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A Proficient Ant Colony Optimization for Improving QOS in MANET

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Abstract

In the current Technology of wireless communication systems,there is a need for the rapid deployment of independent mobile users. Significant examples include establishing survivable, efficient, dynamic communication for emergency/rescue operations, disaster relief efforts, and military networks. Such network scenarios cannot rely on centralized and organized connectivity, and can be conceived as applications of Mobile Ad Hoc Networks. A MANET is an autonomous collection of mobile users that communicate over relatively bandwidth constrained wireless links. Since the nodes are mobile, the network topology may change rapidly and unpredictably over time. The network is decentralized, where all network activity including discovering the topology and delivering messages must be executed by the nodes themselves, i.e., routing functionality will be incorporated into mobile nodes. MANETs uses the efficient distributed algorithms to determine network organization, link scheduleing, and routing. By performing all these operations the QoS sustainability is very essential.In this paper we proposed the QoS parameters to achieve the bandwidth rate and to increase our network throughput.

Keywords: *Ant colony optimization, AntQoS, QoS colony, self-organizing QoS framework, swarm intelligence,QoS Routing.*

1. Introduction

As the number of Internet users continues to grow, network performance requirements must increase right along with them. In addition, many of the latest online services require high amounts of bandwidth and network performance. Network performance is an element of concern both for the user and the service provider. Internet service providers need to apply techniques and technologies to provide the best service possible before their competitors beat them to it.

So we make use of QoS. Quality of service (QoS) refers to a network's ability to achieve maximum bandwidth and deal with other network performance elements like latency, error rate and uptime. Quality of service also involves controlling and managing network resources by setting priorities for specific types of data (video, audio, files) on the network. QoS is exclusively applied to network traffic generated for video on demand, IPTV, VoIP, streaming media, videoconferencing and online gaming.

The primary goal of quality of service is to provide priority to networks, including dedicated bandwidth, controlled jit supply the elemental building blocks that will be used for future business applications in campus, wide area networks and service provider networks.

There are three fundamental components for basic QoS implementation:

1. Identification and marking techniques for coordinating QoS from end to end between network elements
2. QoS within a single network element.
3. QoS policy, management, and accounting functions to control and administer end-to-end traffic across a network.

1.1 QoS parameters

Different applications have different requirements regarding the handling of their traffic in the network. Applications generate traffic at varying rates and generally require that the network be able to carry traffic at the rate at which they generate it. In addition, applications are more or less tolerant of traffic delays in the network and of variation in traffic delay. Certain applications can tolerate some degree of traffic loss while others cannot. These requirements are expressed using the following QoS-related parameters:

- Bandwidth - the rate at which an application's traffic must be carried by the network
- Latency - the delay that an application can tolerate in delivering a packet of data.
- Jitter - the variation in latency
- Loss - the percentage of lost data

If infinite network resources were available, then all application traffic could be carried at the required bandwidth, with zero latency, zero jitter and zero loss. However, network resources are not infinite. As a result, there are parts of the network in which resources are unable to meet demand. QoS mechanisms work by controlling the allocation of network resources to application traffic in a manner that meets the application's service requirements.

