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Emergent Intelligence Based QoS Routing in MANET

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Abstract

Mobile Ad hoc Networks (MANETs) are self-organized, infrastructureless, decentralized wireless networks consist of a group of heterogeneous mobile devices. Due to the inherent characteristics of MANETs, such as frequent change of topology, nodes mobility, resource scarcity, lack of central control, etc., makes QoS routing is the hardest task. QoS routing is the task of routing data packets from source to destination depending upon the QoS resource constraints, such as bandwidth, delay, packet loss rate, cost, etc. In this paper, we proposed a novel scheme of providing QoS routing in MANETs by using Emergent Intelligence (EI). The EI is a group intelligence, which is derived from the periodical interaction among a group of agents and nodes. We logically divide MANET into clusters by centrally located static agent, and in each cluster a mobile agent is deployed. The mobile agent interacts with the nodes, neighboring mobile agents and static agent for collection of QoS resource information, negotiations, finding secure and reliable nodes and finding an optimal QoS path from source to destination. Simulation and analytical results show that the effectiveness of the scheme.

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Keywords: Emergent Intelligence; MANET; Mobile and Static Agents; QoS Routing.

1. Introduction

While traditional wireless networks need central control, fixed infrastructure and essential requirements for their operation, in the Mobile Ad hoc NETworks (MANETs), can exist without having fixed infrastructure [1 2 3 4 5 6]. However the features of MANET leads to various issues such as mobility management, effective routing, power management, security and dynamic topology change, these affect the quality of service (QoS) experienced by the user. The QoS is the collection of guarantee parameters such as available bandwidth, end-to-end delay, error rate, packet loss rate, cost or hop count, etc. [5 7 8], and defines the network behaviour under certain conditions and

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agreements between source and destination. The frequent change of topology in MANET makes the QoS a predominant factor. Routing algorithms are usually finds the shortest paths in terms of distance or delay in delivering the data from source to destination. QoS based routing algorithm is proposed8 to find an optimal path for transferring data from source to destination which satisfies the QoS constraints. The goals of QoS routing are, the selection of an optimal QoS path that should satisfy the QoS resource requirements and an efficient resource utilization. Many of the existing works on QoS routing faces the problems like, sensing the network traffic fluctuations, analyzing the traffic status dynamically and quickly not possible and assigning an appropriate service and finding an optimal QoS path in time is difficult. In our work we use Emergent Intelligence (EI) technique to avoid these problems and to achieve above mentioned goals in MANETs dynamically with quick response. logo We propose EI based QoS routing in MANET, to find an optimal QoS path even under dynamic traffic conditions. We have divided MANET into clusters and in each cluster a mobile agent is deployed. The mobile agent takes the task of collecting available and required QoS resource, trust value assignment to nodes, and periodically communicates with nodes, neighboring mobile agents and static agent for finding QoS paths, negotiation and finding secure and reliable nodes.

The rest of the paper is arranged as follows, Section 2 gives some of the existing works; Section 3 describes some of the definitions; Section 3 discusses the proposed Emergent Intelligence based QoS routing in MANETs; simulation and analysis results are given in Section 4 and conclusions are drawn in Section 5.

2. Some of the existing works

Work in[1], developed a QoS routing protocol for MANET, proposed an algorithm which calculates the bandwidth on a path and builds the QoS path from a source to a destination with reserved bandwidth. Authors have proposed AntHocNet[2], a routing algorithm which is a combination of proactive and reactive behavior; have taken the ideas from Swarm Intelligence, i.e., ant colonies and ant colony optimization. The Work given in[3], has a QoS routing algorithm under insufficient information and probability concept is used to adapt inaccurate QoS parameters. They combined the AFS and TS to find an optimum QoS multicast tree with the maximum probability of satisfying multiple QoS constraints under the given cost. In[9], proposed an agent-assisted QoS-based routing algorithm for wireless sensor networks. They have computed the synthetic QoS of WSNs using the different QoS metrics for Particle Swarm Optimization (PSO) algorithm to improve overall network performance.

