QoS in MANET using Multi-Agent System

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Abstract— Due to complex, dynamic and uncertain environment of MANET causes packet delay, packet loss and huge amount of resource wastage. Because MANET is different from previous networking techniques and so it's architecture is dynamic and ever changing in nature. This architecture poses some new issues which effect the performance of MANET. This paper tackles these constraints that limit the performance of MANET by using agent based technique employing agents which are autonomous and computational entities. One of it's types also include the characteristic of mobility. All these characteristics are suitable for MANET environment. So a multi agent system is proposed using multiple agents to resolve the issues in MANET.

Keywords: Mobile Adhoc Network, Agents, Multi Agent System, QoS;

1. Introduction

1.1 Quality of Service (QOS)

The term QOS widely used in wire and wireless network, in last recent years the most accepted definition for QOS define by CCITT as "The collective effect of service performance which determines the degree of satisfaction of a user of the service" (Recommendation E.800). Which determine the capability of a wireless technology in the term of how successfully it can deliver the high value services? QOS has different meanings from user to users, it based on the requirements and application according to the end user. Therefore, in order to select a particular end user according to its requirements, it's implemented to apply some performance parameters. These parameters for QOS are:

- Jitter
- Delay
- Packet loss ratio
- Packet receive ratio
- Maximum / Minimum bandwidth guarantee
- Resource usage

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1.1.1 Jitter

Latency/Delay varies over different packets; this phenomenon is referred to as jitter.

1.1.2 Delay

Each packet might take a long time to reach its destination, because of queuing, or takes an indirect route to avoid congestion. It also depends on how much physical layer is broken into small parts, as each hardware component will add its impulse response into the packet.

1.1.3 Packet loss ratio:

Packet loss occurs if one or more packets passing through network failed to reach their destination. It can be due to following reasons; signal degradation due to multi-path fading, channel congestion, corrupted packets rejected or due to faulty network hardware etc.

1.1.4 Packet receive ratio:

The proportion of successfully received packets is packet receive ratio. This ratio is more complicated in wireless networks than in wired. Specifically the problems are intensive in mobile networks. Due to the variations of radio wave propagation wireless networks have an inherent unreliability.

1.1.5 Bandwidth:

Bandwidth can be defined as the number of packets per unit-time in a medium. Bandwidth is the most essential parameter of QOS for users. Almost in all wireless technologies it is bounded by physical layer between base station and the end user. Most of the time bandwidth is shared among several users; therefore the number of active users in parallel limits the bandwidth. Since users are interested to get guaranteed bandwidth either in the form of upper bounds on bandwidth usage by any application imposed by the administrator or the lower bound on bandwidth usage i.e. users are provided guarantee to get at least this minimum amount of bandwidth in order to get services.

1.1.6 Resource usage:

Two other QOS attributes such as service coverage area and power consumption that are more specific to MANETs [1]. Today's latest technology made us able to develop those devices that are cheaper and limited in size. These cheaper and limited size devices also impose some constraints on the resources that they have i.e. they have limited processing capability

as compared to the traditional devices, also have limited source of energy and so on. Therefore, these attributes are also equally important for providing QOS in MANETs.

1.2 MANETs

MANET is a self-organizing adaptive combination of mobile devices that are connected with a wireless link. Traditional wireless mobile communication usually support wired fixed infrastructure, on the other hand MANET does not support fixed infrastructure. The devices of MANETs either in a single hop or multi hop paths communicate with each other in a peer-to-peer fashion. Thus mobile devices/ nodes act as both hosts and routers in MANET.

