Jurnal
Teknologi

Full Paper

Enhancing Varying Overhead Ad Hoc On Demand Distance Vector With Artificial Ants

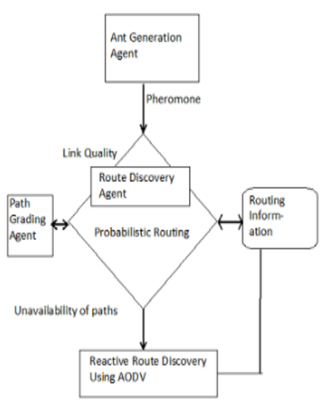
V. Balaji[a*], N. Umapathy[b], V. Duraisamy[c], K. Umapathy[d], P. Venkatesan[d], S. Saravanakumar[d]

[a]Prince Shri Venkateshwara Padmavathy Engineering College, Department of Electronics and Communication Engineering, Ponmar, Chennai, Tamilnadu, India
[b]GKM College of Engineering and Technology, Department of Electronics and Communication Engineering, Chennai, Tamilnadu
[c]Principal, Maharaja Institute of Technology, Coimbatore, Tamilnadu, India
[d]Sri Chandrasekharendra Saraswathi Viswa Mahavidyalaya Department of Electronics and Instrumentation Engineering, Enathur, Kancheepuram, Tamilnadu, India

Article history
Received
1 June 2015
Received in revised form
13 August 2015
Accepted
29 September 2015

*Corresponding author
balaji.phd.auc2008@gmail.com

Graphical abstract



Abstract

A cluster of mobile hosts installed with a wireless transceiver form a Mobile Adhoc Network (MANET), without base stations. Wireless ad hoc networks routing protocols usually focus on finding paths with minimum hop count. In a MANET, a route may suddenly be broken when a host roams away. Even if a route is connected, it may worsen due to host mobility or a better route being formed new in the system. Current protocols stick to a fixed route between a source - destination pair when discovered and it continues till it expires or is broken. A routing algorithm chooses better paths by considering wireless links quality. However, in large networks link quality from source to destination provides multiple options in space domain and finding local minima is crucial for successful routing implementation. This study extends the Varying Overhead Ad hoc On demand Distance Vector (VO-AODV) by introducing an optimization parameter using Ant Colony Optimization (ACO).

Keywords: Mobile Adhoc Network (MANET), Adhoc On demand Distance Vector (AODV), Link quality, Metrics

1.0 INTRODUCTION

Adhoc wireless networks routing has been an active research area for years. Original work was motivated by mobile application environments, with focus on providing scalable routing in mobile nodes. Current adhoc routing protocols choose paths that reduce hop count [1 - 3]. Minimal hop count paths in static adhoc wireless networks can have poor performance as they include wireless links between distant nodes. These can be slow or lossy, resulting in poor throughput [4]. A routing algorithm chooses better paths by considering wireless links quality.

Routing in a reactive protocol like Adhoc On-demand Distance Vector (AODV) has 3 parts: *route discovery*, *data forwarding*, and *route maintenance*. When a mobile host plans communication with another it attempts to discover a good route to destination, to forward data packets. Route maintenance should address problems when a route worsens or is broken by host mobility. In existing protocols [5, 6], a sending host sticks to a discovered route till it expires or breaks, even if the system has better newly formed routes. A solution is to run route discovery procedure frequently to detect this, but this is costly as route discovery activates network flooding [7]. This observation motivated this study's first work: it is proposed to use *route optimization* to refine/improve routes *on-the-fly* while being used for transmission. Not only are data packets sent with less hops and latencies, but it reduces route breakage chances, allowing costly route discovery being called.

Another problem is in rebuilding broken routes. When a node finds its link to next hop broken, it sends a route error packet back to source node in existing protocols, which invokes another route discovery procedure (involving costly flooding). These actions lead to wasting scarce wireless bandwidth and delay. Many works targeted packet flooding reduction [7]. Hence, it is important that a protocol uses route discovery carefully. Many real-time applications do not put up with long delay. These problems worsened with high mobility (frequent route error/discovery packets) or large networks (long way for route error/discovery packets to travel).

