[InnoSpace-2017: Special Edition]

Volume 4, Issue 1, January 2017, pp. 52-60 ISSN (O): 2349-7084

International Journal of Computer Engineering In Research Trends

Available online at: www.ijcert.org

Link quality based Ant based Routing Algorithm (LARA) in MANETs

C.V.Anchugam[1], Dr.K.Thangadurai[2]

[1]Ph.D Research Scholar,
[2]Assistant Professor and Head,
P.G. and Research Department of computer Science,
Government Arts College (Autonomous), Karur-639005, Tamilnadu, INDIA
Email_ID: anchugam.mca@gmail.com, ktramprasad04@gmail.com

Abstract:-Recently a new method is developed to handle the problem of routing in ad hoc network and overcomes the shortcomings of the classical methods; these methods are based on swarm intelligence inspired from biological swarms, such as ants in order to solve some complex problems such as finding food or optimizing route to food in real insect swarms. One of the most known routing algorithms for MANETs, as described Ant based Routing Algorithm (ARA) suffers from some limitations within the pheromone computing since it has not taken the necessary consideration to the characteristics of MANETs such as mobility and the medium constraint. Therefore, in our proposed enhancement to ARA called Link quality based ARA (LARA), it can be included the link quality in route selection and probability computing which have considerably improved the network performance and the system lifetime.

Keywords: MANETs, LARA, Routing, Link quality, Swarm Intelligence, Cross-layer.

1. Introduction

An ad hoc network characteristically refers to some set of networks where all devices have equal status on a network and are free to connect with some other ad hoc network devices in link range. Instead, each node participates in routing by transferring data for other nodes, and so the purpose of which nodes transfer data is made dynamically based on the network connectivity. Nodes are free to move around randomly. An ad hoc network uses no centralized administration. Nodes in the ad hoc network are often mobile, but can also consist of stationary nodes, such as access points to the internet. Every node wishing to participate in an ad-hoc network must be willing to forward packets for other nodes. Thus every node acts both as a host and as a router.

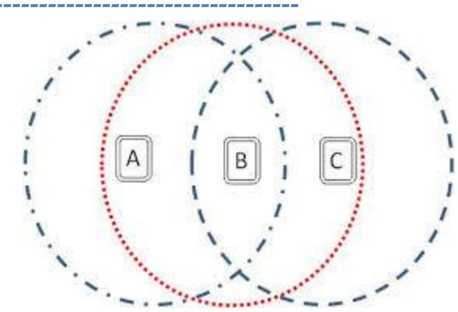


Figure 1. Example of a simple ad-hoc network with three participating nodes

Figure 1, shows a simple ad-hoc network three nodes. The outermost nodes don’t seem to be at intervals transmitter range of each other. However the middle node can be used to forward packets between the outermost nodes. The middle node is acting as a router and the three nodes have formed an ad hoc network.

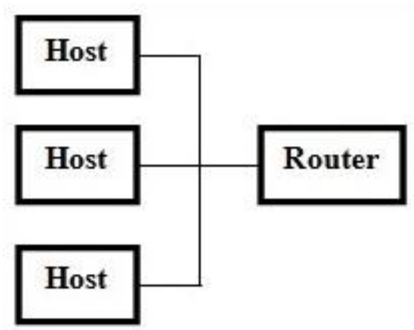


Figure 2: Block diagram of mobile node acting both as hosts and as router

A node can be viewed as an associate abstract entity consisting of a router and a set of affiliated mobile hosts figure 2. A router is an entity, which among other things runs a routing protocol. A mobile host is simply an IP-addressable host / entity in the traditional sense. Ad hoc networks do not rely on a pre-established infrastructure; therefore, they can be deployed in places with no fixed infrastructure wireless mobile ad hoc networks are best suited for conference meetings, lecturer, crowd control, search and rescue, disaster recovery, on-the-fly conferencing applications, networking intelligent devices and automated battlefields.

A Mobile Ad hoc Networks (MANETs) is a collection of communication devices or nodes, that which to communicate without any fired infrastructure and pre-determined organization of available links. Mobile nodes collaborate between themselves for creating and maintaining the connectivity in the networks. Mobile nodes can form unpredictable networks "on the fly" to exchange information without the need of pre-existing network infrastructure.

