ISSN: 2278 – 1323
International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 1, Issue 8, October 2012

A Performance Analysis of Energy Aware and Link Stability based Routing Protocols for MANET

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***Abstract*— Energy efficient routing is be one of the most important design criterion for MANET since mobile nodes are battery powered with limited capacity and which cannot be recharged when ever needed. So, MANET routing is challenged by power and bandwidth constraints. When mobile nodes run out of power, the network gets partitioned and thus some sessions are disconnected. In order to solve this problem and to achieve efficient energy consumption, many solutions have been proposed. All those works are done as the extension of the already existing ad hoc routing protocols such as Reactive, Proactive and Hybrid Routing. Since table-driven protocols consume more energy compared to on-demand protocols, the proposals made modifications to existing reactive protocols. Most of the energy-aware protocols referenced here are implemented as modifications of the basic routing protocols using energy-sensitive metrics. Link stability is also an important challenge of MANET routing. Many routing algorithms have been proposed for providing QoS in terms of link stability. In this work we concentrated on evaluating how these approaches and algorithms affect the energy consumption in the mobile devices and how stable routes are established in the network.**

***Index Terms*—Energy-aware, Energy consumption, Energy efficient routing, MANET, Routing Protocol**

I. INTRODUCTION

A Mobile Ad-hoc Network (MANET) is a self organizing network composed of mobile nodes connected by wireless links without any fixed infrastructure. These types of networks exhibit the features such as dynamic topologies, bandwidth constrained operation, variable capacity links, vulnerable to attacks, and energy constrained operation. The characteristics of MANET such as rapid deployment, de-centralized operation, dynamic multi-hop etc makes it suitable for the application like military battle fields, emergency rescue operations, smart offices, etc. However, wide deployment of MANET has not come yet due to the challenges of MANET [7] such as routing, security and reliability, QoS, power consumption etc among which energy issue is a fundamental one. Energy efficient schemes can impact on the battery power and prolongs the lifetime of the network while wireless communications consume large amount of energy. In wireless scenario, it is a shared environment, and some energy is consumed for neighborhood transmissions: such as nodes spend their batteries not only by sending their own packets, but also by just overhearing packets from other nodes. Energy is also spent by forwarding packets for others. So, power efficient routing is also a most important design challenge for MANET routing. For mobile nodes, power failure can adversely affect its routing responsibility [8] and there by affects the network performance. So, the energy of nodes must be utilized optimally such that, they can perform their functionality successfully. There are energy management techniques that focus on minimizing energy consumption within the network. It is based on making decisions about when to activate or shut down the system components.

As MANET is a multi hop network, the packets are to be send from source node to destination through a number of intermediate nodes. So, the successful delivery of packets depends on the battery resource of each and every nodes and it must be used efficiently in such a manner that will not lead to the early termination of network. Thus, the main objective of all energy efficient routing protocols is to find an active route with better power status among a number of routes between source and destination.

When considering the networks nodes for routing, a path between a source and destination is said to be stable if it consists of most stable neighbors at each hops between them. Features of ad hoc networks such as node mobility, interference, channel fading and absence of infrastructure etc results in frequent link breakages. It also makes the links not very much error resilient. For any routing protocol, it must choose a stable path.

A. Routing in MANET

MANET routing protocols are having the responsibility to find and maintain routes between nodes in a dynamic topology by using minimum resources. They are classified into three main groups such as Proactive routing protocols, Reactive routing protocols and Hybrid routing protocols [9]. Routing is important in MANET due to the following reasons:

Manuscript received Oct, 2012.