Researchers suggested metrics to measure wireless link quality, but metrics relative performance for routing in static adhoc wireless networks was not investigated. This paper studies performance of 3 link-quality metrics, comparing them against minimum hop-count routing.

Expected Transmission Count" (ETX) is the first metric which is based on measuring broadcast packets loss rate between neighboring nodes [8] pairs. The second metric "Per-hop Round Trip Time" (RTT) is based on measuring round trip delay by unicast probes between nodes [9]. The third metric "Per-hop Packet Pair Delay" (PktPair) is based on measuring delay between pairs of back-to-back probes to neighboring nodes. These metrics were incorporated in an AODV based ad hoc routing protocol.

2.0 MATERIALS AND METHOD

Ant Colony Optimization (ACO) uses population-based meta-heuristic to locate solutions to optimization problems. Solutions are by finding paths in a graph, optimal paths denoting good solutions. Path location reflects ant's behavior when they locate paths between food source and its colony. Weighted graphs in ACO find solutions to best path available. Path components are made of edges/nodes in a graph. Paths are constructed incrementally by moving on the graph based on pheromone. Solutions are constructed, evaluated and modified by ants as required by changing trail values/pheromone values of path components. Pheromone information denotes solution quality increasing/decreasing at future ants every iteration.

The problem definition is, as a model in search space of finite discrete decision variables set. A defined constraints set finds solutions and an objective function measures solution quality. Paths satisfying all constraints are feasible solutions.

Let a finite set of available solution components be $C=\{c_{ij}\}$, $i=1,\ldots,n$, $j=1,\ldots,|D_i|$. A set of m artificial ants from finite set elements construct Ant solutions. Partial solution $s^p=\emptyset$, i.e., solution begins with an empty set, when path construction starts. Partial solution s^p is included as path component from feasible neighbors set during construction.

The best probability of solution component choice from N (s^p) is chosen at every step. Probabilistic solution choice components form basis for various ACO variants. Ant System (AS) a best known rule is given as follows [10]:

$$p\left(c_{ij} \mid s^P\right)=\frac{\tau_{ij}^{\alpha}\eta_{ij}^{\beta}}{\sum c_{ij}\in N\left(s^P\right)\tau_{ij}^{\alpha}\eta_{ij}^{\beta}}\,{}'\forall c_{ij}\in N\left(s^P\right) \qquad (1)$$

where τ_{ij} is pheromone value and η_{ij} heuristic value associated with component c_{ij} . α and β are positive real parameters representing relative pheromone importance versus heuristic information.

2.1 A Link Quality Metrics

This paper considers three wireless link quality metrics. Minimum hop-count routing is supported by defining a "HOP" metric. Each metric represents different ideas of what is good link quality. Hop Count metric ensures limited hop-count routing. Link quality for this is a binary concept; either a link exists or doesn't. This metric's advantage is its simplicity. Once topology is known, computing and minimizing hop count between source and destination is easy. Also, such computation needs no additional measurements, unlike metrics described here later. This metric's main disadvantage is that it does not consider packet loss or bandwidth. It was shown [9] that a route which reduces hop count does not necessarily maximize flow throughput. For example, a two-hop path over reliable/fast links exhibits better performance than a one-hop path over lossy/slow link. The HOP metric prefers a one-hop path.

Per-hop Round Trip Time (RTT) metric measures round trip delay between neighboring nodes as seen by unicast probes. In calculating RTT, a node sends a probe packet with a timestamp to neighbors every 500 milliseconds. Neighbors immediately respond with a probe acknowledgment, echoing timestamp enabling sending node to measure its neighbor's round trip time. The node has an exponentially weighted moving average of its neighbors RTT samples.