The used spectrum for wireless transmissions is the spectrum situated around the 2.4 GHz ISM (Industrial, Scientific and Medical), and around the 5 GHz U-NII (Unlicensed-National Information Infrastructure). The transmission range and the emission power are regulated by laws in each country depending on the location where the network is deployed (indoor or outdoor), ranging from 10 m for Personal Area Networks (PAN) to 100-200 m for Local Area Networks (LAN) [1]. Typically MANETs are costless, too easy for use and deployment, which gives them lot of fields of use every day ranging from military applications for connecting soldier in battlefields to civilian or commercial applications such as Public and Personal Area Networks as well as sensor networks for monitoring or surveillance [12].

2. Routing Protocols In MANETS

An ad hoc network consists of a number of handled devices which communicate to each other over wireless channel without any centralized control, or infrastructure. Thus, the network topology may change rapidly and unpredictably, therefore no dedicated node can be defined to perform routing in MANETs. Hence, mobile nodes must collaborate between themselves to perform routing and dynamically establish routes. Thus, any mobile node in an ad hoc network plays two roles, the first one as an ordinary node and the second one as a router in order to participate in the routing process by executing routing algorithms [22]. Therefore, the conventional routing protocols cannot be used for MANETs [4].

Due to all these constraints, lot of routing protocols were defined for ad hoc networks, according to the strategy and the method of routing we can differentiate four categories: Proactive (Table-driven) protocols(e.g: OLSR (Optimized Link State Routing) [11], WRP (Wireless Routing Protocol) [24] and DSDV (Destination Sequenced Distance Vector routing protocol) [21]), Reactive (On-demand) protocols(e.g: AODV (Ad hoc On-demand Distance Vector routing)[20], TORA (Temporally-Ordered Routing Algorithm routing protocol) [19], ARA (Ant-based Routing Algorithm for Mobile Ad-Hoc Networks) [17]), Hierarchical protocols (e.g: ZRP (Zone Routing Protocol) [27], CBRP (Cluster Based Routing Protocol) [13], GSR (Global State Routing protocol) [10] and HARP (Hybrid Ad Hoc Routing Protocol) [18]), Geographical protocols (e.g: DREAM (Distance Routing Effect Algorithm for Mobility) [2], GLS (Geographic Location Service) [14], LAR (Location-Aided Routing protocol) [16] and GPSAL (GPS Ant-Like Routing Algorithm) [5]).

3. Ant Colony Optimization (ACO)

Swarm Intelligence (SI) concept is employed in work on artificial intelligence technique based on the study of collective behavior of great populations. SI based systems are fabricated of a population of simple agents interacting locally with each other as well as with their environment. Examples of such systems can be found in nature, including ant colonies, bird flocking, bee swarming, animal herding, bacteria molding and fish schooling [6].

SI routing algorithms are completely inspired from insect's communities; these communities have many desirable properties from the MANETs perspective, since they are collected of simple, autonomous, and cooperative organisms that are interdependent and collaborate to achieve smart universal objectives and define the universal behaviour of the community, while such individual has relatively little intelligence incompetent of understanding or modifying the community behaviour. Individuals of such community always execute simple actions and the methods of collaboration and communication between these individuals (agents) is simple, however very often generates best solutions compared to the capacity of each individual [26].

In an ant colony for example, the swarm intelligence is achieved by using special form of communication between ants in order to find route to food or to the nest, since ants are very small insect in a big world however they always find their route [9]. Typically, this is done by deposing pheromone on the trail taken by each ant, a substance related to hormones produced by ants during movement, which other ants are able to sense. Ants are attracted by pheromone and therefore follow the exact trail to the nest or food [25]. Ants follow trails with higher pheromone concentration which often optimizes their route to food and leads to follow the shortest trail and causes a self-accelerated reaction with none centralized intervention.

