fig 7. Bandwidth consumption is reduced and constant.

V. CONCLUSIONS

We have detailed our proposed solution for resource allocation in cloud for urban traffic management solution. Through simulation we have proved that our solution is able to reduce the resource consumption in cloud and the bottlenecks for achieving scalable performance are removed. With our simulation experiments we have also proved the bandwidth needs between the data centers is also managed effectively to achieve higher workloads for agents.

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