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a) Host mobility: It is due to the dynamic topology that changes over time. The routing protocol must be capable of managing link failure/repair due to mobility

b) Distributed Environment: Minimum control overhead as there is no any centralized control.

c) Bandwidth constrained: Total bandwidth is shared

d) Energy constrained: Battery resource is constrained

Following are the main characteristics of MANET routing

- Distributed Operation
- Efficient ie; low control overhead
- Self-configuration
- Resilience to changing network topology

An efficient routing protocol should maximize network throughput and lifetime, while minimizing delay in transmission. Routing protocols coming under energy awareness must balance delay constraints, battery lifetime and routing efficiency in order to achieve a better route discovery. The common means of energy consumption in routing occurs during exchange of route information. In case of route with small number of hops, energy is consumed significantly compared to a route with large number of hops. The lifetime of a node is degraded as it is used more frequently.

In this work, we concentrate on analyzing performance of some energy-aware and link stability based routing protocols. The focus is given to the power consumption and link stability aspects of each protocol. The Link Stability and Energy Aware Routing Protocol in Distributed Wireless networks [1] accounts for link stability and minimum drain rate energy consumption by using a novel strategy. It uses a bi objective optimization formulation for the correctness of proposed solution. Energy Efficient, Secure and Stable routing protocol for MANET [2] is another protocol which combines the aspects of both energy efficiency and stability along with secure routing. This protocol is incorporated with AODV and refined version of Stable and Secure Routing protocol (SSRP). EE-OLSR [3] is another approach towards energy efficient routing. It is an advanced version of classical OLSR protocol including some modifications in MRP selection. Link Stability Routing protocol under video transmission for MANET [4] proposes a modified version of existing AODV protocol to discover stable path for sending video and data packets. It is capable to cope up with the node mobility. Energy Efficient Routing Protocol Avoiding Route Breaks based on DSR [5] is proposed to reduce the cost of managing the link failures by avoiding route breaks. It considers both link and node stability as a metric. QoS based Power Aware Routing in MANETs [6] selects an energy stable end-to-end path. The bandwidth and energy constraints are built in into DSR route discovery mechanism. It also provides a route repair mechanism in case of link failures.

Rest of the paper is organized as follows. Section II gives a performance evaluation of selected energy efficient routing protocols; section III provides the comparison of link stability based routing protocols and their performance; Section IV summarizes the performance evaluation and conclusion of this work.

II. Performance Evaluation of Energy Aware Routing Protocols

As energy is an important criterion for routing, most of the research works are going under this section. All the works are done as a modification of existing ones but having drawbacks also. This is because no any approach can perform better in every network conditions. In wireless networks, as the nodes functions are solely based upon their battery level, the energy consumption must be effectively managed. Only by considering the energy consumption of the network, we cannot predict the energy efficiency of the system. For that, both the network lifetime and node lifetime must be considered. So that, energy aware routing protocol [10] must be designed in such a way that, it prolongs the network lifetime along with high performance. In Minimum energy routing, route with minimum energy consumption may get frequently used and its energy gets exhausted leading to failure of nodes. Energy efficiency can be obtained by considering different parameters in routing like energy of nodes, battery level etc. The common alternatives for maintaining efficient energy in a network are;

(a) Minimize the energy consumption for packet transmission and reception

(b) Exploit time taken for network partitioning due to link breaks

(c) Minimize the variations in node's energy level

(d) Total cost for sending a packet should be minimized

There are two approaches for energy efficient routing. First is called transmission power control approach in which it reduces the total energy consumed per packet transmissions. As discussed earlier, it will lead to network failure since same paths are being used repeatedly. Another approach is to prolong the system lifetime which completely focuses on load balancing of nodes. There are some fundamental concepts used for efficient energy utilization. They are,

(a) Residual Energy-It gives battery status indicating the remaining battery capacity of a node

(b) Energy Drain Rate- Gives the rate at which a node spends its energy. This metric can be used to estimate node lifetime. For an efficient routing, energy drain rate cost must be minimized.

Floriano De Rango et al. proposed a Link Stability and Energy Aware Routing protocol (LEAR) protocol [1],in which the next hop towards destination is the neighbor node that maximize (minimize) the joint link-stability-energy metric. The energy needed to send a packet is calculated while ignoring the energy spent for overhearing a packet. Power dissipation is calculated in terms of both power consumption at transmitter and receiver. For any node i, its non destination neighboring node j is selected as a node that has enough energy to receive the information sent from node i and which is also capable of transmitting the information to another relay node. For any node, the energy to transmit the packet should be lower or equal to the residual energy. Minimum drain rate along with drain rate index and residual

energy is considered for measuring the energy dissipation rate of a given node.