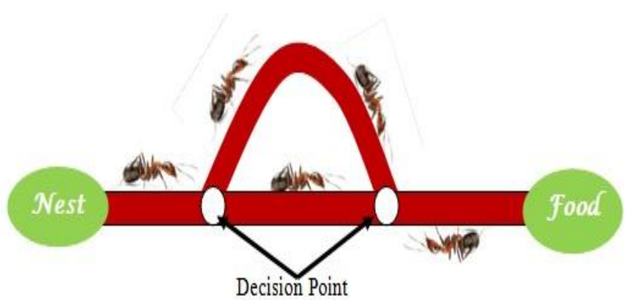


Figure 3. Real ant colony path shortening

Figure 3 shows scenario ants are start from their nest and walk in the direction of the food. When an ant reaches a meeting point, it has to decide which branch to take next. The first ant randomly follows one of the two branches. When coming back ants take another way to the nest and select one of the two branches, however after a while the concentration of pheromone will be more in the shortest branch and therefore ants follow the shortest path by mean of pheromone concentration. The behaviour of ants in order to find the shortest path from the nest to food can be used for routing optimization in MANETs, since an ant colony can be viewed as an ad hoc network composed of small devices and confronted to the same problem which is finding the shortest route in a decentralized fashion.

The reason behind choosing ACO for routing in MANETs is its distributed nature and the randomness of ant movement as well as the nature of the environment which is always constrained and unpredictable for ants. The algorithm used for optimization is a purely distributed executed by the collaboration of small agent with limited capacities and intelligent. This has lot of implications for MANETs, since in a MANETs nodes are constrained by power, storage and processing power, a purely distributed algorithm like ACO reduce computation load and message exchange which may reduce the network overhead and improve the routing service over ad hoc network.

3.1. ACO meta-heuristic for routing in MANETs:

In this section we are going to present a simple example of using ant colony optimization meta-heuristic for routing in order to find the shortest path between two nodes in MANETs, the specifications given in this section are the basis of any ant colony based routing algorithm for MANETs [8]. The following assumptions and notation are used:

- We consider a connected graph $G = (V,E)$, where $|V| = n$, n is the number of nodes in the network.
- Each two neighbours i and j are connected by an edge $e(i,j) \in E$ if they are in the transmission range of each other.
- We denote N_i the set of one hop neighbours of i.
- $\phi_{i,j}$, is the artificial pheromone deposed by ants corresponding to the edge $e(i,j)$ connecting i and j.
- Each ant when visiting an intermediate node in search of the shortest path deposits a constant amount of the artificial pheromone $\Delta\phi_{i,j}$.

$$\phi_{i,j} = \phi_{i,j} + \Delta\phi_{i,j}$$

- The artificial pheromone $\phi_{i,j}$ is used by the ant on node i to compute the probability of using j as next hop for routing using the following equation,

$$P_{i,j} = \begin{cases} \dfrac{\phi_{i,j}}{\sum_{j \in N_i} \phi_{i,j}} & j \in N_i \\ 0 & j \in N_i \end{cases}$$

----------- (1)

$$\sum_{j \in N_i} P_{i,j} = 1$$

- Artificial pheromone is decreased periodically using the following equation:

$$\phi_{i,j}(t+\theta) = (1-q)\phi_{i,j}(t), q \in (0,1)$$

----------- (2)

Assume that a node s wants to find a path to a destination d using the ant colony algorithm described above:

- The source node s launches the operation of finding route to d by sending artificial ants over the whole network.

- Each ant travels over the network and deposit artificial pheromone on each used edge until it arrives to the destination node.
- Routes are selected according to the probability computed using the existed pheromone on each link using equation (1), by choosing the route having the best probability.

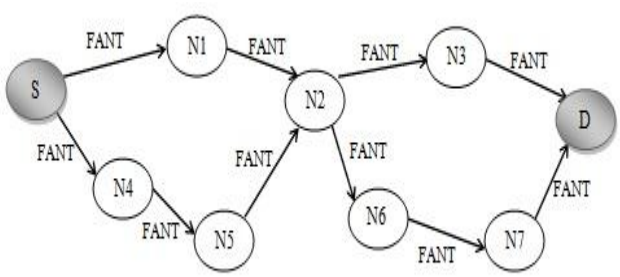
4. Ant Based Routing Algorithm (ARA)

Ant based Routing Algorithm (ARA) uses specific method and mechanisms developed for ad hoc network in order to handle path establishment and maintenance [8]. Typically, ARA routing management process is composed of:

- Route discovery in which the route is established using forward and backward ants
- Route maintenance phase in which the pheromone is updated according to equations (1) and (2)
- Finally an error handling phase in order to treat link failures

4.1. Route Discovery Phase

The objective of this phase is finding a route between a source node *s* and a destination node *d* (Figure 4). Two classes of ants exist for this purpose; the first one is called Forward ANT (FANT) which is defusing over the whole network in order to find all possible routes to *d*. Thus FANT travel between full network and update pheromone on every visited node using equation (1) until it arrives to destination node *d*, at each time the FANT is received by an intermediate node, this last create a record in its pheromone table if it does not exist or increase the existed pheromone with $\Delta\phi_{i,j}$. In the other hand the Backward ANT (BANT) establish the final route to the source node *s*, like the pheromone is increased by FANT and BANT and according the time will be decreased.