3. Definitions

In this section we describe some of the definitions which are used in our work.

a) Agents: Represent the autonomous execution and context oriented reasoning, which are classified as static and mobile agents based on mobility in the heterogeneous network. [1] Mobile Agent: Periodically roams to multiple locations in the network, it executes the process on behalf of the user (i.e., collecting, delivering, on spot decision taking, etc.). [2] Static Agent: An immovable and embedded into the client computer or server. It communicates by using remote procedure calling or messaging.
b) Emergent Intelligence (EI): It is an intelligence process to solve the problems with the help of group of agents and nodes. This scheme dynamically monitors behavior and abnormalities of entities in the group and provides the information to the respective agents during interaction to take decisions and which will be used later for sharing with other agents.

4. Proposed EI based QoS Routing in MANET

The scheme deploys a static agent (SA) on the centrally located node which has rich resources and divides the MANET into clusters as shown in Figure 1 (a) by using coordinate or logical zone formation method[10]. The SA creates and dispatches a MA to each cluster and it sets up the path from source to destination depending upon the resource information provided by the MAs. As MA progresses, by using EI it forms a group of neighbor nodes as shown in Figure 1, and they periodically interact with each other. During interactions they all share their resource information, neighbor nodes feedback, etc.

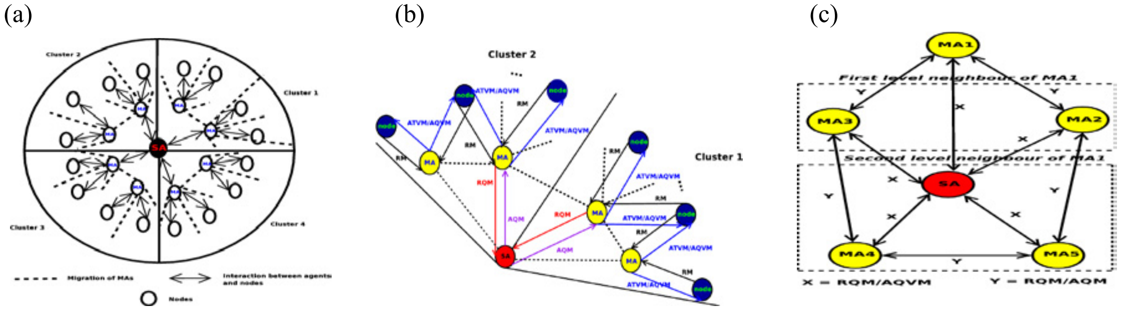

Figure 1. (a) MANET scenario with cluster; (b) Emergent Intelligence among MA, nodes and SA in the cluster; (c) Emergent Intelligence between MAs and SA.

By using these information the MA selects a node which satisfies QoS requirements given by the source node. This process continues till the destination node is found and all these selected nodes form an optimal QoS path from source to destination. Depending upon resource information given by the neighbor nodes, the MA computes the trust value and assigns to them. Each node shares the information to the MA such as Residual and Total memory (RM and TM), Computational Power (CP), Transmitter Power (TP), Total power of node (TN), Packet loss (PL) and Feedback about its neighbor nodes(F_{nb}^{i}). The i^{th} node feedback is computed by using the following equation.

$$F_{nb}^{i} = \frac{\sum_{k=1}^{N} F_k}{N} \quad (1)$$

Where F_k is the k^{th} node feedback and contains the information about number of packets received and acknowledged in the past history, and N is the total number of i^{th} neighbor nodes. The value of F_i^{nb} is given as $F_i^{nb} = \begin{cases} 1; if\ F_i^{nb} \geq 0.5 \\ 0; \quad otherwise \end{cases}$
and the MA computes the trust value of the i^{th} node, TV_i, is given by

$$TV_i = \frac{\left(\frac{RM}{TM}\right) + \left(\frac{TP+CP}{TN}\right)}{2 - \alpha * PL} * F_{nb}^{i} \quad (2)$$