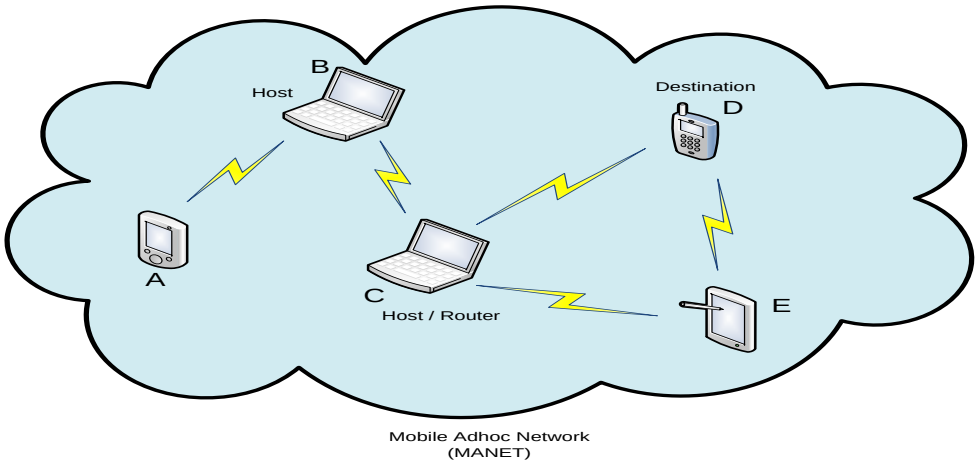

Figure Caption

If node C, itself wants to interact with node D, it act as a host on the other hand if node B wants to interact with node D it is unable to communicate directly with it because it does not came under the communication range of node D, so it route its traffic to node C which now act as a router to send node B's data to node D.

1.3 QOS support in MANETs (Issues and Challenges)

The difference in nature from traditional network introduces unique challenges and issues for supporting QOS in MANETs. The most important features of MANET's are: variable link properties, mobility node, life battery limitation, memory and bandwidth, hidden and exposed terminal problem, route maintenance, no central authority, and security so on. These QOS issues in MANETs can also be seen from a layered perspective. In which each layer exhibits its own issues in order to support QOS in MANETs.

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1.4 Agents

Agents are entities that are autonomous, computational that perceiving their environment with sensors and actuators [2]. Response through actuators agent technology would be desirable for these highly distributed networks in terms of intelligent

network management and data harvesting for example [3]. The term agents with its true sense in computer science, is abstractly a combination of computer software and data [4]. As discussed above agents are autonomous in nature, which means that for an agents to be able to act without a human owner or supervisor even in environments that are more difficult in nature like dynamic environment, specialized capability to move and conceptually to migrate between nodes, on the other hand mobile agents are sort of software agents which have some special properties that differentiate them from standard programs. Some of these properties are mandatory and some of these are optional [2]. Mandatory properties of mobile agents include decision, making autonomy, goal oriented behavior, and temporal continuity. On the other hand optional properties include mobility, cooperative, mutual and learning. Similarly different kind of agents makes up a Multi Agent System (MAS).

2. Background and Related Work

QOS in MANET is an emerging area of research these days. A lot of research has been going on to provide QOS in MANETs due to their rapid adoption in many diverse areas like health, monitoring, military, and so on[]. A typical QOS architecture should support the QOS at all levels. These levels can be viewed as a layered perspective i.e. providing QOS at each concerned layer[]. Like providing QOS at application layer that include issues like providing simple and flexible user interface, dynamic QOS ranges, as proposed in [5], where dynamic ranges are introduced instead of fixed point of QOS parameters that can be used for resource reservation in dynamic nature MANETs. Other application layer techniques include support for adaptive real-time, like support for video/audio streaming based on compression algorithms and so on. Supporting QOS at transport layer plays an important role.

Several people tries to enhance the performance of TCP by introducing several techniques like local retransmission, split-TCP connection, forward error correction, congestion control and so on. Work has been done in this direction to improve TCP performance in MANETs [6][7][8], dependent on explicit feedback mechanisms to distinguish error losses produces by congestion losses so that appropriate actions can be performed when packet losses occur. We can say that transport layer support is necessary for achieving end-to- end QOS in MANETs.

Similarly supporting QOS at network layer provides QOS aware routing protocol that are also an emerging area of research these days several techniques has been proposed for QOS routing in MANETs ranging from editing traditional routing algorithms to applying computational intelligence techniques to achieve better results like [8] presents a survey on QOS routing using ACO. Article [9] presents a brief survey on support for QOS at MAC layer. QOS architecture based on agents supports all these features as mentioned in [10], agent based techniques has several advantages over traditional approaches.

