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Research Article

Context Aware Routing in MANET with Hybrid ACO and Artificial Bees Colony Algorithm

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Abstract: The recent usage of small, portable and low cost devices has increased with most of them communicating through a wireless medium. As such devices self-organize, reconfigure without a fixed infrastructure, they form an ad hoc network known as Mobile Ad hoc Network (MANET). Mobile nodes ensure a dynamic, but an unpredictable topology, making routing challenging. Many routing protocols were suggested, with the numbers increasing daily. Context aware routing is a new MANET routing trend based on setting network context through a conceptual model. This study proposes context aware routing with a hybrid Ant Colony Optimization (ACO) -Artificial Bee Colony (ABC) algorithm to select optimal routes. Simulations are with limited nodes in a MANET. Performance evaluation is through parameters like end to end delay, retransmission attempts and throughput. The results revealed that ANT BEE algorithm improves performance when compared with Dynamic Source Routing (DSR) and ABC algorithm.

Keywords: Ant Colony Optimization (ACO), Artificial Bees algorithms (ABC), context aware routing, DSR, MANET

INTRODUCTION

MANETs are peer-to-peer multi hop mobile wireless networks with neither fixed communication infrastructure nor Base Stations (BSs) (Yoo and Agrawal, 2006). MANETs are initially meant for use in dangerous situations like rescue and battle field operations to ensure that emergency personnel/soldiers are aware of location of chemical, biological and hazardous material. In such networks, Mobile Nodes (MNs) come under a common authority (military or government agency) and are deployed to collaborate towards a common objective. Such MANETs are called closed or managed ad hoc network. But interest in MANET commercialization in catching up due to its portability and also due to the proliferation of mobile communication devices like laptops, PDAs, cell phones and radio devices. Various MNs from different manufacturers makes up a MANET in a self-organizing manner sharing resources for global connectivity with own goals. Such MANETs are called open or a pure ad hoc network.

MANETs have no fixed infrastructure. Each network node acts as host and router. Each node communicates directly with neighbor node in transmission range. Route between two far away nodes in one hop distance, communicate through multi hop path, the latter having many intermediate nodes. Some MANET issues include (Chlamtac *et al*., 2003):

- No fixed boundaries for wireless medium
- Unprotected wireless channel
- Unprotected wireless medium compared to wired channel
- Chances of hidden terminal related problems occurring

Mobile node in a MANET behaves as both host and router, capable of communicating with nodes through direct wireless links or multi-hop wireless links (Beaubrun and Molo, 2010). Ad hoc network applications examples include businessmen sharing information in meetings or conferences, soldiers relaying battlefield information and disaster relief personnel coordinating efforts post fires or earthquakes. In such applications, MANETs can become key components in 4G architecture as they offer multimedia services to mobile users in areas which are without existing communications infrastructure. As MANET nodes are mobile, links are created and destroyed unpredictably, which makes determining routes between a pair of nodes wanting to communicate with each other challenging. Routing protocols are classified as proactive and reactive protocols. Proactive protocols ensure that routing information is disseminated from

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each node to others regularly and locate routes continuously while reactive protocols only locate routes on demand, i.e., only when a source needs information to be forwarded to a destination. Performance analysis reveals that reactive protocols usually outperform proactive protocols. Dynamic Source Routing (DSR) is a representative reactive routing protocol.

Reactive routing protocol, DSR is based on source routing concept-a method where each packet carries complete route (a series of nodes) from source to destination. It consists of two phases:

- Route discovery
- Route maintenance

Route discovery is when a source has to send a packet, without knowing a route to the destination. Source broadcasts a Route Request (RREQ) to its immediate neighbour, which on receipt, checks if it is the destination, or has an alternate route to the destination. If so, the node unicasts a Route Reply (RREP), response to source, informing it of the route to the destination. RREP follows a path which is the reverse of that followed by RREQ. Or else, the node appends its address to RREQ and rebroadcasts packet to neighbours, which in turn process similarly.