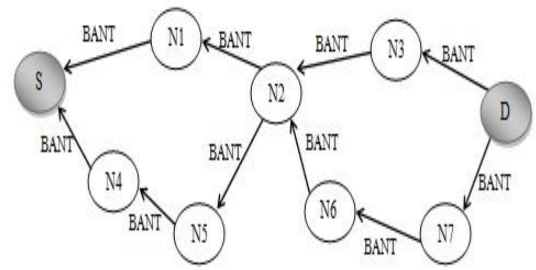


Figure 4: FANT and BANT in ARA

Pheromone table structure:

The pheromone table is similar to the routing table in classical routing, except that for the pheromone table is stored information corresponding to only one hop neighbours. This table is updated using forward and backward ants. Whenever the forward ant visits an intermediate node for the first time an entry is created containing:

- The identifier of the source node which has initiated the route discovery.
- The identifier of the next hop used to reach the destination node.
- The initial value of the pheromone, which is the same for all new created entries.
- The pheromone table is updated using two ways:
  - The first way using forward and backward ants, since at each visit of these ants the pheromone is increased with a fixed amount such as in real systems.
  - Periodically, the value of pheromone is decreased according to time in order to emulate the biological pheromone which loses concentration due to time.

4.2. Route Maintenance and Error Handling

Route maintenance operation is responsible of maintaining routes during communication, by updating the pheromone tables as delineated above and managing link errors if they exist. Link errors are caused by node mobility and detected by the MAC layer. The MAC layer decide that a link is lost if it does not receive acknowledgement for data packets once a predefined range of makes an attempts. If this case appears this node is dropped from the pheromone table then the corresponding node tries to search out an alternative route in his table to be used as next hop in place of the primary one and continue the information forwarding, otherwise an error message is sent to the source node in order to launch new route discovery mechanism.

5. Link Quality Based ARA (LARA)

As devoted above ARA suffers from some design limitations, since it do not gives the necessary consideration to the ad hoc networks uniqueness in the method of pheromone update and route selection. Hence, in this section we are going to improve the ARA by defining a new mechanism of pheromone computing which includes some of the most important characteristics of ad hoc network which are the link quality and the devices' constraints. Link quality is the most promise parameters, since it define the ability of a given link and devices to support the density of the traffic for the period of connection. The link state between two neighbours can be affected by lot of parameters such as distance, battery power and mobility [23]. Thus, in the next sections we are going to define a method for link state evaluation using cross-layer design between the physical layer and the network layer, used for pheromone update. The second parameter used in route selection will be the number of connections over the same path, in order to choose paths with fewer connections (traffic) as route in order to save resources of intermediate nodes over this path by distributing the network traffic over other nodes of the network which increases the system lifetime as well as end to end delay.

5.1. Link Quality Evaluation:

We define link quality between two neighbours as the ability of this link to be as long as possible stable, have less bit errors and reach its destination with the maximum signal strength [7]. In literature link quality is usually evaluated according to the received signal strength, because the transmission power of the wireless medium is proportional to the link quality, since a signal with high strength is more stable and has less bit errors. Equation (3) gives the reception power P_r for a signal transmitted with power P_t at a distance d:

$$P_r = P_t X G_r X G_t X \frac{\lambda^2}{(4 X \pi X d)^2} \quad \text{----- ---------} \ (3)$$

Where, P_r - received power, P_t - transmitted power, G_t - antenna gain of the transmitter, G_r -antenna gain of the receiver, λ – wavelength, d – distance. From the equation (3) evaluating the link quality according to the received signal strength can be descriptive for other network reasons such as:

- The battery power of nodes, this factor is very important since a node with less energy in its battery have small transmission range which affects the quality of links with its neighborhood; in the other hand it cannot forward data for long time. From equation (3) whenever the battery level is low the transmission power is also low and therefore the reception power is low, thus this link has not high quality.
- The distance and obstacles (walls), from equation (3) links quality or the reception power is relative to the distance and obstacle between nodes since whenever the distance and the obstacles increase, the link quality decreases.
- The mobility of nodes, the link between two nodes is directly affected by nodes' mobility in the way that the link quality decreases whenever neighbours are leaving away from each other and increases whenever they go closer.

