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A STUDY ON MULTICAST ROUTING MAODV ALGORITHM USING HYBRID SWARM INTELLIGENCE

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ABSTRACT

Wireless Mesh Networks (WMNs) are the evolutionary self-organizing multi-hop wireless networks to promise last mile access. Due to the emergence of stochastically varying network environments, routing in WMNs is critically affected. In this paper, we first propose a fuzzy logic based hybrid performance metric comprising of link and node parameters. This Integrated Link Cost (ILC) is computed for each link based upon throughput, delay, jitter of the link and residual energy of the node and is used to compute shortest path between a given source terminal node pair. Further to address the optimal routing path selection, two soft computing based approaches are proposed and analyzed along with a conventional approach. Extensive simulations are performed for various architectures of WMNs with varying network conditions. It was observed that the proposed approaches are far superior in dealing with dynamic nature of M-AODV is compared to Adhoc On demand Distance Vector (AODV) algorithm.

KEYWORDS: Wireless Mesh Networks, Integrated Link Cost, M-AODV.

Index Terms- AODV, CSMA/CA, DSRC, MAC layer, Modified AODV (M-AODV) Routing Protocol, Artificial Swarm Intelligence, Wireless Mesh Network, Routing, Fuzzy Logic.

1. INTRODUCTION

Introduction Wireless mesh networks (WMNs) have emerged as an evolved network technology to provide better services and cost effective solutions to the users. In typical wireless mesh network, there are two kinds of nodes, i.e., mesh routers (MR) and mesh clients (MC). The mesh routers form the backbone of the WMNs and provide network access for the mobile clients. Each mesh router operates not only as an access point but also as a relay node that can forward packets to other mesh routers according to the routing information. Mesh routers are stationary with power supply otherwise clients which may be mobile or stationary with limited power or ability. These networks have properties like dynamically self-organized, self-configured and self-healing that come into the advantages of easy deployment and maintenance, high reliability, and large coverage.

Self configuring Wireless Mesh Networks (WMNs) are easily deployable, scalable, robust and cost effective wireless networks where nodes are having capability to automatically create and maintain mesh connectivity between them. Broadband home, community, neighborhood and enterprise networking are some of the applications of WMNs. The data packets, starting from the source node, hop from one node to another until it reaches the terminal node. Wireless Mesh Routers (WMRs) and Wireless Mesh Clients (WMCs) are two types of nodes in WMNs. WMRs are capable for gateway/repeater functions as well as additional routing functions to maintain mesh networking. Based on the functionality of the nodes, the architecture of WMNs can be further categorized into three main groups namely: (1) Infrastructure/Backbone WMN: In infrastructure type WMNs mesh routers with gateway functionality form an infrastructure mesh for client nodes. (2) Client WMNs: Client WMNs provide peer-to-peer networks and client nodes perform routing along with self-configuration functions. (3) Hybrid WMNs: Hybrid Mesh is the combination of infrastructure and client meshing. Client nodes can access the network through mesh routers as well as directly meshing with other client nodes.[1] The parameters to analyze the performance of a WMN can be categorized as per flow, per node, per link, inter flow and network wide parameters. Commonly used performance metrics are Hop Count, Per-Hop Round Trip Time (RTT)[2]; Per-Hop Packet Pair Delay and Expected Data Rate (EDR)[3]; Expected Transmission Count (ETX)[4], 2003; Expected Transmission on a Path (ETOP)[5]; Expected Transmission Time (ETT) and Weighted Cumulative ETT (WCETT)[6]; Effective Number of Transmissions (ENT)[7]; Bottleneck Link Capacity (BLC)[8]; Low Overhead Routing Metric[9]; Airtime Cost Routing Metric[10] etc. Hop Count Metric is the simplest one however; in most cases the minimum hop-count is not enough for a routing protocol to achieve good performance. Other routing metrics are critically affected by high overhead, low performance, high complexity or in-appropriate load balancing. The impact of performance metrics on a routing algorithm is discussed by Draves et al.[6]

2. SWARM INTELLIGENCE

Swarm intelligence (SI) is the collective behavior of decentralized, self-organized systems, natural or artificial. SI systems are typically made up of a population of simple agents interacting locally with one another and with their environment. The inspiration often comes from nature, especially biological systems. The agents follow very simple rules, and although there is no centralized control structure dictating how individual agents should behave, local, and to a certain degree random, interactions between such agents lead to the emergence of "intelligent" global behavior, unknown to the individual agents. Natural examples of SI include ant colonies, bird flocking, animal herding, bacterial growth, and fish schooling.