Route maintenance is carried out on the route in use to detect link breaks caused by node mobility. Each node on present route has to sense whether the link to next-hop is broken. If so, it unicasts a Route Error (RERR) message to source, informing it of the situation. On receipt, source stops further packets using faulty route and initiates route discovery to get a new route to destination if no alternate route is available (Seet *et al*., 2006).

Policy based approach ensures an efficient and balanced solution for free migration and mobile nodes deployment. Allowing context aware routing, in wireless networks having mobile nodes results in the configuration of application changes and network layers thereby improving automatic decision making (Antonis *et al*., 2006). The parameters like nodes number, transmission range and type, cost and bandwidth are identified to select context aware routing parameters which are selected and weights identified before designing routing algorithm (Peizhao *et al*., 2008).

Optimization reduces communication setup linked latency as available routes are established before use, which is appropriate due to multiple packet flows and changed source/destiny pairs. In reactive protocols, like DSR protocol, route discovery procedures are used on demand when a source has a new connection pending for a new destination. This usually consists of flooding of query packets which eventually produce destination route as a reply. But such techniques fail to guarantee the creation of optimal routes regarding hops vs. distance (Calafate *et al*., 2003).

This study suggests context aware routing through a hybrid ACO Artificial Bee Colony (ABC) algorithm to select optimal routes. The benefit of using an optimization method like ACO is that it does not utilize the gradient of the subject to be optimized, so the process can be used for a host of optimization problems. When the gradient is too difficult or even impossible to derive, ACO is especially useful. The main objective of this proposed algorithm is to evaluate and increase the performance parameters such as an end to end delay, number of retransmissions attempt and throughput. Simulations were with moderate MANET nodes number. Performance evaluation used parameters like end to end delay, retransmission attempts and throughput. Results showed that ABC algorithm improved performance when compared with Dynamic Source Routing (DSR).

LITERATURE REVIEW

A context-aware adaptive routing for delay-tolerant mobile networks was proposed by Musolesi and Mascolo (2009) which showed the design, implementation and evaluation of Context-aware Adaptive Routing (CAR) protocol for delay tolerant unicast communication in intermittently connected MANETs. Based on exploiting nodes as message carriers among network partitions to achieve delivery it revealed that the choice of best carrier was through the use of Kalman filter based prediction techniques and utility theory. It discussed the CAR implementation over opportunistic networking framework, revealing applications of general principles as the basis for the proposed approach.

A robust and scalable integrated routing in MANETs using Context-Aware Ordered Meshes (CAROM) was proposed by Menchaca-Mendez and Garcia-Luna-Aceves (2010). Experiment results based on simulations revealed that CAROM attained the same or better data delivery and end-to-end delays compared to conventional unicast/multicast routing schemes for MANETs (AODV, OLSR and ODMRP). It also proved that CAROM incurred a fraction of traditional routing schemes signaling overhead.

A context-aware cross-layer optimized video streaming in wireless multimedia sensor networks was proposed by Shu *et al*. (2010). The optimized Multi-Path Multi-Priority (MPMP) transmission scheme, where a Two-Phase geographic Greedy Forwarding (TPGF) multi-path routing protocol in the network layer explored maximum number of node disjoints routing paths. Simulation revealed that MPMP scheme effectively maximized gathering of valuable information, guaranteeing end to end transmission delay.

Generalized Storage Aware Routing (GSTAR) for mobility in future mobile internet was proposed by

Nelson *et al*. (2011). Describing GSTAR, a mobility centric generalized storage-aware routing approach based on key design principles, separating names from addresses, delayed binding of routable addresses, in network storage and conditional routing decision space.

Garbinato *et al*. (2010) compared various context aware broadcasting MANET approaches to evaluate their respective performances. It showed four approaches regarding context, network traffic aware approaches, context-oblivious approaches, power-aware approaches and location aware approaches. It aimed to present the four different broadcasting approaches and measuring algorithms performance built on them.