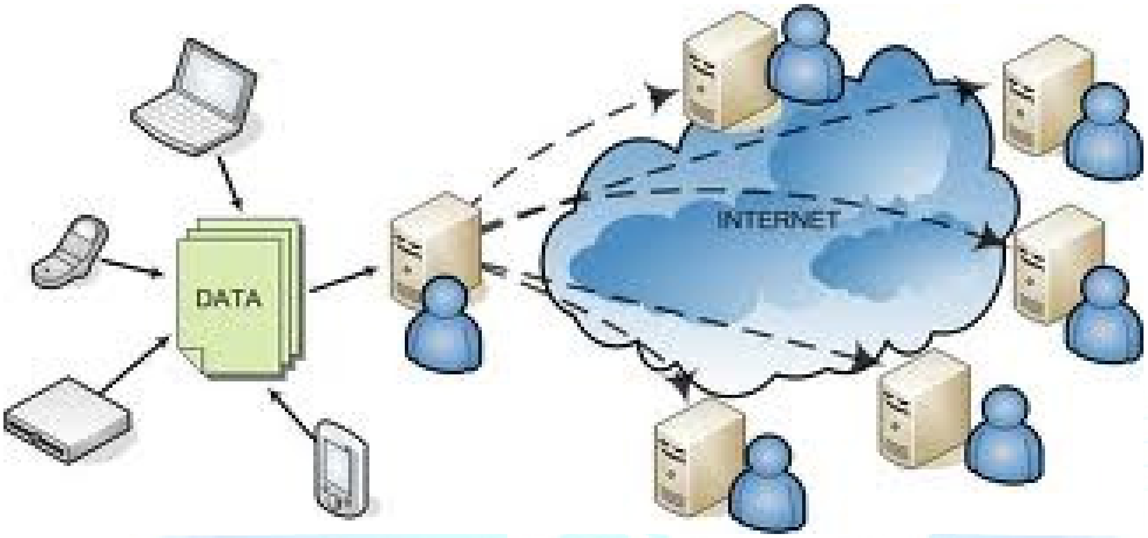


Fig: quality of service

2. Literature Survey

In recent years, a large number of MANET routing algorithms have been proposed. These algorithms all deal with dynamic aspects of MANETs in their own way, using reactive or proactive behavior or a combination of both.

The proposed algorithm in this paper is hybrid one was said by Jianping Wang, Eseosa Osagie, Parimala Thulasiraman and Ruppa K.Thulasiram,"HOPNET "A hybrid ant colony optimization routing algorithm for mobile ad hoc network,"

OLSR protocol is the enhanced version of pure link state routing protocol that chooses the optimal path during a flooding process for route setup and route maintenance is said by Suman Banik, Bibhash Roy, Biswajit Saha and Nabendu Chaki in their paper **"**Design of QoS Routing Framework based on OLSR Protocol,"In ACO, During their trip to food as well as their return trip to nest, they lay a chemical substance called pheromone, which serves as a route mark that the ants have taken was proposed by] Rajeshwar Singh, D K Singh and Lalan Kumar, in "Ants Pheromone for Quality of Service Provisioning In Mobile Adhoc Networks,"

3. Existing Framework

Unfortunately nodes in MANETs are limited in energy, bandwidth. These resources constraints pose a set of non trivial problems; in particular, routing and flow control**.** The Internet Engineering Task Force (IETF) had standardized Integrated Services (IntServ) and Differentiated Services (DiffServ) for promising QoS-enabling frameworks. IntServ provides end-to-end QoS guarantees to individual flows by performing per-flow resource reservation,but does not scale well for larger networks due to the perflow management. DiffServ enhances the network scalability by aggregating individual flows into different traffic classes through the pre-defined QoS parameters per class, but does not perfectly guarantee.

The required QoS for individual flows.New attempts such as IntServ over DiffServ [1], DiffServ wit EAC [2], and DiffServ with MPLS-TE [3] had been made to combine the strengths of IntServ and DiffServ. Although these researches may accomplish their goals, class-based QoS mechanisms have some non-trivial engineering and technical issues:
1) how many classes should be provided,
2) how can QoS paramters be defined for each class,
3) what are best business models for each class, and
4) how can resource utilization be increased using the isolated resources per class.

And also the complexity increases due to various characteristics like dynamic topology, time varying QoS requirements, limited resources and energy etc. QoS routing plays an important role for providing QoS in wireless ad hoc networks. The biggest challenge in this kind of networks is to find a path between the communication end points satisfying user's QoS requirement. An algorithm of ant colony optimization for mobile ad hoc networks has been described in [5]. But the QoS issues end-to-end delay, available bandwidth, cost, loss probability, and error rate is not considered in [5].

A hybrid QoS routing algorithm has been proposed in [6]. In [6], the authors used ant's pheromone update process approach for improving QoS. But the authors described only bandwidth. Other QoS issues are not considered in [6]. Shahab Kamali. et.al [7] implemented a new ant colony based routing algorithm that uses the information about the location of nodes. The problem of finding multiconstrained paths has high computational complexity,And thus there is a need to use algorithms that address this difficulty.