There should me ore related work

3. Proposed Agent based Architecture for QoS in MANET's

Proposed architecture mainly consist of two types of agents

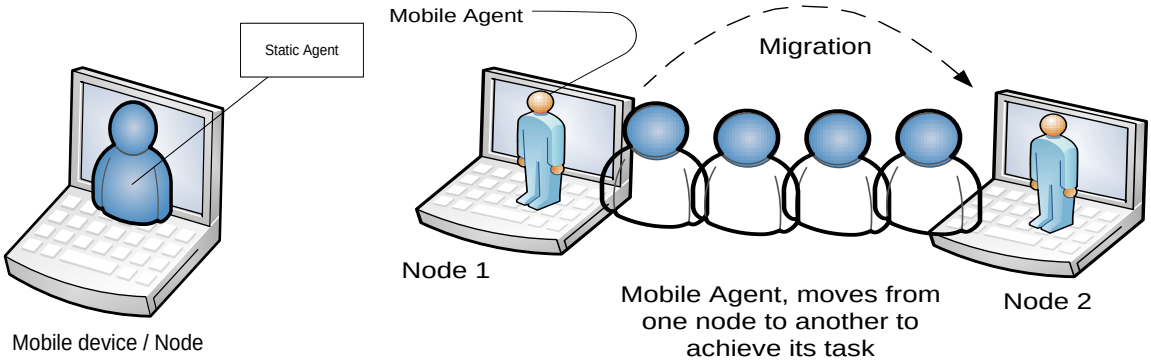


Figure Caption

3.1 Static Agent [would suggest to add these in paragraph rather than sections]

Types of agents that reside in the node/mobile device to accomplish its tasks, Theses type of agents don't have the capability to move from one node to another. Following types of static agents are used in our proposed model of QOS for MANET's

3.1.1 Agent Manager (AM)

AM plays an important role in our proposed model. The major task of AM is to initialize core agents and in case of system failure reinitialize or restart agents working in different part of the network that are stopped due to system failure and also keep track of agent's activities and their states working at different parts of the network. On each node AM is automatically created by the system, and all these services discussed are built-in.

3.1.2 Agent Communication Manager (ACM)

ACM Provides, communication mechanism for agents i.e. how they interact with each other within the network. ACM is basically a part of AM.

3.1.3 Security Agent (SA)

Security is one of fundamental issue in MANET's, SA provides essential security measures to protect its environment from different types of attack e.g. running of malicious code by a migrating agent, restricting access of migrating agent to unauthorized data and so on.

3.1.4 Resource Monitoring Agent (RMA)

RMA, monitors different resources associated to each node / mobile device like battery of the mobile node, link capacity / bandwidth, delay information and so on.

3.1.5 Event-Profile Manager (EPM)

EPM maintains a profile about the occurrence of different events as a consequence of operation either performed by node itself or the mobile agent's visit.

3.1.6 Directory Management Agent (DMA)

DMA Provides naming services to agents within the network, because unique name and id assignment is also an important function in an agent based environment. DMA is also created whenever the system is initialized. Also the task discussed and others like yellow pages (used for assisting other agents) in the network are the default task of the DMA. DMA is second and last agent that is created automatically.

3.1.7 Path Manager Agent (PMA)

PMA is a core agent that is responsible for providing smooth flow of network traffic while satisfying QoS requirements for this purpose it maintain multiple paths between source and destination, Route finding Agent is created to find multiple paths for this purpose.

3.2 Mobile Agents

Mobile Agents are the type of agents that have the capability of migration from node to node. Mobile Agents can travel to the network to gather information required to accomplish their tasks. Neighboring node selection for migration / movement of the agent can be random or predefined.

Following types of mobile agents are part of our proposed model.

3.2.1 Route Finding Agent (RFA)

RFA is a mobile agent, travels to the network to find multiple QoS-aware paths between the source and destination.

