Routing in Wireless Mesh Networks Using Mobile Agents

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Abstract -- **In this paper, we present the optimized routing technique for wireless mesh network based on the Hopfield neural network and mobile agent technology with primary goal to find an optimal route. Mobile agent technique is used to share the information of network conditions. Here, we realized the proposed routing technique through two independent methods. They are both based on the Hopfield neural network. In first method, an optimized route is selected based on multi criteria optimization in order to provide the best possible usage of resources. In second method, all routing minute to minute information is detected and shared all over the network. In this procedure, mobile agent technology has been proposed here. For optimization of the route, criteria are number of hops, link capacity and link occupancy. These criteria should use network resources as optimally as possible.**

Keywords: Component; Mobile technology; Hopfield neural network; Optimization.

I. INTRODUCTION

WIRELESS mesh networks (WMNs) are self-configurable and, self-healing wireless networks. Access point (AP), gateways, mesh clients, mobile nodes, mesh routers are the main components of a wireless mesh networks. In WMNs data is transferred hop by hop. And to forward a packet from source to destination, a number of hops may have to be visited. As the small network is extended to a large network, the chances of degradation of performance and reliability of routing process are more. Mostly several routing protocols used for MANETs are also used for WMNs. But when the size of a WMN is extended to a large area, the performance in such a network is going to be degraded. In the last few years, a number of routing algorithms for wireless mesh networks have been developed. But most of the algorithms are designed taking into consideration that all the nodes into network will take full cooperation in routing the packets form source to destination. Also some traditional already existing protocols such as DSR and AODV only takes one parameter 'minimum hop count' for routing decisions. Also there are several limitations in the existing protocols. But several other parameters must have to be considered such as signal power, mobility of the node, buffer occupancy, trust level etc of a node on a wireless network. But, it is not guaranteed that all the nodes in the wireless network will cooperate to each other in routing the packets from source to destination. Some nodes may refuse to forward packets as expected and due to this reason the reliability and performance of the network may be degraded. Fluctuations in number of users have influence on a rapidly changing topology. These changes occur randomly and dynamically. Furthermore, ad hoc networks, as opposed to cellular networks, are limited to a higher extent by the battery power of the network nodes. Also, limitations are related to the bandwidth and rate speed. WMN can be a standalone network, but at the same time it can be connected to any other public or private network. Nodes in WMN have to support traffic even in the cases when some of the communicating nodes become out of range. All these reasons, especially frequent network topology changes, make classical routing algorithm inappropriate for these networks.

In this paper, we present the routing algorithm for WMNs based on the Hopfield neural network, mobile agent technology with primary goal to find optimal path through dynamic network topology. This information is used for routing packets into the WMN. For this purpose, we used mobile agent technique. Mobile agent logic is realized by the Hopfield neural network, too. In this way, updated messages are broadcasted all over the network via optimized flooding technique.

The paper is organized as follows: Section I consists of brief descriptions of a wireless mesh networks. Related work is given in Section II. In Section III basic principles of Hopfield neural network work are given. Mobile technology is explained in section IV. Proposed routing technique is presented in Section V. Some simulation work is given in Section VI. Section VII concludes the paper.

II. RELATED WORK

In [3] S. Kumar *et al.* propose a framework for optimal routing in the WMN, an investigation work for the suitability of Big - Bang Crunch (BB-BC), a soft computing based approach to evaluate shortest/ near shortest path. Here, a fuzzy logic based inference mechanism evaluates the cost measure based on throughput, delay, jitter and residual energy at each node. A large number of simulation works has been taken out.

In [4] K.Sasikala proposes a Neuro fuzzy logic routing scheme. In this work, an algorithm NF-AODV is explained. The proposed sheme consists of a well-organized tree construction scheme which manages to decrease data overhead compared to customary ad-hoc routing protocol. To implement the proposed scheme, an auto-configuration scheme is used which provides nodes with topologically correct IP addresses and reduces system overhead. To evaluate the NF-AODV, a number of metrics are used such as average delay, pdf etc.

In [5] Nenad Kajie *et al*. propose a hybrid routing protocol for WMNs. In this work Hopfield neural network and mobile agent techniques are used. Here, mobile agent techniques are controlled by the Hopfield neural network. To achieve a better optimization, routing protocol observes real network parameters and real network environment with the help of mobile agent/ server technology. The proposed routing protocol is based on link state routing and takes into consideration several parameters such as number of hops, bandwidth, load and delay.

In [6] Nenad Kajic *et al*. proposes a routing algorithm for MANET. This algorithm is based on neural network. Here mobile agent technology is used to collect the information regarding link status and current updated network conditions. The proposed algorithm is completed in three phases: first, finding the shortest path, second, enabling the physical connection with MANET router, and third, enabling the logical connection with one of the gateways for providing the end MANET router. In case of route recalculation, the proposed algorithm takes into consideration the criteria's such as number of hops, link capacity and link occupancy.

III. HOPFIELD NEURAL NETWORKS

- The Hopfield network consists of a single layer of processing elements where each unit is connected to every other unit in the network other than itself.
- The units in the Hopfield model act as both input and output units.
- Hopfield model is an auto associative memory model, patterns rather than associated patterns pairs, are stored in memory.
- This type of network was described by J.J. Hopfield in 1982. Hopfield network is very simple: it has 'n' neurons which are all networked with each other. A Hopfield network is able to recognize unclear pictures correctly. However, only one picture can be stored at a time. In practical applications one must assume that many pictures will be given, which have to be stored and then classified.
- Training a Hopfield net involves lowering the energy of states that the net should "remember". This allows the net to serve as a context addressable memory system, that is to say, the network will converge to a "remembered" state if it is given only part of the state. The net can be used to recover from a distorted input the trained state that is most similar to that input.
- The two main difference between Hopfield and iterative auto associative net are that, in the Hopfield net,
  - Only one unit updates its activation at a time, and
  - Each unit continues to receive an external signal in addition to the signal from the other units in the net.
- This is called associative memory because it recovers memories on the basis of similarity. Suppose if we train a Hopfield a net with five units so that the state (1,0,1,0, 1) is an energy minimum, and we give the network the state (1,0,0,0,1) it will converge to (1,0,1,0,1). Thus, the network is properly trained when the energy of states which the network should remember are local minima.