4. Proposed Framework

4.1 Ant Colony Optimization

The ACO meta heuristic is based on generic problem representation and the definition of the ant's behavior. ACO adopts the foraging behavior of real ants. When multiple paths are available from nest to food, ants do random walk initially. During their trip to food as well as their return trip to nest, they lay a chemical substance called pheromone, which serves as a route mark that the ants have taken 4]. Subsequently, the newer ants will take a path which has higher pheromone concentration and also will reinforce the path they have taken. As a result of this autocatalytic effect, the solution emerges rapidly.

To illustrate this behavior, let us consider the experiment shown in Figure 1. A set of ants moves along a straight line from their nest A to a food source B (Figure 1a).

At a given moment, an obstacle is put across this way so that side (C) is longer than side (D) (Figure 1b). The ants will thus have to decide which direction they will take: either C or D. The first ones will choose a random direction and will deposit pheromone along their way. Those taking the way ADB (or BDA), will arrive at the end of the obstacle (depositing more pheromone on their way) before those that take the way ACB (or BCA). The following ants' choice is then influenced by the pheromone intensity which stimulates them to choose the path ADB rather than the way ACB (Figure 1c). The ants will then find the shortest way between their nest and the food source.

In most cases, an artificial ant will deposit a quantity of pheromone represented by $\Delta\tau_{i,j}$ only after completing their route and not in an incremental way during their advancement. This quantity of pheromone is a function of the found route quality.

Pheromone is a volatile substance. An ant changes the amount of pheromone on the path (*i*, *j*) when moving from node *i* to node *j* as follows:

$$\tau_{i,j} = \sigma \,.\, \tau_{i,j} + \Delta\tau_{i,j} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

where σ is the pheromone evaporation factor. It must be lower than 1 to avoid pheromone accumulation and premature convergence.

At one point *i*, an ant chooses the point *j* (i.e. to follow the path (*i*, *j*)) according to the following probability:

$$P_{i,j} = \frac{(\tau_{i,j})^{\alpha} \,.\, (\eta_{i,j})^{\beta}}{\Sigma_{(i,k)\in C} (\tau_{i,k})^{\alpha} \,.\, (\eta_{i,k})^{\beta}} \quad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

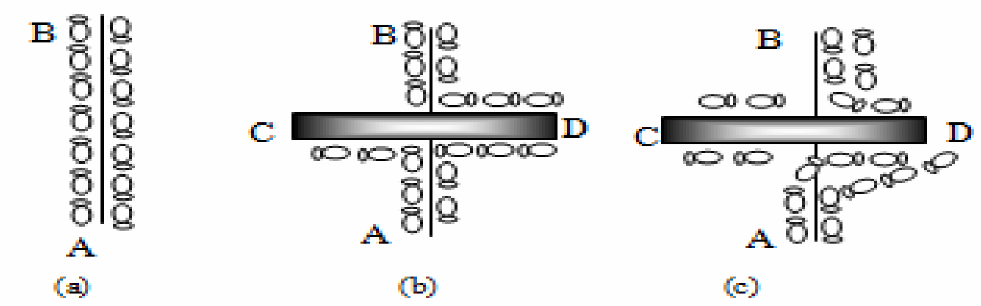


FIg : Behaviour of the Ants for searching the food

where,

- $\tau_{i,j}$: is the pheromone intensity on path
- $\eta_{i,j}$: is the ant's visibility field on path (i, j)
(an ant assumes that there is food at the end of this path).
- α and β : are the parameters which control the relative importance of the pheromone intensity compared to ant's visibility field.
- C: represents the set of possible paths starting from point i
((i,k) is a path of C).