A context aware, group based service discovery in MANETs was proposed by Ilka *et al*. (2012) which suggested a solution using context sources as a services advertisement board. Using group information resulted in intelligent routing request, increased discovery speed and decreased exchange packets number. To evaluate this, simulation tools were developed with results indicating that use of context sources, ensures that the approach has acceptable numbers of exchanged packets and good performance.

For Fast Movement Scene (Wei and Jia-Zhi, 2011) proposed a Context-Aware Optimized Link State Routing protocol (CAOLSR). Experiments showed that CAOLSR achieved high performance, outperforming Hierarchical Optimized Link State Routing protocol (HOLSR), Optimized Link State Routing protocol (OLSR) and Destination Sequenced Distance Vector (DSDV) in fast-moving node networks.

Context-Aware Security and Trust (CAST) framework for MANETs was proposed by Li *et al*. (2013) using policies which studied a CAST framework for MANETs, where varied contextual information like battery status, communication channel status and weather condition were collected to determine whether misbehavior was due to malicious activity. Simulation illustrated that CAST accurately distinguished malicious nodes from faulty nodes with limited overhead.

MDRP: A Content aware Data Exchange Protocol for MANETs was proposed by Eichler (2007) which identified need for content-aware message routing protocol explaining a scenario where it was applicable. The simulation results presented proved MDRP functionality in different scenarios. The conclusion highlighted the protocol's advantages over conventional routing concepts.

Yi *et al*. (2012) presented impacts of internal network contexts on performance of MANET routing protocols. Context of the network affected network performance. Context was related to internal/external parameters. MANET routing generated conceptual model by separating internal contexts from external contexts. TTL increment parameter in RREQ message was chosen as context parameter and performance evaluated in AODV routing protocol. Results were compared to routing protocols like AODV and OLSR. When related to TTL increment parameter change, performance improvement was ensured.

Channel aware routing in MANET's with secure hash algorithm was presented by Kiran Rao and Vasundra (2012). Channel aware routing to extend AODV protocol was proposed. AODV is a table driven protocol with each routing table having entries like sequence number, destination IP address, number of hops and entries expiration time. AODV found loop-free and multiple link-disjoint paths between source and destination. Secure hash algorithm was used to ensure the integrity.

MATERIALS AND METHODS

In this research, context aware routing with a hybrid ACO Artificial Bee Colony (ABC) algorithm is used for selecting optimal routes. Simulations are conducted with a moderate number of nodes in MANET. Performance is evaluated by using the parameters such as an end to end delay, number of retransmissions attempt and throughput. Results prove that ANT BEE algorithm improves the performance when compared to the Dynamic Source Routing (DSR) and ABC algorithm.

An artificial bee colony includes three groups of bees in ABC algorithm. They are employed bees, onlookers and scouts. The colony's first half consists of employed artificial bees, with the second half including onlookers. There is only one employed bee for every food source, i.e., the number of employed bees equals the number of food sources around a hive. Employed bees whose food sources are abandoned by bees becomes a scout.

In the first step, ABC generates a randomly distributed initial population P (G = 0) of SN solutions (food source positions), where SN denotes population size. Each solution x_i (i = 1, 2... SN) is a D-dimensional vector, where D is the number of optimization parameters. After initialization, positions (solutions) population is subjected to repeated cycles, C = 1, 2, ..., MCN, of search processes of employed bees, onlookers and scouts. An employed bee produces position (solution) modification in her memory based on local information (visual information) testing nectar amount (fitness value) of new source (new solution). After employed bees complete search process, they share nectar information and position information with onlooker bees on dance area. Onlooker bees evaluate nectar information from employed bees and choose a food source with probability related to nectar amount:

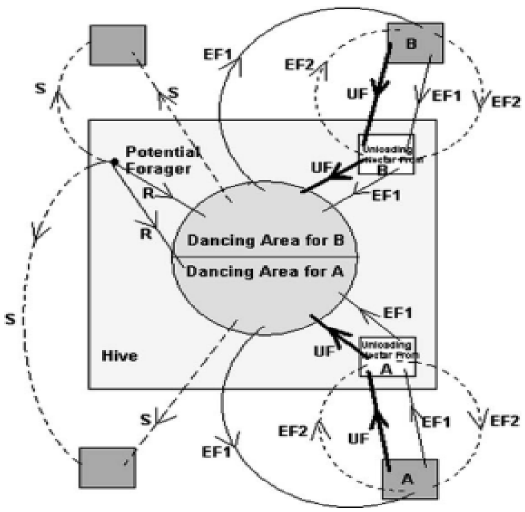

Fig. 1: Behavior of honeybee foraging for nectar

$$p_i = \frac{fit_i}{\sum_{n=1}^{SN} fit_n}$$

where, fit_i is fitness value of solution i which is proportional to nectar amount of food source in position i and SN is the number of food sources equal to the number of employed bees (Karaboga and Akay, 2009; Karaboga and Basturk, 2007) (Fig. 1).

Pseudo-code of the ABC algorithm is given below:

1: Initialize the population of solutions xi = i i = 1;...; SN
2: Evaluate the population
3: Cycle = 1
4: Repeat
5: Produce new solutions t_i for the employed bees by using (7) and evaluate them
6: Apply the greedy selection process for the employed bees
7: Calculate the probability values Pi for the solutions xi by (6)
8: Produce the new solutions t_i for the onlookers from the solutions xi selected depending on Pi and evaluate them
9: Apply the greedy selection process for the onlookers
10: Determine the abandoned solution for the scout, if exists and replace it with a new randomly produced solution x_i by (8)
11: Memorize the best solution achieved so far
12: Cycle = cycle + 1
13: Until cycle = MCN

Ant Colony Optimization (ACO) is an iterative algorithm where many artificial ants are considered in each iteration. Each builds a solution by walking from vertex to vertex on graph not visiting any vertex already visited in the walk. At each solution construction step, an ant selects the following vertex for visit, according to stochastic mechanism biased by pheromone: when in vertex *i*, the following vertex is selected stochastically among those previously unvisited. Specifically, if *j* was not visited earlier, it is selected with a probability proportional to pheromone associated with edge (*i*, *j*). At iteration's end, based on ant constructed solutions quality, pheromone values are modified to bias ants in future iterations to construct similar solutions to the best ones constructed already.

The importance of original Ant System (AS) is in being the prototype of many ant algorithms that collectively implement an ACO paradigm. AS follows an outline in the previous subsection specifying elements as follows (Di Caro *et al*., 2008; Dorigo, 2006).

The move probability distribution defines probabilities $p_i\psi$ to be equal to 0 for infeasible moves, otherwise they are computed by a formula:

$$p^k_{\iota\psi} = \begin{cases} \dfrac{\tau^{\alpha}_{\iota\psi} + \eta^{\beta}_{\iota\psi}}{\sum_{(\iota\zeta)\in tabu_k} \left(\tau^{\alpha}_{\iota\zeta} + \eta^{\beta}_{\iota\zeta}\right)} & \text{if } (\iota\psi) \in \text{tabu}_k \\ 0 & \text{otherwise} \end{cases}$$

where ∝-pheromone factor and β-heuristic factor are generally defined by the user (0≤∝, β≤1). These parameters control the importance of trail versus visibility and thus influence the solution.