Where PL is packet loss and $\alpha = \begin{cases} 0; if\ PL = 0 \\ 1; otherwise \end{cases}$.
The trust value of a node indicates the reliability of a node and it identifies the nodes which are suitable for reliable routing. These reliable nodes help to choose an alternative path for successful routing the packets from source to destination. This process continues till the boundary node of a cluster is reached. The periodical interactions between MA and nodes in groups make updating of the QoS resource information and trust value. The MA of a cluster provides the Bandwidth available, Available number of reliable nodes, Cost of links, Delay involved with nodes and links, Resources of nodes, etc., to the SA during interaction and it stores in its database. In our work we have considered the following QoS parameters and their mathematical representations are as follows:
1. Bandwidth Available: The residual or unused bandwidth of the link is BW(m, n). The minimum available or unused bandwidth at any link along the path given source s and destination d and is given by, $BW(P) = min\{BW(path)\}$,Where $P = s \rightarrow i \rightarrow \ldots \rightarrow d$ and $path = \{(s, i), (i, j), \ldots, (t, d)\}$.
2. Delay: It is the total sum of transmitting, receiving, propagation, processing and forwarding delay on all the links on P and source node (s) delay and is given by $Delay(P) = \sum_{i \in path} Delay(i) + Delay(s)$.
3. Packet Loss rate: It is the loss of a path and is given as, $loss(P) = 1 - \prod_{i \in path}(1 - loss(i))$.
4. Cost: It is the number of hops from source to destination and is given as,$Cost(P) = \sum_{i \in path} Cost(i)$.
Different applications and services need different QoS requirement. The source node computes the required QoS, such as BW_{req} ,D_{req} ,C_{req} and PL_{req} are required bandwidth, delay, cost and packet loss, respectively. These requirements are the constraints for the establishment of the optimal QoS path from source to destination and are given as follows: 1. Bandwidth constrained: $BW(P) \geq BW_{req}$; 2. Delay constrained: $Delay(P) \leq D_{req}$; 3. Loss constrained: $loss(P) \leq PL_{req}$; 4. Cost constrained: $Cost(P) \leq C_{req}$;

5. TV of nodes on a path P. The optimal QoS path is a multiplicative function of the above QoS parameters and is given by

$$Optimal\ QoS = BW(P) * Delay(P) * loss(P) * Cost(P) * \frac{\sum_{j=1}^{n} TV_i^j}{n} \quad (3)$$

Where n is the total number of nodes in the source to destination path i. Whenever a node wants to send data to destination, it computes these required QoS resource information and provides to the MA. The MA finds an optimal QoS path from source to destination by using EI technique. The EI is very much suitable for providing sufficient resource required, suspending an unimportant application, providing an alternative path, etc. It derives the group intelligence from the periodical interaction among MA, SA and nodes. Following are the message formats used for interaction between agents and nodes.

1. Resource Message (RM)=$< SN, SA, MA, Info >$, Where SN: Sequence number, SA: Source address of nodes in a group, MA: MA address in a group and Info: Contains nodes and paths QoS resource information and neighbor nodes (NNs) feedback.
2. Agent Trust Value Message (ATVM)=$< SN, SA, NA, Info >$, Where SN: Sequence number, SA: Source MA address, NA: NNs address in a group and Info: Contains the trust value of NNs in a group.
3. Agent QoS Value Message (AQVM)=$< SN, SA, NA, Info >$, Where SN: Sequence number, SA: Source MA address, NA: NNs or MAs address in a group and Info: Contains the available and required QoS data and paths.
4. Required QoS Message (RQM)=$< SN, SA, NA, Info >$, Where SN: Sequence number, SA: Source MA or SA address, NA: SA or Neighborhood MAs address and Info: Contains the required QoS and cluster resource data.
5. Available QoS Message (AQM)=$< SN, SA, MA, Info >$,Where SN: Sequence number of AQM, SA: SA address, MA: Source MA address and Info: Contains the available QoS information and optimal QoS paths.