5.2. Implementation of link quality evaluation:

As explained above, it has chosen to evaluate the link quality according to the received signal strength. In the other hand the received power can only be measured on the physical layer. Therefore, we need a cross-layer between the physical and the routing layers in order to transmit the value of the received signal strength from each neighbor to the routing layer. The implementation of the cross layer can be described as follow: Each node captures the entire packets exchanged within its neighborhood in order to take information about all its neighbours regarding the link quality. Thus, at each time a new packet is received the corresponding node creates a record containing the identifier of the sender and the received signal strength (Figure 5). This record is sent to the network layer and saved in pheromone table.

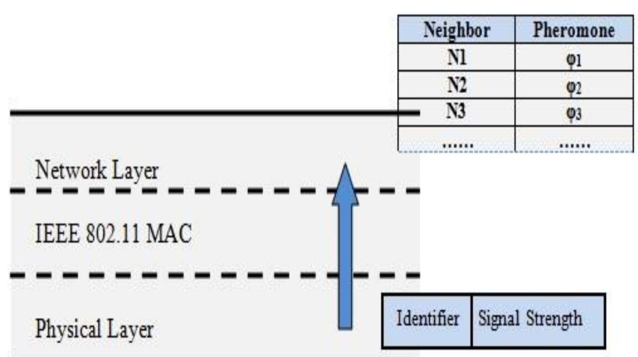


Figure 5. Link quality evaluation Cross-layer

Pheromone computing:

As said in previous sections, our proposed method to compute pheromone is based on the link state between neighbours, in the way that the greatest value is given to the best link. In the previous section, the proposed method for link state evaluation can be based on the received signal strength, which gives us the possibility to implicitly evaluate other network parameters such as the battery power and therefore the distance between nodes which may be concluded according to the signal strength. Thus, the pheromone value is given using the following equation

$$\phi_{i,j} = Pr_{i,j}$$

Where $Pr_{i,j}$ is the power level of the received signal from the edge (i,j). Using the value of $\phi_{i,j}$ it can be compute the probability of using this edge for routing according to the link quality factor using the following equation:

$$P_{lq} = \frac{\phi_{i,j}}{\sum_{j \in N_i} \phi i, j} \; j \in N_i \quad \text{---------------} \quad (3)$$

N_i is the set of all neighbor nodes of node i. It has been explained before, in classical or other algorithms the same path continues to be used until an anomaly occurs, otherwise all the traffic will be forwarded over the same path which consumes intermediate nodes' resources. Hence, proposed method to avoid such situation by including the connectivity factor to measure the number of connections forwarded by a link in pheromone computing. The connectivity factor is expressed by the probability of using the edge (i,j) according to the number of connection using the following equation :

$$P_{cn} = \frac{C_{i,j}}{\sum_{j \in N_i} C_{i,j}} \; j \in N_i \quad \text{---------------} \quad (4)$$

Where $C_{i,j}$, is the number of connection forwarded by the edge (i,j). Routes will be chosen according to the link quality as well as the number of connections over the same edge, therefore the final value of probability to use the edge (i,j) for routing is given by:

$$P_{i,j} = \frac{P_{cn(i,j)} + P_{lq(i,j)}}{2} \quad \text{---------------} \quad (5)$$

$$\sum_{j \in N_i} P_{i,j} = 1$$

Pheromone Update:

The operation of pheromone update is intended to change the value of pheromone for each neighbor according to some criteria such as time or some system parameters such as in our case the link quality, since the link quality change during the system lifetime and therefore the pheromone must be accordingly changed. In our proposed scheme the pheromone and similar to biological systems is decreased according to time, thus the amount of pheromone is decreased in regular intervals of time using the same equation given in literature:

$$\phi_{i,j}(t+\theta) = (1-q)\phi_{i,j}(t), \quad q \in (0,1)$$

In addition to time factor, the pheromone is increased or decreased according to the link quality with each neighbor. Thus, the pheromone is increased whenever the received signal strength increases for example when the corresponding neighbours move close to each other, or decreased whenever the corresponding nodes go far from each other or if they move in an area where there are some obstacles such as walls.