Research in SI started in the late 1980s. Besides the applications to conventional optimization problems, SI can be employed in library materials acquisition, communications, medical dataset classification, dynamic control, heating system planning, moving objects tracking, and prediction. Indeed, SI can be applied to a variety of fields in fundamental research, engineering, industries, and social sciences.

The main objective of this special issue is to provide the readers with a collection of high quality research articles that address the broad challenges in application aspects of swarm intelligence and reflect the emerging trends in state-of-the-art algorithms.

3. AODV WITH PROACTIVE & REACTIVE WITH HYBRID SWARM INTELLIGENCE

A. Proactive or Table Driven Routing Protocol Proactive protocol

Its one of the old ways of acquiring routing in mobile ad hoc networks.[2]-[3], [7]-[15] These protocols maintain consistent overview of the network. Each node uses routing tables predesigned to store the location information of other nodes in the network. This information is used to transfer data among various nodes of the network. Some of the common proactive protocols are like that Ad Hoc Wireless Distribution Service (AWDS) where layer two wireless mesh routing protocol used, Highly Dynamic Destination Sequenced Distance Vector routing protocol called DSDV, Babel routing protocol inspired by DSDV, Cluster head Gateway Switch Routing protocol (CGSR), Direction Forward Routing protocol (DFR), Distributed Bellman-Ford Routing Protocol (DBF), Guesswork routing protocol, etc. Certain memory spaces in a node are always reserved for proactive routing techniques applied. Table-driven protocols may not be considered as an effective routing solution for mobile ad hoc network. Nodes in mobile ad hoc networks operate with low battery power and with limited bandwidth. Presence of high mobility, large routing tables, and low scalability result in consumption of bandwidth and battery life of the nodes. Excessive memory capacities are spending to store large routing table. Moreover continuous updates can create unnecessary network overhead. For this network jamming may occur due to this routing protocol.[8][10]

B. Reactive or On-Demand Routing Protocol

This type of protocols finds a route on demand by flooding the network with route request packets. Actually, a route is decided on the availability of least distance, less overload or overhead, less consumption of electrical power, traffic solution, etc., and this protocol is changing in nature. It initiates a route discovery process, which goes from one node to the other until it reaches to the destination or an intermediate node which has a route to the destination. The main disadvantages of such algorithms are as followings: i. High latency time in route finding. ii. Excessive flooding can lead to network clogging, i.e., the network is blocked or congested. iii. It is the responsibility of the route request receiver node to reply back to the source node about the possible route to the destination. The source node uses this route for data transmission to the destination node. Some of the better known on-demand routing protocols are such as Robust Secure Routing Protocol (RSRP), Modified AODV (M-AODV), Multirate Ad Hoc On-demand Distance Vector (Mu-AODV), Reliable Ad Hoc On-demand Distance Vector (R-AODV), AODV-UCSB (University of California, Santa Barbara), AODV-UV (Uppsala University), KernelAODV, Minimum Exposed Path to the Attack (MEPA) in MANET, Ant-based Routing Algorithm for MANET, Admission Control enabled On-demand Routing (ACOR), Dynamic Source Routing (DSR) and Temporary Ordered Routing Algorithm (TORA), etc. Among these protocols, AODV routing protocol is more useful in ad hoc mobile networks. We are discussing the AODV protocol and modifying it as M-AODV for better performance in detail.