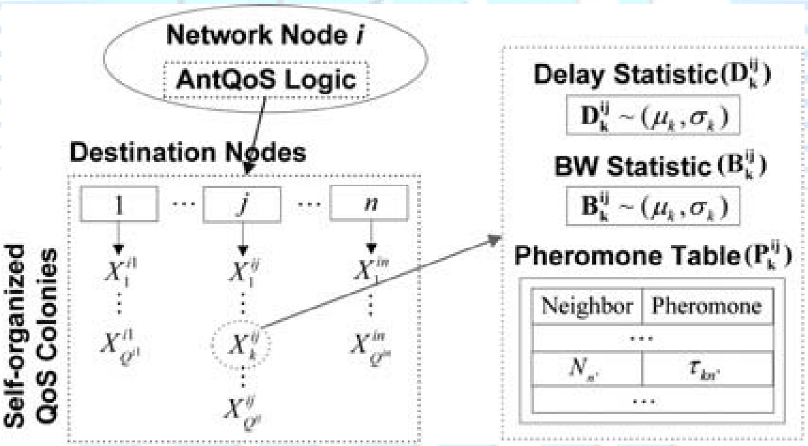


FIG : AntQoS logic in node for the self-organizing QoS

This figure illustrates the AntQoS logic in node Ni for the self organizing QoS. The logic is composed of a proper number of QoS colonies X . $Xijk$ is the k-th ($k = 1, \cdot\cdot\cdot ,Qij$, where Qij is the number of organized QoS) organized virtual sub colony which contains three data structures: 1) the end-to-end delay statistic $Dijk$ with sample mean μdk and variance σdk estimated over measured delays by artificial ants from Ni to Nj ($Ni \neq Nj, Nj \in V$, where V is the vertex set in a network), 2) the remaining bandwidth statistic $Bijk$ with sample mean μbk and variance σbk estimated over measured remaining bandwidths, and 3) the pheromone table $Pijk$ with the pheromone trails $\tau kn'$ (Nn' $\in \{Ni\}$, where $\{Ni\}$ is the set of neighbors of Ni) indicating the learned desirability moving to neighbor Nn' .

4.2 OLSR Routing Protocol

The Optimized Link State Routing Protocol (OLSR) [3] is a proactive routing protocol. It is introduced by the IETF MANET working group for mobile ad-hoc networks for accuracy and stability. OLSR protocol is the enhanced version of pure link state routing protocol that chooses the optimal path during a flooding process for route setup and route maintenance.

In OLSR, only symmetric links are used for route setup process. The key concept here is the selection of Multipoint Relays (MPR) among one-hop neighbors such that they cover all two-hop neighbors. The 'Hello Message' should be small in size to minimize the overhead. All the nodes are informed about the subset of all the available links and the link between MPR and MPR selectors.

Every participating node maintains the topological information about the network. This is done by a Topology Control (TC) message. A node generates TC message to only for those neighbors in its MPR selector set after a time interval. Each node in the network also maintains a routing table to all known destinations in the network.
Routing table is calculated from Topological Table, taking the connected pairs. The routing table contains Destination address, Next Hop address and Distance. This routing table is recalculated after every change in neighborhood table or in topological table.

The perfect network context for OLSR is low mobile and dense Ad Hoc networks. OLSR overhead control signals do not require for a reliable transmission link, which is suitable for wireless networks. OLSR supports node's mobility as far as it is traceable by its neighbours.

4.3 Network Routing using ACO

Mobile adhoc network routing is a difficult problem because network characteristics such as traffic load and network topology may vary stochastically and in a time varying nature. The distributed nature of network routing is well matched by the multi agent nature of ACO algorithms. The given network can be represented as a construction graph where the vertices correspond to set of routers and the links correspond to the connectivity among routers in that network. Now network route finding problem is just finding a set of minimum cost path between nodes present in the corresponding graph representation which can be done easily by the ant algorithms.

4.4 General Characteristics of ACO algorithms for routing

The following set of core properties characterizes ACO instances for routing problems:
1)Providing traffic-adaptive and multipath routing.
2)Relying on both passive and active information monitoring and gathering.
3) Making use of stochastic components.
4) Not allowing local estimates to have global impact.
5) Setting up paths in a less selfish way than in pure shortest path schemes favoring load balancing.
6) Showing limited sensitivity to parameter settings[4].

This paper proposes a QoS routing algorithm.

The proposed approach has two phases namely path discovery phase and path maintenance phase. When a source node has to pass data to a destination node with QoS requirements it starts with the path discovery phase. Once the path is found,the data transfer will take place. While data transmission is going on, it is also required to maintain the path to the destination. This is very much desirable and required in mobile ad hoc networks and hence is done in the path maintenance phase.