Route discovery

Similar to ARA, the route discovery mechanism is intended to find routes over the network, as well as updating pheromone table such as in swarm intelligence based routing. To accomplish the discovery and establishment of routes over the network, two classes of ants are defined which are forward and backward ants.

Forward ANT (FANT):

Forward ants are intended to discover routes; it is launched by the source nodes and broadcasted over the entire network until it arrive s to the destination node. During its trip over the network, the FANT causes pheromone update because the reception of FANT is the event which launches all kinds of pheromone update. The structure of the forward ant can be described as follow (Table 1), where:

- *Packet Type:* This field is one byte size; its value describes the purpose of the packet, data, FANT or BANT, in this case it is fixed to FANT.
- *Source IP Address:* This field is four bytes and describes the IP address of the source node.
- *Destination IP Address:* This field is four bytes and describes the IP address of the destination node.
- *IP list:* This field is an array of four bytes and contains the list of IP addresses followed by the FANT during its broadcasting over the network.
- *Pheromone list:* This field is an array of four bytes and contains the amount of pheromone carried by each link traversed by the FANT.
- *Sequence number:* this field is four bytes and contains a unique sequence number used to avoid route loops, similar to DSR.
- *Time-To-Live (TTL):* This field is one byte and describes the remaining allowed hop count for the FANT. It is fixed to 255 and decremented at each visited node.

Table 1. Forward ANT (FANT) packet structure

Packet Type	*Sequence Number*	*TTL*
Source IP		

Destination IP
IP List   .
Pheromone List   .

Backward ANT (BANT):

Backward ant is intended to establish the final route; it is launched by the destination and sent to the source node using unicast. Only, one BANT is sent to destination; across the route containing the greatest probability. Thus, whenever the destination node receives a set of FANTs it chooses the one having the greatest probability computed as described above and sends it back to the source node. The structure of BANT packet is similar to the FANT except that it does not contain the list of pheromone (Table 2), because it is not used by the source node:

- *Packet Type:* is fixed to BANT.
- *Source IP Address* contains the address of the destination node.
- *Destination IP Address* contains the address of the destination node.
- *Reversed IP list:* This field is an array of four bytes and contains the reversed list of the list retrieved from the FANT.
- *Time-To-Live (TTL)* is fixed to the length of the reversed list.

Table 2. Backward ANT (BANT) packet structure

Packet Type	*Sequence Number*	*TTL*
Source IP		
Destination IP		
IP List .		

5.3. Route Maintenance and Error handling:

The route maintenance is similar to the original ARA and no modifications are done. Hence, whenever a link between two neighbours fails included in the routing process, a route error packet is sent to the source node which launches a new route discovery as described above intended to establish a new path between the corresponding nodes. The route error packet structure is similar to ARA:

- *Error Source Address:* The address of the node originating the Route Error (node has discovered the link failure).
- *Error Destination Address:* The address of the node to which the Route Error must be delivered
- *Error Type field:* in our proposed is always set to NODE_UNREACHABLE.

6. Simulation Result Analysis

In order to test the performance of our proposed algorithm regarding the end to end delay and the system lifetime, we have compared link quality based ARA to AODV using NS2 simulation tool. Simulations have been performed within the network area of 670*670 m2 during 200s. Nodes move within this area with the speed of 20 m/s using four CBR connections. The pause time was set to 40s and the number of nodes was varied from 10 nodes to 40 nodes. As we have presented above the link quality based ARA does not use the same procedure as ARA, it combines some of the mechanisms of ARA and DSR. The simulation given in the following subsections does not use the parameter of the number of connections between each pair of nodes.

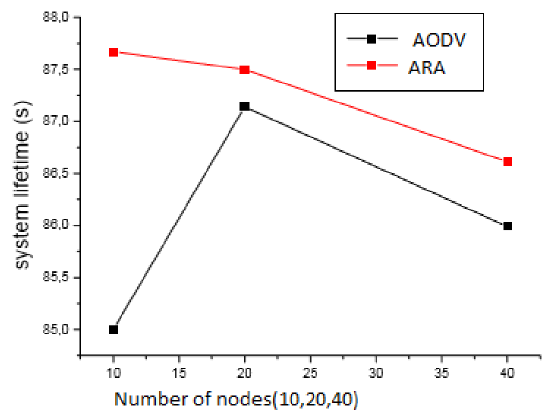


Figure 6. System lifetime according to the number of nodes

Figure 6 show the system lifetime according to the number of nodes which is set to 10, 20 and 40. As we can observe the system lifetime using link quality based ARA is always higher compared to AODV, since the network traffic using link quality based ARA follows paths with the highest link quality which distribute the network traffic and save the system resources.