Pseudo code for ACO:

```
if (forward ant)
{
    Get the next node based on the distance value
if (the link is available and no loop caused) then
{
•   Update forward ant with network status (stack)
•   Send forward ant to the next node
}
Else if (no such link exist)
{
•   Create backward ant and load contents of forward
    ant to backward ant (queue).
•   Send backward ant toward source along the same
    path as forward ant
}
}
```

Proposed ACO-ABC: The parameters, α-pheromone factor and β-heuristic factor in ACO, controls the importance of trail versus visibility and thus influence the solution. The pheromone parameter balances the intensification and diversification. Higher values of α intensifies search for solutions around high value pheromone trails. The heuristic parameter regulates the greediness of the search. The value of β is dependent upon the instance to be solved. In the proposed ACO-ABC, ABC finds values of α and β to be used for ACO.

RESULTS AND DISCUSSION

Simulations are conducted with a moderate number of mobile nodes. Two routing algorithms are implemented. First one is on demand DSR routing. Second one is DSR routing Hybrid Ant Colony Optimization with Artificial Bee Colony (ABC) algorithm for selecting optimal routes. To evaluate the performance parameters such as the end to end delay, throughput and the number of retransmission attempts have taken. Figure 2 to 4 shows the results graphically.

The results showed that the throughput obtained from proposed ant bee algorithm increased averagely at a rate of 51.25 and 8.87% compared to DSR and Artificial Bee DSR method, respectively.

From Fig. 3 it is seen that the end to end delay obtained from proposed ant bee algorithm decreased averagely at a rate of 27.98% and slightly increased at a rate 2.61% compared to DSR and Artificial Bee DSR method, respectively.

From Fig. 4 it is showed that the no of retransmission attempts obtained from proposed ant bee algorithm decreased averagely at a rate of 6.89 and 1.23% compared to DSR and Artificial Bee DSR method, respectively.