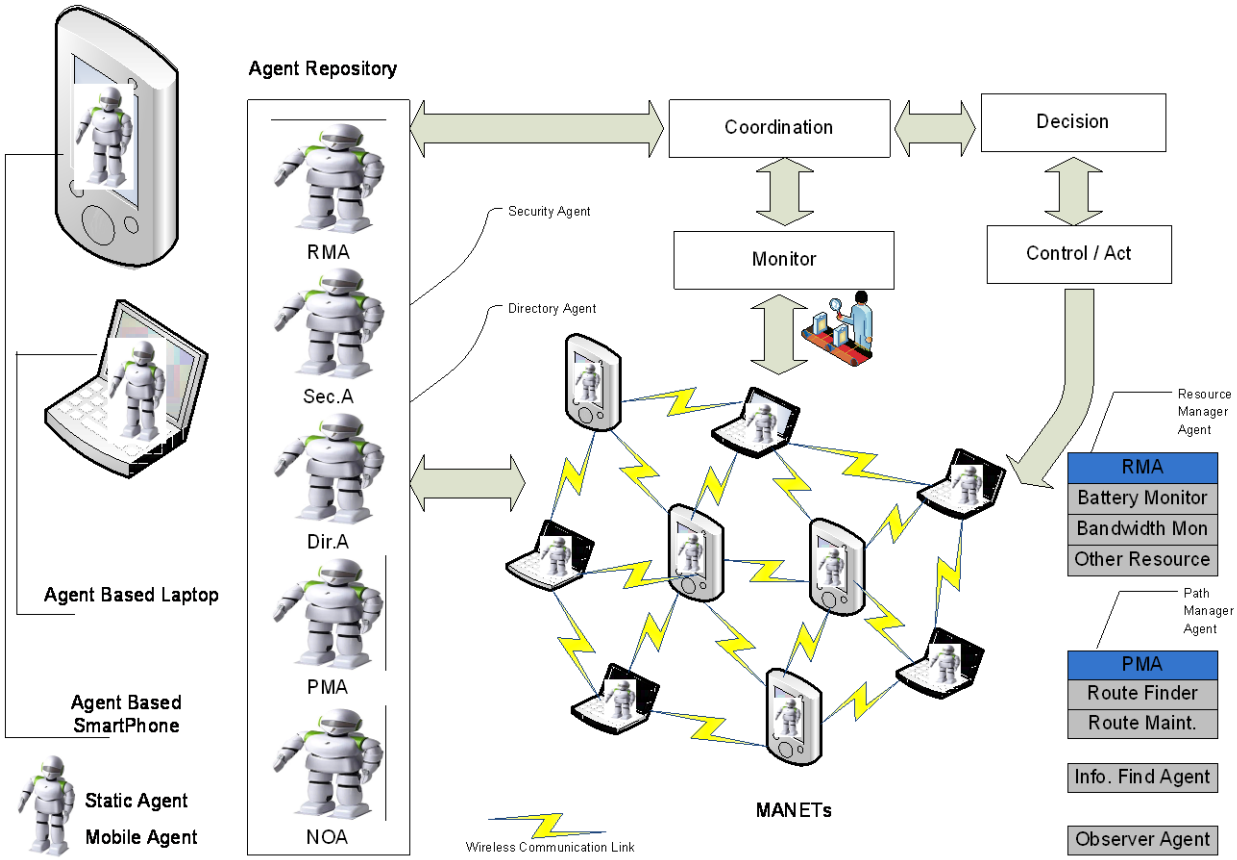
3.2.2 Neighborhood Information Agent (NIA)

NIA is a mobile agent that gathers information about its neighboring nodes and make a profile of each neighbor on the bases of QoS metrics like available bandwidth, delay at that node and so on that can be used by RFA to find QoS path.

3.2.3 Network Observer Agent (NOA)

NOA is a mobile agent that travels within the network by replicating to observe the behavior of the network like congestion in any part of the network that can be helpful to alert its neighboring nodes about it.

Figure1: depicts general overview of our proposed model in which we have an agent repository that contain agents that we have discussed above and the process of achieving QoS.



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Algorithm 1 Agent Manager (AM) [Please add more description/explanation using text]

1. Initialize the Agent based system by creating core agents.
2. Create a database of states of agents
3. If (system==working properly)
   Then administer the system as per workflow model like agent creation, suspending, termination and so on.
4. Else
5. If (system failure == full)
   Then reinitializes the system and restart all agents.
   If (system failure == partial)
   Then only restart that part of the system and restart effected agents with their previous states.