4.5 Path Discovery Phase

STEP 1: Let the source node *S* has data to send destination *D* with QoS requirements higher transmission rate, less delay and more bandwidth. A list of nodes that are progressively visited by the ant is called visited nodes list. This list forms the route R from the source node to destination node.

STEP 2: Initially choose the source node S. The visited nodes list will be initialized to source node (S).

STEP3: S initiates a Path_Request_Ant to destination through all its neighbors which are in 1-hop distance from S. The Path_Request_Ant contains source address, destination address, hop count and bandwidth.

STEP 4: After that the pheromone evaporation of all the 1- hop distance nodes will be calculated. Each node *(i)* maintains a table called "PMtab" a table of Pheromones specifying the quantity of available pheromone on each link (V_i, V_j). This quantity is initialized to constant C.

STEP 5: Then we calculate the pheromone evaporation of all the 2-hop distance nodes.

STEP 6: At last we calculate the path preference probability value of each path from source S with the help of pheromone evaporation of every node.A node j from a set of adjacent nodes (j, k, …., n) of i is selected as MPR node such that it covers all the 2-hop distance nodes and its path preference probability is better than others.

STEP 7: If calculated path preference probability value is better than the requirements, the path is accepted and stored in memory.

STEP 8: When the Path_Request_Ant reaches the destination,it will be converted as path_Reply_Ant and forwarded towards the original source.The Path_Reply_Ant will take same path of corresponding Path_Response_Ant but in Reverse direction.

STEP 9: The path with higher path preference probabaility will be consider as the best path and data transmission can be consider as the best path.

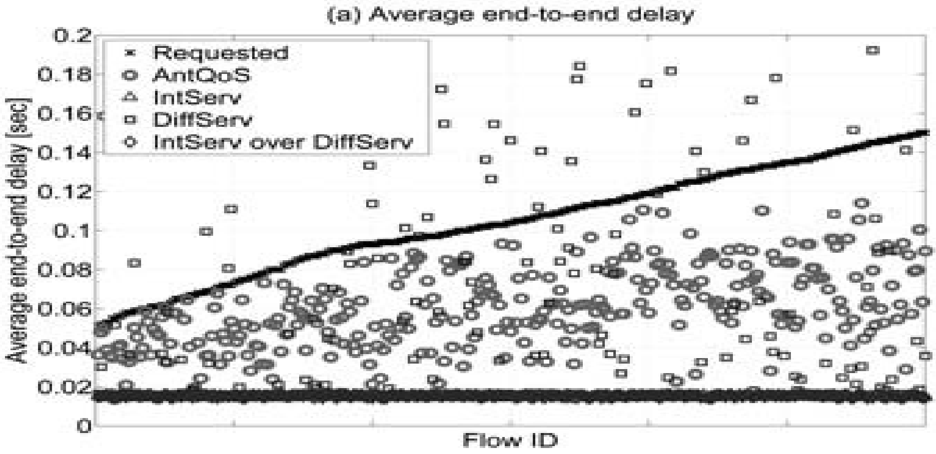
4.6 Path Maintenance Phase

When the data transmission is going on, the paths are reinforced positively making it more desirable for further selection. Also when session is going on, the load on the selected path may increase causing more delay and less available bandwidth; Nodes might have moved causing link failures.

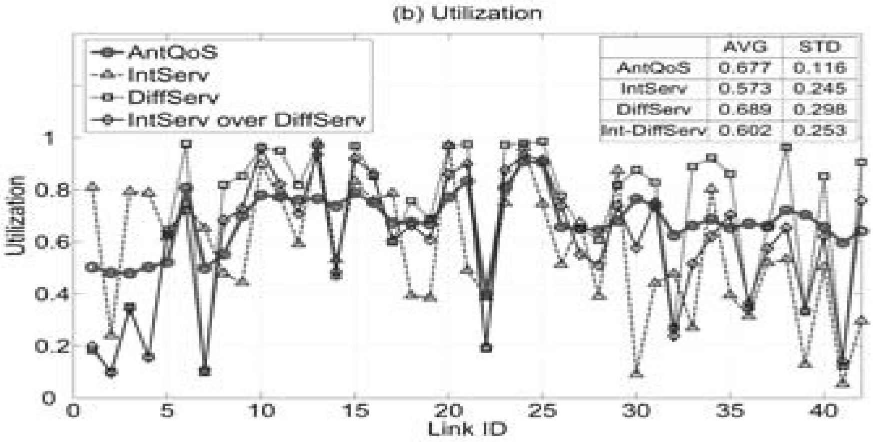
In such case, the path preference probability will automatically decrease and hence alternate routes can be used which are found during route discovery phase. The alternate routes are also periodically checked for their validity even though they are not currently used.