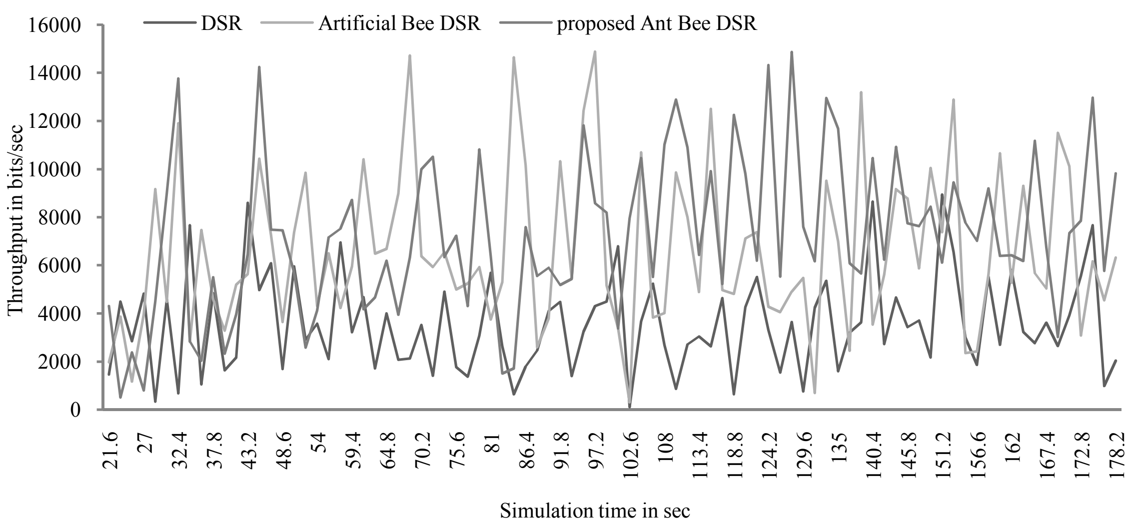

Fig. 2: Throughput in bits/sec

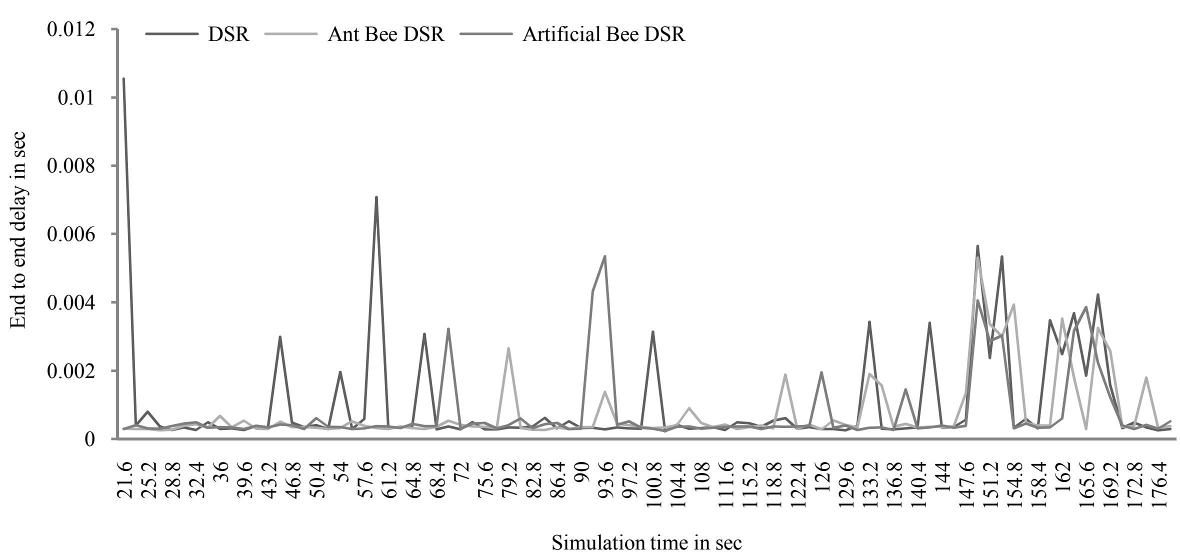

Fig. 3: End to end delay in sec

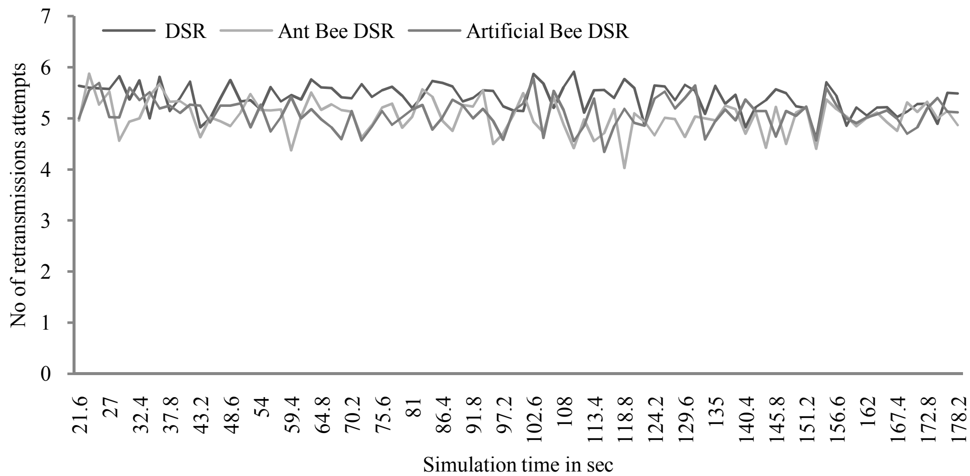

Fig. 4: No of retransmission attempts

CONCLUSION

This study suggests a context aware routing with hybrid ACO Artificial Bee Colony (ABC) algorithm to select optimal routes. Simulations were through limited MANET nodes. Performance evaluation is through the use of parameters like end to end delay, retransmission attempts and throughput. The results revealed that ANT BEE algorithm improved performance compared to DSR and ABC algorithms. The throughput increases by 51.25 and 8.87% for the proposed ACO-ABC optimization when compared to DSR and Artificial Bee DSR method, respectively.

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