Algorithm 2 Security Agent (SA)

1. Authenticate all mobile agents (MA) interested for migration.
2. Only provide access to those resources / information for that they are authenticated.

3. If MA tries to perform any malicious activity either trying to running malicious code or trying to access unauthorized information. Secure the system, notify about it to AM, request to suspend the agent, and decrease the counter of being trusted party of the originating node.

Algorithm 3 Resource Monitoring Agent (RMA)

1. Initialize parameters to be monitored
2. If (QoS parameters == custom)
   Then use these parameters for resource monitoring and send periodic updates to EPA to update the status.
3. Else
   Use default QoS parameters, and send periodic updates to EPA to update the status.

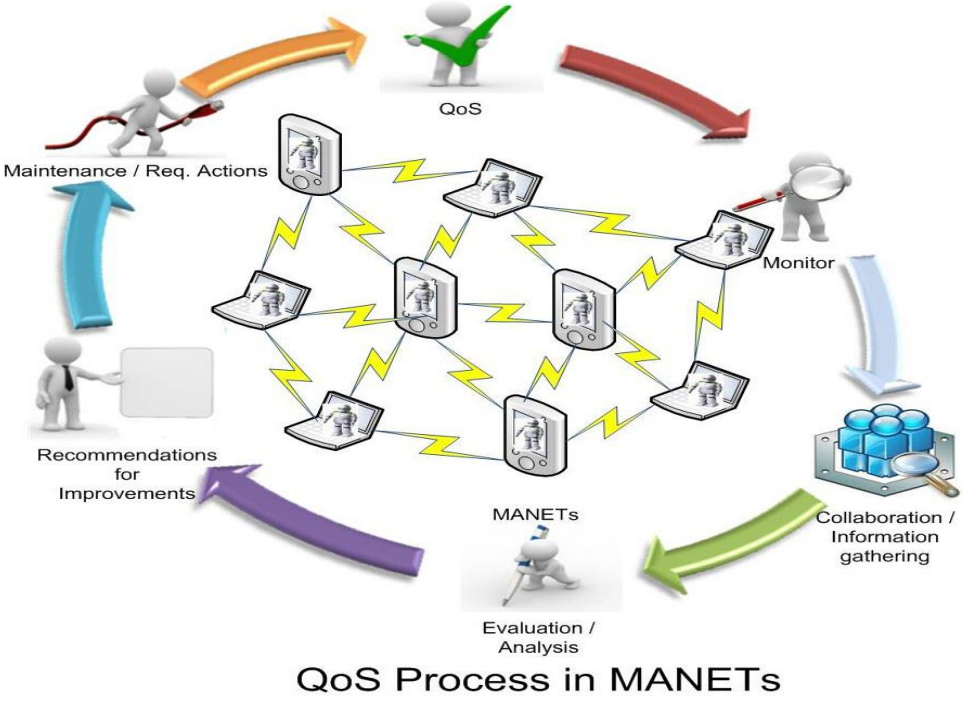
Algorithm 4 Path Manager Agent (PMA)

1. Create and Initialize Neighborhood information Agent (NIA periodically checks for its neighbors by sending hello messages to observe the change in neighborhood.
2. If (route==null or reliability of route = low)
   Then Create and initialize Route finding Agent
3. Maintain routing table on the bases of reliability and QoS requirement (maintains two path one is selected as main and the other one is selected as alternate route)
4. Check path reliability
   If (reliability = low)
   Then request PMA to create NIA to get neighborhood information
   If (NIA has an update)
   Then re-create RFA to find path
5. If (main path = down or lose)
   Then route traffic to alternate route and create NIA to find another route between source and destination.
6. If (both path = down or lose)
   Then update the status in EPA to inform neighborhood about the change and start buffering those packets. And create RFA to find routes.
   And if (RFA = fails to find route (for a limited amount of time))
   Inform all neighbors by updating information to EPA that use alternate path.