The basis of Per-hop Packet Pair Delay (PktPair) metric is measuring delay between a back-to-back pair probes to a neighboring node. It is meant to correct distortion of RTT measurement caused by queuing delays. To calculate this, a node sends two probe packets back-to-back to neighbors every 2 seconds. The first probe packet is small, and the next large. Neighbors calculate delay between receipt of first and second packets and reports this back to sending node. The sender has an exponentially weighted moving average of neighbor's delays. The routing algorithm's aim is in reducing sum of delays. A new packet Link Quality Format (LQF) which is an extension of 'Hello' message is introduced which in turn introduces a link quality integer metric by which neighbor nodes rate link quality to destination. Figure 1 shows the packet format.

Link Quality format
Source Id
Link Quality Value
Intermediate Node Id

Figure 1 The additional packet overheads introduced

Varying Overhead AODV (VO-AODV) proposed in literature has the following steps.

- At time t1, for duration n, compute power from nodes si transmit data to node D. Let power computed from each node be Pi. Total power from all nodes for duration is ∑Pi.
- At time t2, for duration n, compute power from same sources. Let power computed for each node be Pj from a received packet. Total power computed is given by ∑Pj.
- Compute x=∑Pj - ∑Pi.
- If x is positive, increase ART from reference value by x/Pimax.
- If x is negative decrease ART from reference value by x/Pimax provided computed value is not below minimum set threshold value.

As link quality is measured using extended hello message, ACO techniques find local minima and local maxima and identify best route among available routes. The proposed routing algorithm's block diagram is seen in Figure 2.

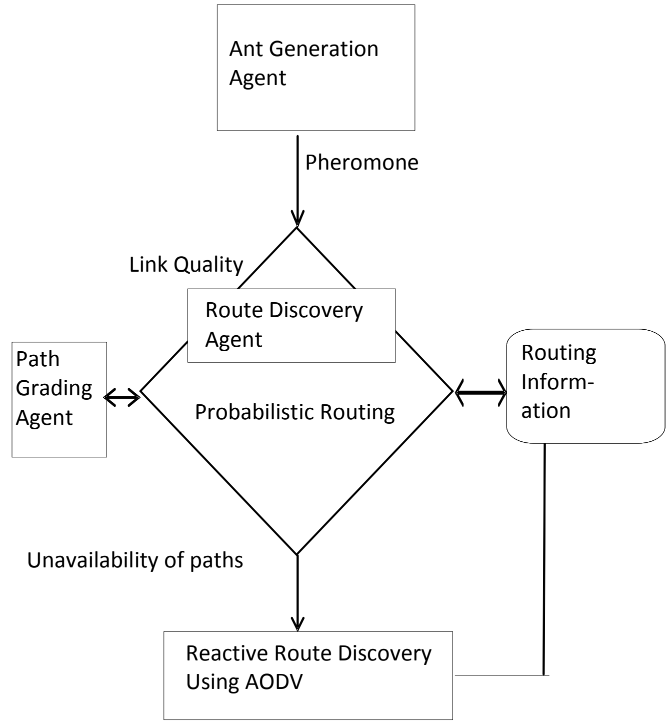


Figure 2 Block diagram of proposed ACO optimization

3.0 RESULTS AND DISCUSSION

Twenty nodes with random mobility and speeds were implemented in a 490000 sq. m network using OPNET. Each node has a transmit power of 0.005 watts. Each node randomly transmits raw unformatted data to every other node in the network. Simulation in each scenario was carried out for 600 second. The proposed method was compared with AODV. Figure 3 shows the throughput of the proposed network using ACO.

From Figure 3 it is seen that the proposed system improves the throughput by more than 40% compared to regular AODV. Figure 4 shows the route discover time.

The proposed algorithm involves additional control overheads it can be observed that the route discovery time increases considerably compared to AODV.

4.0 CONCLUSION

This study proposed to optimize VO-AODV route discovery for networks where link quality changed continuously. Ant colony optimization was used to grade path with dynamic modification of route time out. The suggested protocol increased throughput compared to AODV. Route discovery time was higher compared to conventional AODV and further work is required to decrease route discovery time which affects streaming traffic.