Whenever a node wants to send data (is called source node) to a destination, it computes the required QoS resources, such as BW_{req}, D_{req}, PL_{req}, C_{req}, etc., and shares with the MA during interaction by using RM as shown in Figure 1 (b). The MA forms a group, which consists of a collection of all neighbor nodes, it interacts and assigns TV to them by using ATVM and selects a node which satisfies the QoS requirements given by source node by using AQVM. The MA migrates to the next node in the same cluster and performs the same functions till the destination or a boundary node of the cluster is reached. The selected node makes an optimal QoS path from source to destination node in the cluster. If the destination node is not available in the same cluster (say cluster1), MA1 gets the destination node cluster information from the SA as shown in Figure 1 (c) and it forms a group, consists ofMA2 and MA3. TheMA1 interacts periodically and also, as and when required with them by using RQM. During interactions, they share information, such as optimal QoS path from source to destination, cluster information, etc., by using AQVM. TheMA1 selects an optimal QoS path from the source to the destination node depending upon the required QoS. If neighbor MAs have no information about the destination node, then each of the 1^{st} level neighbor MAs (MA2 and MA3) form a group, consists of their neighbor MAs as shown in Figure 1 (c). They interact with their neighbor MAs and shares information, and select an optimal QoS path and provides to their respective MAs, and then 1^{st} level neighbor MA provides information to the MA1. The MA1 selects an optimal QoS path among the paths given by the neighbor MAs based on the QoS constraints provided by the source node.

During the failure of nodes on the selected optimal QoS path, the MA takes feedback from their (failure node's) neighbor nodes for providing an alternate path in the network. If the MA fails, then SA creates another MA and provides an alternate path by using the information available in it. If SA itself fails, then a node having rich resource becomes the SA and logically divides the MANET into clusters. Hence, finding an optimal QoS path for routing from source to the destination node problem in the MANET is solved by using EI. Algorithm 1, given below provides the QoS resource information collection and TV assignment in each cluster and Algorithm 2, given below provides the EI based QoS (EI-QoS) Routing scheme for MANETs.

5. Simulation Results

The proposed scheme is simulated by using NS2. For the simulation we have used the AODV routing protocol, 600 nodes with mobility 20 m/sec and 50 m communication range of each and simulation is run for 900 sec.

Algorithm 1 QoS resource information collection and TV assignment in a cluster

1: Begin
2: Let n be number of cluster, nb be number of neighbor nodes and BN be boundary node
3: Let N be the node in which mobile agent runs; S be the source node; and D be the destination node
4: **for** cluster i = 1 to n **do**
5: SA creates and deploys MA_i at i^{th} cluster
6: **end for**
7: **for** cluster i = 1 to n **do**
8: **if** N $\neq$ BN_i **then**
9: MA_i at node N forms a group, which consists of nb
10: **for** j = 1 to nb **do**
11: MA_i collects QoS resource info and node resource info; computes and assigns TV to j^{th} node of $cluster_i$
12: **end for**
13: MA_i sends all QoS info of group to SA and migrates to next node in $cluster_i$
14: N = next node
15: **end if**
16: **end for**
17: End