C. Hybrid Routing Protocol

It combines both the proactive and the reactive approaches.[3]-[15] Zone routing protocol (ZRP) is a notable example. The routing is initially established with some proactively prospected paths and then serves the demand from additionally activated nodes through reactive flooding. The choice for one or the other method requires predetermination for typical cases. The main disadvantages of such algorithms are: i. It depends on amount of nodes more to be activated. ii. Reaction to traffic demand depends on gradient of traffic volume. The following protocols are important in hybrid protocols that ARPAM is used specialized for aeronautical MANETs, Hybrid Routing Protocol for Large Scale Mobile Ad Hoc Networks with Mobile Backbones (HRPLS).[9]

Link State routing protocol (HSLS) using a mathematical optimization to mix link state and reactive routing to optimize network data updates in space and time, Hybrid Wireless Mesh Protocol (HWMP) protocol for IEEE 802.11 is inspired by a combination of AODV and tree-based proactive routing, Order One Routing Protocol (OORP) in which proactive or reactive distance vector are combined with a hierarchy and that is not used to route data, Scalable Source Routing (SSR) uses routing messages along a virtual ring, Temporally Ordered Routing Algorithm (TORA) is used for routing data across Wireless Mesh Networks or Mobile Ad Hoc Networks, Zone Routing Protocol (ZRP), etc.

D. Hierarchical Routing Protocol

With this type of protocols, the choice of proactive and of reactive routing depends on the hierarchical level where a node resides. The routing is initially established with some proactively prospected routes and then serves the demand from additionally activated nodes through reactive flooding on the lower levels. The choice for one or the other method requires proper attribution for respective levels. The main disadvantages of such algorithms are followings: i. It depends on depth of nesting and addressing scheme.[11]

Table 1: Architectural details of WMNs

Infrastructure WMN			Client WMN			Hybrid WMN
No. of Nodes	Area (mxm)	Radio Range of a node (meters)	No. of Nodes	Area (mxm)	Radio Range of a node (meters)	No. of Mesh Routers
9	500 x 500	200	10	500 x 500	250	2
16	500 x 500	200	20	500 x 500	250	4
25	500 x 500	200	30	1000 x 1000	350	6
64	1000 x 1000	200	50	1000 x 1000	350	9
100	2000 x 2000	200	100	2000 x 2000	500	20
In the case of Hybrid WMN the number of nodes, coverage area and radio ranges are same as that of Client WMN.						

4.1 Model Performance

In order to investigate and optimize the performance of routing algorithm of WMNs simulations were performed for a variety of static and dynamic scenarios in MATLAB. We considered 9, 16, 25, 64 and 100 node networks for infrastructure WMN. These networks were placed within a 500m X 500m, 1000m X 1000m, 2000m X 2000m area. For Client and Hybrid WMNs. 10, 20, 30, 50 and 100 node networks were considered within the same area. We varied transmission range of the nodes from 200 meters to 500 meters. In all the network models node number 1 acts as source and transmits data packets to the last node which is the terminal node (e.g 10th node is the terminal node in a 10 node WMN). The data transmission is made possible through multiple hops via various adjoining nodes. In this type of wireless communication multiple routes/paths are accessible. Decision as regard to which path or route is to be used for any type of traffic, depends upon the current value of the ILC measure (distance). The proposed algorithms were implemented in MATLAB v 7.6 (R2008a) along with AODV for different architectures of WMNs with varying number of nodes, iterations as well as with different radio ranges and areas. The architectural details are provided in Table 1. The minimal path set is computed by these three approaches for the same network architecture. Table 2 combines the results for Client and Hybrid WMNs and Table 3 shows the numerical results for Infrastructure WMN respectively. Each table represents the integrated link cost and processing time for a specific source-terminal node pair for varying number of nodes and iterations.