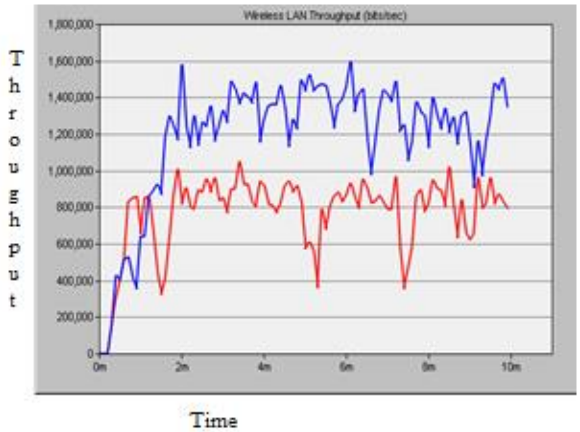


Figure 3 The throughput of the proposed system compared with AODV

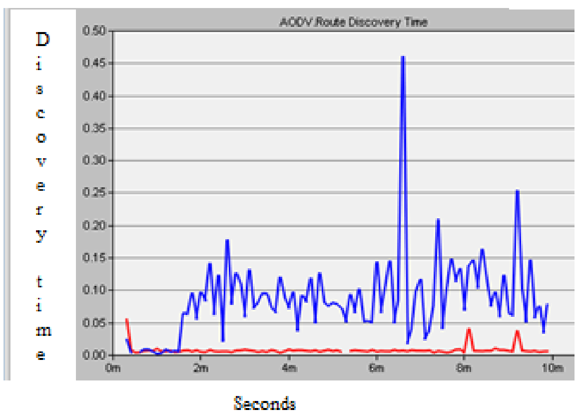


Figure 4 Route discovery time

Acknowledgement

We are grateful for the Vice-Chancellor, Registrar, The Dean (E&T) and HOD of ECE Department of Sri Chandrasekharendra Saraswathi Viswa Mahavidyalaya providing funding for the Author 1.

References

[1] D. B. Johnson and D. A. Maltz. 1996. Dynamic Source Routing In Ad-Hoc Wireless Networks. In T. Imielinski and H. Korth, editors. *Mobile Computing*. Kluwer Academic Publishers,
[2] V. D. Park and M. S. Corson. Apr 1997. A Highly Adaptive Distributed Routing Algorithm For Mobile Wireless Networks. *INFOCOM*.
[3] C. E. Perkins and P. Bhagwat. Sept. 1994. Highly Dynamic Destination-Sequenced Distance Vector Routing (DSDV) for Mobile Computers. *SIGCOMM*.
[4] D. De Couto, D. Aguayo, J. Bicket, and R. Morris. Sept. 2003. High-Throughput Path Metric for Multi-Hop Wireless Routing. *MOBICOM*.
[5] R. Dube, C. Rais, K. Wang, and S. Tripathi. Feb. 1997. Signal Stability Based Adaptive Routing For Ad–Hoc Mobile Networks. *IEEE Personal Communications*.
[6] Z. J. Haas and M. R. Pearlman. November 1997. The Zone Routing Protocol for Ad–Hoc Networks. Internet Draft RFC http://www.ietf.org/html.charters/manet-charter.html.
[7] S. Y. Ni, Y. C. Tseng, and J. P. Sheu. August 1999. The Broadcast Storm Problem in a Mobile Ad Hoc Network. *Proc. ACM MOBICOM.*
[8] D. De Couto, D. Aguayo, J. Bicket, and R. Morris. Sep 2003. High-Throughput Path Metric For Multi-Hop Wireless Routing. *MOBICOM*.
[9] A. Adya, P. Bahl, J. Padhye, A. Wolman and L. Zhou. 2004. A Multi-Radio Unification Protocol for IEEE802.11 Wireless Networks. *BroadNets*
[10] M. Dorigo, V. Maniezzo, and A. Colorni. 1996. Ant System: Optimization By A Colony Of Cooperating Agents. *IEEE Transactions on Systems, Man and Cybernetics–Part B*. 26(1): 29–41.