Algorithm 2 EI based QoS Routing for MANETs

1: Begin
2: Let feasible path fp = 0, temp = 0; QoS resource info collection and TV assignment is done using Algo. 1;
3: S request an application or data destined to D; S computes BW_{req}, D_{req}, PL_{req}, C_{req} and sends to MA;
4: **if** N$\neq$D and N$\neq$BN **then**
5: MA forms group, generates and broadcasts RQM;
6: Group of node responds by sending RM, which contains QoS parameters;
7: MA migrates to the next node in the same cluster and N = next node;
8: **end if**
9: **if** D is in the same cluster **then**
10: MA gathers QoS parameters of all available path (AP) to D
11: **for** k = 1 to AP **do**
12: **if** QoS constraints satisfies for a path **then**
13: Computes optimal QoS path by using Eq.3; **fp=fp+1**;
14: **end if**
15: **end for**
16: MA chooses one feasible path among them and communicates it to the source;
17: **else**
18: **if** temp $\neq$ 0 **then**
19: end
20: **else**
21: MA informs BW_{req}, D_{req}, PL_{req}, C_{req} of S to SA; SA forms group, which consists of all MA;
22: **for** i = 1 to n-1 **do**
23: temp = 1; Go to step 4
24: **end for**
25: **end if**
26: **end if**
27: End

For the performance measuring of our proposed scheme, we have considered three metrics such as end to end packet delay, throughput and packet loss rate. From Figure 2 (a), we can find that the QoS-EI algorithm2 reduces 10% to 50%end to end packet delay as compared to QoS without EI, to improve the performance with the number of nodes increasing. EI is more efficient to work in the situation where more number of nodes will be there; it makes the group and infers the intelligence of the group during the communication between them.

(a) (b) (c)

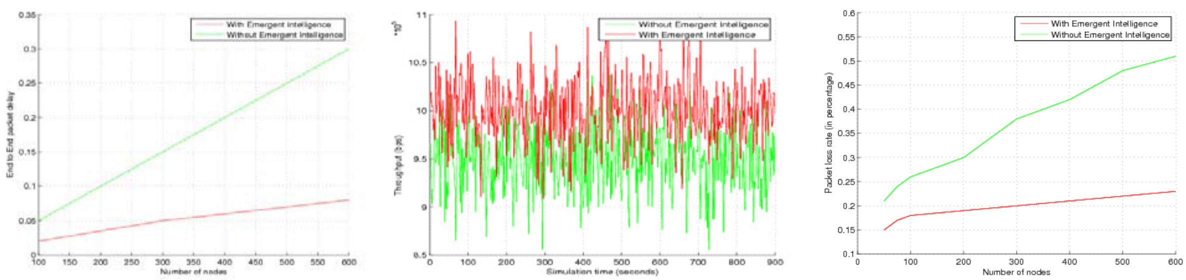

Figure 2. (a)Number of nodes vs End to end packet delay ; (b) Simulation time vs Throughput; (c) Number of nodes vs Packet loss rate.

From Figure 2 (b), we can find that the performance of the proposed QoS-EI increases the throughput as compared to QoS without EI. Due to the EI, makes the concurrent communication in a group result in more effective, especially in the large number of nodes. The performance measure of the proposed QoS-EI makes 5% to 50% reduction of packet loss rate as compare to QoS without EI as shown in Figure 2 (c). With the increasing of number of nodes result in minimum reduction of packet loss rate and hence it is more flexible. From Figure 3 (a) and (b), we can find that the analytical and simulation performance of the proposed QoS-EI end to end packet delay and packet loss, respectively. EI-QoS algorithm makes very less variation of end to end delay and packet loss as we increase the number of nodes in the MANET and it shows that simulation results are very close with the analytical results. Figure 3 (c) shows that the performance of the QoS metrics with the time, equation 3 used to find the QoS path by considering bandwidth, loss, delay, cost and trust value of nodes on the path from source to destination. The proposed QoS-EI algorithm maintains the minimum QoS is above 68% and it is shown by simulation and analysis in Figure 3 (c). Hence, by using proposed scheme improves the metrics and results into the more effectiveness. The performance measure such as end to end delay, packet loss, throughput and QoS results obtained by proposed EI-QoS scheme shows more effective, efficient and improved as compared to the results obtained by authors in[9].