7. Conclusion

In this paper we have investigated swarm intelligence based routing, this class of routing which is more promising in the nearer future by emerging new mechanisms and ideas. As devoted above, swarm intelligence is very suitable for ad hoc networks, regarding its distributed fashion to treat and resolve complex problems using analogy to biological swarm of insects. We have also presented ant routing algorithm, one of the most known routing algorithm for MANETs, as described ARA suffers from some limitations in the pheromone computing since it has not taken the necessary consideration to the characteristics of MANETs such as mobility and the medium constraint. Therefore, in our proposed enhancement to ARA called LARA we have included the link quality in route selection and probability computing which have considerably improved the network performance and the system lifetime. In the rest of this thesis we are going to treat the aspect of security in ad hoc and sensor networks by proposing a lightweight implementation of public key infrastructure in order to secure communication over these networks, next chapter gives a set of specifications for implementing a PKI over reactive routing protocols for mobile ad hoc networks.

8. References

[1]. Al Agha K., Pujolle G., Vivier G., "Reseaux de mobiles et reseaux sans fil", 2nd edition, Eyrolles, 2005.

[2]. Basagni S., Chlamtac I., Syrotiuk V. R., Woodward B. A., "A Distance Routing Effect Algorithm for Mobility (DREAM)", In Proceedings ACM/IEEE Mobicom, pages 76-84, October 1998.

[3]. Camp, T., Boleng, J., Williams, B., Wilcox, L., Navidi, W., "Performance comparison of two location based routing protocols for ad hoc networks", INFOCOM 2002, Twenty-First Annual joint conference of the IEEE Computer and Communications Societies, Proceedings, IEEE, Volume. 3, 2002, pp. 1678 –168.

[4]. Clausen T., Jacquet P., Viennot L., "Comparative Study of Routing Protocols for Mobile Ad hoc Networks", Med-Hoc-Net'02, Sardegna, Italy, September 2002.

[5]. Daniel Camara, Antonio Alfredo F. Loureiro, "A Novel Routing Algorithm for Hoc Networks", Baltzer Journal of Telecommunications Systems, 18:1-3, Kluwer Academic Publishers, 2001, pp. 85-100.

[6]. DiCaro G., Dorigo M., "Ant Colonies for Adaptive Routing in Packet-Switched Communications Networks", Proceedings PPSN V - Fifth International Conference on Parallel Problem Solving from Nature, Amsterdam, Holland, September 27-30, 1998, pp. 673-682.

[7]. Gerharz M.L, De Waal C., Frank M., Martini P., "Link Stability in Mobile Wireless Ad Hoc Networks", Proceedings of the 27th Annual IEEE Conference on Local Computer Networks (LCN), Tampa, Florida, November 2002.

[8]. Gunes M., Sorges U., Bouazisi I., "ARA - the Ant Colony Based routing Algorithm for MANETs", Proceedings ICPP Workshop on Ad hoc Networks, Vancouver, Canada, 2002, pp. 7985.

[9]. Heusse M., Snyers D., Guérin S., Kuntz P., "Adaptive agent-driven routing and load balancing in communication network", Proceedings ANTS'98,First International Workshop on Ant Colony Optimization, Brussels, Belgium, October 15-16, 1998.

[10]. Iwata A., Chiang C.-C., Pei G., Gerla M., Chen T.-W., "Scalable Routing Strategies for Ad Hoc Wireless Networks", IEEE Journal on Selected Areas in Communications, Special Issue on Ad-Hoc Networks, Aug. 1999, pp.1369-1379.

[11]. Jacquet, Paul Muhlethaler, Amir Qayyum, Anis Laouiti, Laurent Viennot, Thomas Clausen, "Optimized Link State Routing Protocol", Internet Draft, draft-ietf-manet-olsr-04.txt, work in progress, June 2001.

[12]. Jagannathan Sarangapani, "Wireless Ad Hoc and Sensor Networks Protocols", Performance, and Control", Taylor & Francis Group, LLC, 2007.