Features of Proposed Modified AODV Protocol Ad hoc On-Demand Distance Vector (AODV) routing protocol[7]-[15] is more popular and effective one in ad hoc networks like MANET and VANET communications. It is jointly developed in Nokia Research Center, University of California, Santa Barbara and University of Cincinnati. Since AODV is a reactive protocol, it establishes a route to a destination only on demand. It is capable of both unicast and multicast routing. Complexity of a protocol is measured by lowering the number of messages to conserve the capacity of the network, from that point of view AODV assures no extra traffic for communications along the existing links. AODV is invented from the Bellmann-Ford distant vector algorithm. We adopt to modify this AODV protocol by artificial swarm (ant colonies) intelligence technique.[15] Swarm Intelligence system is based on ant colonies. A colony of ants is able to find the best, i.e., the shortest path between their food source and nest by discharging chemicals, named pheromones. Pheromones are volatile in nature; all ants choose to move over tracks of high pheromone concentration. In the shortest path pheromone concentration is increased and the other ants are forced to choose this path. Likewise each node's (node's) position is identified by its latitude indicated by North or South from the Equator and longitude indicated by East or West from the Prime Meridian which are obtained from Global Positioning System, i.e., GPS antenna system. This latitude, longitude, and the movement of a node's direction in form of destination sequence number are broadcasted to all other node which are noted and updated in the look up table for routing purpose. All base station node maintain a look up table in form of the destination sequence number (nearest node) in a particular direction and periodically (say 2~3 minute) refresh it. In case a node wants to send information to another distant node, first of all it collects the information about the location of the destination node according to its destination sequence number. Then in that direction the shortest distanced available node within the source node's power coverage zone is connected according to the look up table of destination sequence numbers, and further this process is going on till the terminal (destination) node reached. This connection is set up through intermediate nodes and terminal node according to suggested Modified AODV (M-AODV) protocol. Modified AODV (M-AODV) finds a route from a source to a destination only when the source node wants to send one or more packets (traffic) to that destination either through several intermediate nodes or directly according to the source node's transmitting power coverage zone. The established routes are maintained as long as they are required by the source. It employs the destination sequence numbers to identify the most recent path. This destination sequence number is computed according to the nearest latitude, longitude, and direction of movement of the node in Modified AODV protocol. Here swarm (ant colonies) intelligence technique[15] is applied through the latitude, the longitude, and the direction of movement of a node which act as pheromone in ant colonies. A Route Request (RREQ) is flooded throughout the network and it contains the source address or identifier (SrcID), the source sequence number (SrcSeqNum), the destination address or identifier (DestID), the destination sequence number (DestSeqNum), the broadcast identifier (BcastID), and the time to live (TTL) field. Destination sequence number (DestSeqNum) is determined in accordance with latitude, longitude (both in normalized form, i.e., divided by 3600), and direction of movement of the intermediate or the terminal destination nodes (nodes) with respect to the source or the previous intermediate node.

The difference between Modified AODV and Dynamic Source Routing (DSR) is that DSR uses source routing in which a data packet carries the complete path to be traversed; hence

DSR uses high power consumption, large bandwidth and network overloading. The Modified AODV protocol is loop free and avoids the counting to infinity problem by the use of sequence numbers. This protocol offers quick adaptation to mobile ad hoc networks with low processing and low bandwidth utilization. Modified AODV protocol may be upgraded as quickest route discovery process by taking least information in Route Request (RREQ) packet which consists of source address or identifier (SrcID), the destination sequence number (DestSeqNum), the broadcast identifier (BcastID), and the time to live (TTL) field. Furthermore TTL field value is optimized in accordance with the cell structure and average number of nodes lying in the cell.

CONCLUSION

In this paper we have discussed Ad Hoc Network working principles with different routing protocols, among which AODV and Modified AODV routing protocol is the simplest and highly useful one for ad hoc mobile network. Malicious On-Demand Distance Vector Routing (MAODV) protocol is used to show the affect of malicious nodes on the performance of Adhoc On-Demand Distance Vector Routing (AODV). In MAODV malicious nodes are inserted at random locations in the existing AODV. For detection and removal of malicious nodes another protocol Reverse on Demand Distance Vector (RAODV) has been proposed. RAODV has been developed to take care of security of on-demand routing. AODV has been chosen as base protocol. RAODV is a secured protocol incorporated over AODV protocol, which overcomes the disadvantages of AODV and ensures the secure communication. It successfully detects and removes malicious nodes. It also establishes a new path which is more stable and secured for MANET routing. RAODV performance has been analyzed based on different metrics like Packet Delivery Ratio, Average End –To- End Delay and Throughput. The proposed protocol is compared with AODV and MAODV using analyse study. It recognizes the malicious node during the transmission and after removing them it establishes a stable and secure communication between source and destination.

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