(a) (b) (c)

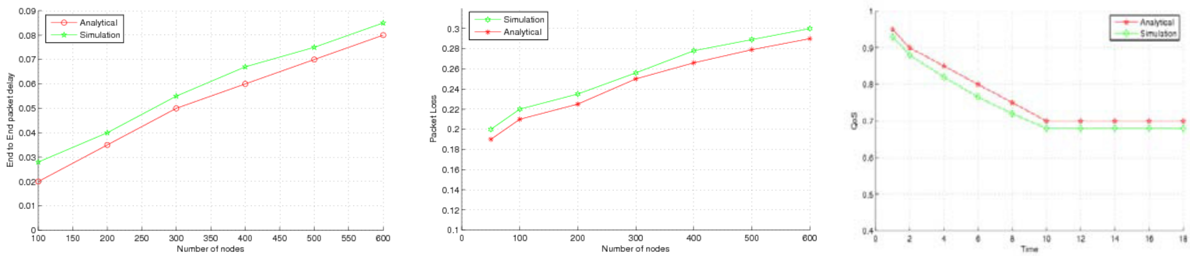

Figure 3. (a) Number of nodes vs End to end packet delay; (b) Number of nodes vs Packet loss; (c) Time vs QoS.

6. Conclusion

The proposed scheme focus on finding an optimal QoS route from source to destination by using Emergent Intelligence technique. The scheme exploits the functionalities of Emergent Intelligence in the agents; the trust value and reliability of the node resources; multi-QoS constraints, such as bandwidth, delay, packet loss rate and cost required for application for finding an optimal QoS path. Results obtained in the simulation and analytical show that our proposed scheme quickly finds the feasible QoS paths from source to destination. Finally, compared the proposed results with the results obtained by the authors in[9] and it obviously shows its improvement in the quality of service in MANET including end to end delay, packet loss, and QoS.

7. References

1. Zhu, C., Corson, M.S.. Qos routing for mobile ad hoc networks. In: *INFOCOM 2002. Twenty-First Annual Joint Conference of the IEEE Computer and Communications Societies. Proceedings. IEEE*; vol. 2. IEEE; 2002, p. 958–967.
2. Di Caro, G., Ducatelle, F., Gambardella, L.M.. Swarm intelligence for routing in mobile ad hoc networks. In: *Proceedings of the IEEE Swarm Intelligence Symposium*. 2005, p. 76–83.
3. Wang, J., Wang, X., Huang, M.. Tabu artificial fish swarm algorithm based intelligent qos multicast routing algorithm. In: *Computational Intelligence and Security, 2008. CIS'08. International Conference on*; vol. 1. IEEE; 2008, p. 56–60.
4. Liu, Z., Kwiatkowska, M.Z., Constantinou, C.. A biologically inspired qos routing algorithm for mobile ad hoc networks. In: *Advanced Information Networking and Applications, 2005. AINA 2005. 19th International Conference on*; vol. 1. IEEE; 2005, p. 426–431.
5. Delavar, A.G., Hoseyny, S., Maghsoudi, R.. Bco-based optimized heuristic strategies for qos routing. *The Journal of Mathematics and Computer Science* 2012;5(2):105–114.
6. Chakrabarti, S., Mishra, A.. Quality of service challenges for wireless mobile ad hoc networks. *Wireless Communications and Mobile Computing* 2004;4(2):129–153.
7. Chen, S., Nahrstedt, K.. Distributed quality-of-service routing in ad hoc networks. *Selected Areas in Communications, IEEE Journal on* 1999;17(8):1488–1505.
8. Jawhar, I., Wu, J.. Quality of service routing in mobile ad hoc networks. In: *Resource Management in Wireless Networking*. Springer; 2005, p. 365–400.
9. Liu, M., Xu, S., Sun, S.. An agent-assisted qos-based routing algorithm for wireless sensor networks. *Journal of Network and Computer Applications* 2012;35(1):29–36.
10. Keerthi, T.D.S., Venkataram, P.. Locating the attacker of wormhole attack by using the honeypot. In: *Trust, Security and Privacy in Computing and Communications (TrustCom), 2012 IEEE 11th International Conference on*. IEEE; 2012, p. 1175–1180.