In Energy Efficient, Sunil Taneja and Ashwani Kush proposed Secure and Stable Routing Protocol for MANET [2], a routing mechanism that provides energy efficient, secure and stable routes. Here, the Secure Routing done in three steps. Diffie-Hellman Algorithm is used for generation of secret key and hashing to generate subsequent keys over selected route. Here, Encryption and Decryption is performed using XOR operation. The Energy Efficient and Stable Routing is performed by means of a per hop power aware forwarding which is based on some threshold energy value ETh. Even though this protocol gives a Stable and Energy efficient algorithm with best packet delivery ratio which is simple and robust, it should not support large traffic and enhanced TCP connections. Qos is also not ensured and there is no multicast transmission support

Floriano De Rango and Marco Fotino in their work EE-OLSR [3]: Energy Efficient OLSR Routing Protocol for Mobile Ad-Hoc Networks introduced a routing protocol to prolong network lifetime without losses of performance. It uses the concept of Multi Point Relays (MPRs), which reduces the message overhead. In the EA-Willingness Setting mechanism, each node associated with variable used "willingness" where, longer the node lifetime- HIGH willingness and vice versa. Overhearing Exclusion is another feature where OLSR does not takes any advantage from unicast network information. It uses Energy-aware Packet Forwarding for route discovery. EE-OLSR outperforms OLSR by providing a better traffic load balancing and throughput. It provides a normalized control overhead, enhanced node lifetime, high packet delivery ratio, and lower end-to-end delay.

In the work by Vinay Rishiwal et al. , QoS Based Power Aware routing in MANETs [6], the proposed mechanism selects an energy stable, QoS constrained end to end path. It performs the routing in two phases, where first phase deals with Route discovery with bandwidth and energy constraints and the second phase deals with Route repair mechanism for finding a new energy stable path. Route discovery algorithm performs an Energy based path selection. The work also provides a mechanism for Route maintenance by considering the cases such as link failure due to energy depletion and Topological changes. This protocol yields better packet delivery ratio, better throughput, average end to end delay and efficient route reconstruction. But a priori estimation of bandwidth and admission control is needed to ensure bandwidth availability which is its drawback.

III. Performance Evaluation of Link Stability Based Routing Protocols

In Link stability and Energy Aware Routing Protocol [1], the node with best trade-off between the energy consumption and link stability is chosen. The mechanism uses a statistical based approach to differentiate the most stable link from others. For that, the link residual life time is evaluated which gives a measure of the link stability. Classification of the links is done on the basis of link ages according to a coefficient $R_{i,j}(a_{i,j})$. But one drawback of this concept is that, it will not promote the discrimination of links with same age. So, the travelled distance is also is taken into consideration where, the crossed distance is stored and its average is taken. This is selected why, if there exists two or more links with same residual energy. In this case, link with shorter average distance is selected. This mechanism will not consider the number of reordering operations of the links with different residual lifetimes. It concludes that, higher the residual lifetime for a link, the reliability also will be higher. If the average travelled distance is higher, chances for link breaks is also higher.

Sachidanandh S Joshi proposed Link Stability Routing Protocol Under Video Transmission [4] for MANET, a routing protocol for video applications with higher bandwidth and reliability requirements. Here, Route discovery is based on stability of the path. Neighbor nodes with maximum hello packets are considered as more stable. It is found out using Neighbor Stability ie, Consistency of neighbors and Path Stability ie, Path consistency between source and destination. The stability metrics used are hello count and link loss. These Metrics are appended on request packets to get measure of stability of paths. The mechanism ensures high video delivery ratio and high throughput. But, the all the functioning is based on assumption that all nodes will participate and also it concentrates only on path stability.