5. Performance Evaluation

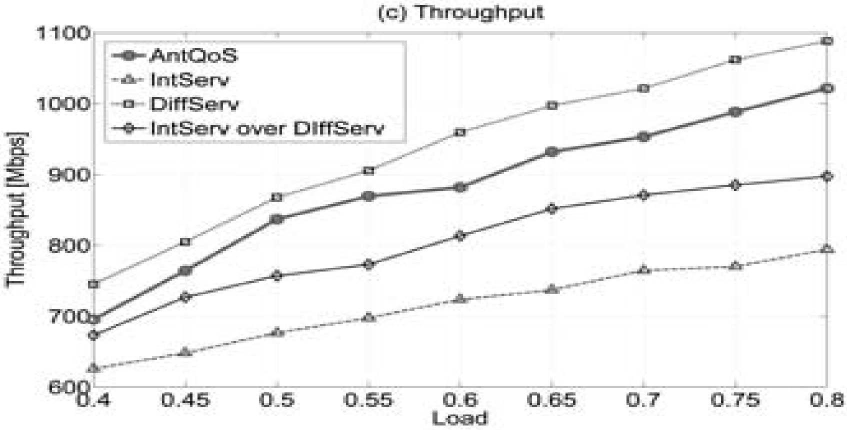
We evaluate the performance of AntQoS framework and compare it with that of DiffServ, IntServ, and IntServ over DiffServ (Int-Diff) frameworks,



FIGURE(a): Average end-to-end delay



FIGURE(b): Utilization of all links



FIGURE(c): Throughput according to the offered load.

When an ant searches for a route, it chooses probabilistically one node among its neighbour's nodes that are not visited yet. The routing probability value between V_i and V_j is computed by the composition of the strength of pheromone values (equation 5) and the visibility values.

$$P_{i,j} = \frac{[\tau(V_i, V_j)]^{\alpha} \cdot [\eta_{i,j}]^{\beta}}{\sum_{k \in M}[\tau(V_i, V_k)]^{\alpha} \cdot [\eta_{i,k}]^{\beta}} \quad \ldots\ldots\ (6)\ [2]$$

where:

- $\tau(V_i, V_j)$ is the amount of pheromone on the link (V_i, V_j).
- $\eta_{i,j}$ is the visibility of the link (V_i, V_j).
- α and β are two parameters that show the relative
- Significance of the pheromone and the visibility during the process of QoS route discovery.
- M: is the set of all possible neighbor nodes V_k, not visited yet by the ant.

6. Conclusion

This proposed routing strategy can be optimized to support multimedia communications in mobile ad hoc networks based on Ant Colony framework. The major complexity in mobile ad hoc network is to maintain the QoS features in the presence of dynamic topology, absence of centralized authority, time varying QoS Requirements etc. The challenges reside in ad hoc networks is to find a path between the communication end points satisfying user's QoS requirement which need to be maintain consistency. The algorithm consists of both reactive and proactive x components. In a reactive path setup phase, an option of multiple paths selection can be used to build the link between the source and destination during a data session.

For multimedia data to be sent, we need stable, failure-free paths and to achieve that the paths are continuously monitored and improved in a proactive way. Our previous work [8] also guaranteed QoS based proactive routing using flooding technique by best utilization of network resources.

This proposal is based on ant-like mobile agents to establish multiple stable paths between source and destination nodes. Ant agents are used to select multiple nodes and these nodes use ant agents to establish connectivity with intermediate nodes. In future, this work can be extended for multicasting by using swarm intelligence with other QoS objectives such as load balancing, energy conservation, etc.

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