Algorithm 5 Neighborhood information Agent (NIA)

1. If (hop count==0)
   Terminate
2. Else
   Periodically check for neighbor's connectivity by sending hello messages (if neighbor has an update it will also notify within the response of hello message)
3. If (hello response contain any update notification) then send NIFA mobile agent to Collect information from all neighbors and update EPA

Figure 2 depicts general process of Agents working to achieve QoS in MANET's.



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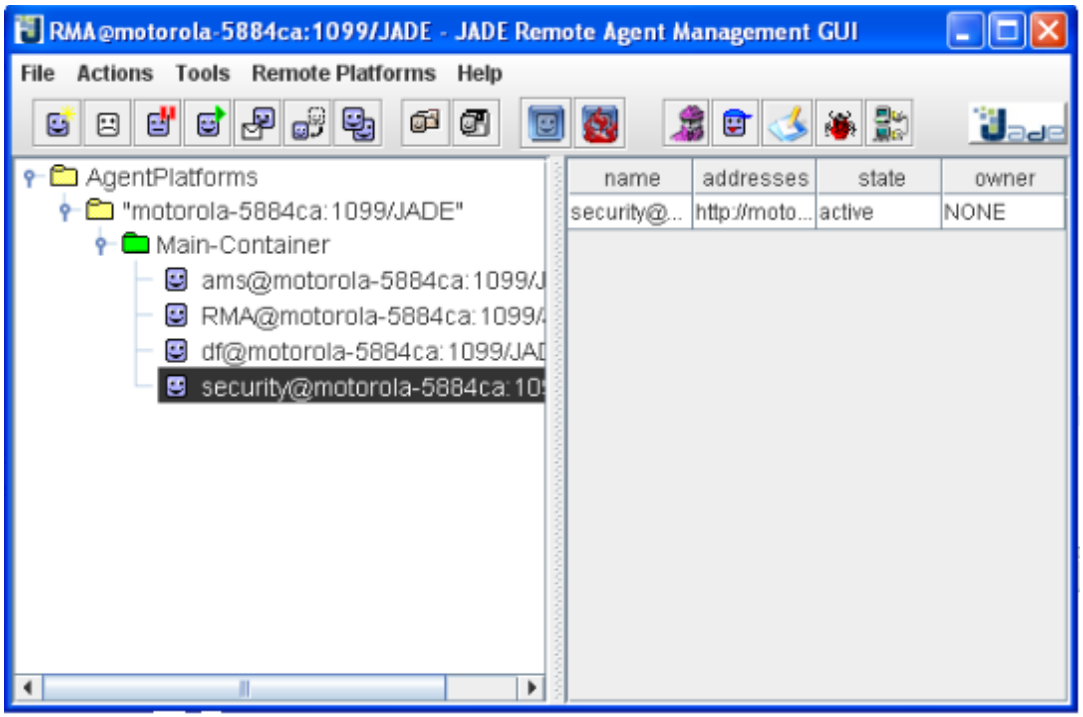
4. Experiments

AODV routing protocol is selected as a candidate for neighborhood discovery and routing. In order to select a good candidate for this purpose AODV is compared with its other class members. Results show that the performance of AODV is better than its competitors.

On the other hand JADE is selected for implementing agent based system due to several benefits that it provides on other tools.



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5. Conclusion

QoS in MANET is achieved by using multi agent based system. In multi agent system the work load is divided into several agents. AM initializes core agents and reinitializes in case of system failure while RMA manages hardware resources like battery, bandwidth, etc. There are other agents to manage security, profile, paths. In this way, multiple agents communicate and perform the different tasks needed to perform. Due to the asynchronous communication of agents the network traffic reduces significantly as compared to traditional methods. While on the other hand by using agents' nodes requires more resources and computational processing. This will be entertained in future. Need to add more details with detailed scenario.

The performance of AODV is verified for homogeneous network only. Due to heterogeneous nature of MANET it is necessary to check its performance in heterogeneous network. Another task that will be performed in future is to modify the routing protocol to limit its broadcast to only its first neighbors this will leads towards less traffic of route request, route replies that can become the reason for network congestion. With respect to JADE, mobile agent work which is pending due some technical reason will be completed in future.

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