Ashish Kumar et al. addressed an Energy Efficient Routing Protocol Avoiding Route Breaks [5] based on DSR protocol. In their work, the authors proposed a protocol to reduce the cost of link failures. It deals with avoiding route breaks by considering node and link stability. Node stability is measured by means of two metrics called Link Expiration Time and remaining energy. The combination of these metrics generates a measure which reduces the cost of managing the link breakages. Stable path is found out in terms of received signal power strength and traffic level. Higher the value of link expiration time, higher will be the link stability. Proposed method is a modification of DSR route discovery mechanism by taking Link Stability Measure as a preemptive measure. In route discovery process, the RREQ packet carries information such as Node's Stability (NS), Traffic level (TL), Weak Node (WN) and type of data. Each node maintains a Neighbor Information Table (NIT) which stores the information like traffic level and received Power (RP). Neighbor nodes with only their traffic level <=TL are selected. The destination selects a path with disjoint nodes. Path selection is also based on the type of data. Route maintenance is done when LSM falls below a threshold value LSM_{thr}. This protocol reduces the routing overhead as the route selection is based on traffic level and stability criterion. The selected path satisfies both energy aware and traffic load constraints and also meets the QoS objectives. Even though link breaks are reduced, delay is the main drawback of this approach.

Rekha Patil et al. proposed a Link Stability Based On Qos Aware On - Demand Routing for Mobile Ad Hoc Networks [11]. The task of QoS routing is to optimize the network resource consumption while satisfying the application requirements. So, there is no centralized control over links. Further the link quality varies due to mobility of nodes. Existing quality of service based routing protocols

have a capacity of not making the changes in link quality once the path is established and cost matrix is set to zero and link quality is not taken in to concern to choose the stable paths. Therefore the performance of such system degrades with high mobility. Hence in this work they stress on incorporating link quality estimation based on mobility prediction of nodes and the primary transmission path is changed in case of a improved route in terms of link quality is obtained. They blend the idea of link stability, cost matrix and power consumption to discover better path in terms of both stability and cost along with QoS support.

Several QoS routing protocol claims to provide best routing and packet delivery solution to MANET. Most of these QoS techniques are node centric which means the time of processing route request decides if it can provide adequate QoS to path before forwarding route request. But variations in link quality should integrate quality of all links through which data transmission is possible. There are major factors like mobility, cost, power and energy efficiency need to be considered to guarantee better network performance. Especially while assuring QoS in MANET environment nodes should not expire due to power constraints or the links should not expire due to mobility in the middle of the transmission. So our target is to select a more stable path considering higher link stability and less cost along with power discrepancy. They presented a routing algorithm which performs better in terms of cost and link quality.

The method finds the stable paths with minimum probability of link failures in the path. Power loss can also be a constraint for representing link stability. In this work they focused on incorporating link quality estimation based on mobility prediction of nodes incorporate same in the (AODV) routing decision to avoid routing through the bad quality links and establish new routes. The transmission path is changed to a better route in terms of link quality obtained. A technique is proposed for estimating the link quality between the nodes. Each node finds its position through the GPS (Global Positioning System). Also a unique mechanism of accumulating new path as and when a path with better link quality is available. The cost matrix is calculated based on link stability between nodes and power is also calculated. It has some limitation random mobility of nodes with very high speed produces improper link quality measurements, multipath fading and wide channel noise affects the link quality. They have proved that, the throughput and packet delivery ratio are significantly improved in their work and control overhead is reduced to ensure better performance. There is however slight increase in latency which is attributed by more packet delivery and causes updates of layer.

IV. CONCLUSION

In this survey paper we have discussed about various energy efficient and link stability based protocols with the importance of energy efficiency and stability of links. We conclude that there is not a single protocol which can give the best performance in ad-hoc network when considering both the above parameters. Performance of the protocol varies according to the variation in the network parameters. Sometimes the mobility of the node of the network is high reflecting on the node and its link stability and sometimes it is low. But energy of the node and stable links are our prime concern.

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