[13]. Jiang M., Li J., Tay Y. C., "Cluster Based Routing Protocol (CBRP)", Functional Specification Internet Draft, draft-ietf-manet-cbrp.txt, work in progress, June 1999.

[14]. Jinyang Li, John Janotti, Douglas S. J. De Coutu, David R. Karger, Robert Morris. "A Scalable Location Service for Geographic Ad Hoc Routing", M.I.T. Laboratory for Computer Science.

[15]. Johnson D., Maltz D., Y-C. Hu, Jetcheva J., "The Dynamic Source Routing Protocol for Mobile Ad Hoc Networks", Internet Draft, draft-ietf-manet-dsr-09.txt, work in progress, April 2003.

[16]. Ko Y.-B., V. N. H. "Location-Aided Routing in mobile Ad hoc networks", In Proceeding ACM/IEEE Mobicom, October 1998, pp. 66-75.

[17]. Mesut Gunes et. al, "ARA - the ant-colony based routing algorithm for MANETs", In Stephan Olariu, Proceedings of the 2002 ICPP Workshop on Ad Hoc Networks (IWAHN 2002), IEEE Computer Society Press, August 2002, pp. 79-85.

[18]. Navid Nikaein, Christian Bonnet, Neda Nikaein. "Hybrid Ad Hoc Routing Protocol – HARP", proceeding of IST 2001: International Symposium on Telecommunications.

[19]. Park V., Corson S., "TORA (Temporally-Ordered Routing Algorithm routing protocol)", Internet Draft, draft-IETF-MANET-TORA-spec- 03.txt, work in progress, June 2001.

[20]. Perkins C., Royer E., Das S., "Ad hoc On-demand Distance Vector (AODV) Routing", Internet Draft, draft-ietf-manet-aodv-11.txt, work in progress, Aug 2002.

[21]. Perkins C. E., Bhagwat P., "Highly Dynamic Destination-Sequenced Distance Vector (DSDV) for Mobile Computers", Proceedings of the SIGCOMM 1994 Conference on

Communications Architectures, Protocols and Applications, Aug 1994, pp 234-244.
[22]. Siva Ram Nurthy C., Manoj B.S., "Ad hoc wireless networks Architectures and Protocols", le Prentice Hall, 2004.
[23]. Sridhar K. N., Lillykutty J., Rajeev S., "Performance Evaluation and Enhancement of Link Stability Based Routing for MANETs", 1st International Workshop on Mobile and Wireless Networking (MWN 2004), Montreal, Quebec, Canada, August 15, 2004.
[24]. Tsu-Wei Chen, Mario Gerla, "Global State Routing: A New Routing Scheme for Ad hoc Wireless Networks", Proceedings IEEE ICC'98.
[25]. White T., "Swarm intelligence and problem solving in telecommunications", Canadian Artificial Intelligence Magazine, Spring, 1997.
[26]. White T., "Routing with swarm intelligence", Technical Report SCE-97-15, Systems and Computer Engineering Department, Carleton University, September, 1997.
[27]. Zygmunt J. Haas, Marc R. Pearlman, Prince Samar, "The Bordercast Resolution Protocol (BRP)", Internet Draft, draft- ietf-manet-zone-zrp-04.txt, work in progress, July 2002.

About The Authors

C.V.Anchugam is presently doing Ph.D in P.G. and Research Department of Computer Science, at Government Arts College (Autonomous), Karur, Tamilnadu, India. She has received her B.Sc(Computer Science) degree from Sri Saradha College of Arts and Science, Karur, Tamilnadu, India in 2002. She has received her MCA degree from M.Kumarasamy College of Engineering, Karur, Tamilnadu, India in 2005.She has published number of papers in esteemed national/international conferences and journals. Her interests are in Cryptography, Network security and Ad hoc networks.

Dr.K.Thangadurai, is presently working as Assistant professor and HoD in P.G. and Research Department of Computer science, Government Arts College (Autonomous), Karur. He has seventeen years of rich teaching experience with more than ten years of research experience in the field of Computer Science. He has worked as the HoD of PG Department of Computer Science at Government Arts College (Autonomous), Karur. He has published technical papers in many National and International Conferences and Journals. His areas of interest are Software Engineering, Network Security, Data Mining, etc.,