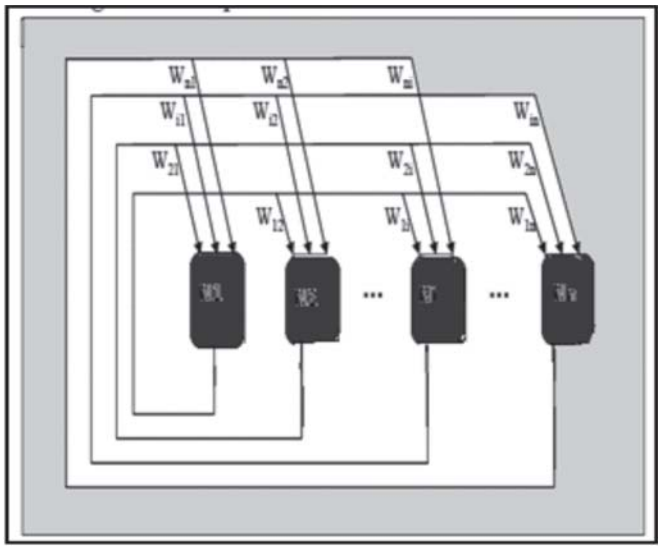

Figure 1. Hopfield Neural Network.

IV. MOBILE AGENT TECHNOLOGY

Mobile agent technology has been promoted as an emerging technology that makes it much easier to design, implement, and maintain distributed systems.

Mobile agents:

- Performs some processing at each host.
- Are small software entities.
- Are active objects.
- Are autonomous programs.
- Contains code, state and attributes.
- Decide when and where to move next.
- Having two types of mobility i.e. strong mobility and weak mobility.
- Encapsulate protocols.
- Execute asynchronously.
- Are robust and fast tolerant.
- Have several advantages such as reduced communication costs, asynchronous execution, direct manipulation,

dynamic deployment of software, easy developments of distributed applications; reduce bandwidth consumption and network loads.

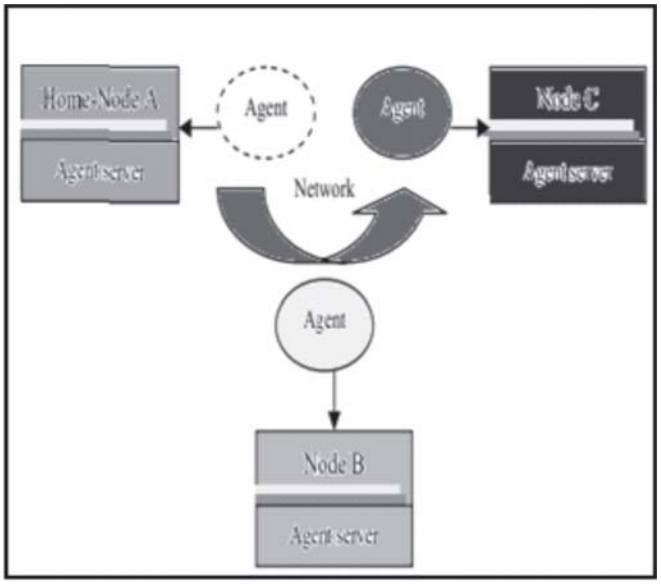

Figure 2. Mobile Agent Technique.

Java is one of the supporting languages for mobile agent technology. Mobile agent technology have several applications i.e. remote information retrieval, network management, cloud computing, mobile computing, software testing, active networking, and active documents.

- In mobile agent system, the agent visits the each node one by one and collects the necessary information from each node. Each node having a agent server. Mobile agent can easily communicate with agent server for sharing the information on the network.
- Mobile agents cooperate and communicate each other on the network.
- Mobile agents leave and collect information with each node with the help of agent server integrated with each node on the network.
- Mobile agent updates the routing table with the help of information collected by it and after this work; it also collects local information at this stage and then visit the next node.
- To minimize the overhead on the network the size of mobile agent must be small as well as possible.
- The events in the life cycle of the mobile agents are: (i) retraction (ii)disposal (iii)communication (iv) creation (v) dispatch (vi) cloning (vii) deactivation (viii) activation.
- Every mobile agent can access any node at an arbitrary time and share network information with its routing table.
- Every agent server can generate any number of mobile agents on the network. Every mobile agent has some path and needs to go through all known routers in network and come back to all its agents' server.
- Role of a mobile agent is to travel through a network and to discover every kind of changes, producing the information on it.
- Any change in the network can change all previously found "best" routes, and this procedure has to be repeated.
- Besides that link status changes have to be detected and observed by neural network. After recalculation, traffic can be rerouted if there is a better solution.

V. PROPOSED ROUTING TECHNIQUE

In the proposed algorithm, the procedure starts with the connection of a new user to a network. The WMN router detects the new device. We organize routing process into several phases. To accomplish the proposed routing algorithm, the following steps have to be followed:

Step1: Finding the shortest WMN routes (should be realized by software in mobile device),

Step 2: Enabling the physical connection with WMN router (which requires changing of the routing table data in the WMN router),

Step 3: Enabling the logical connection with one of the gateways for providing the connectivity to the distribution system over the end WMN router.

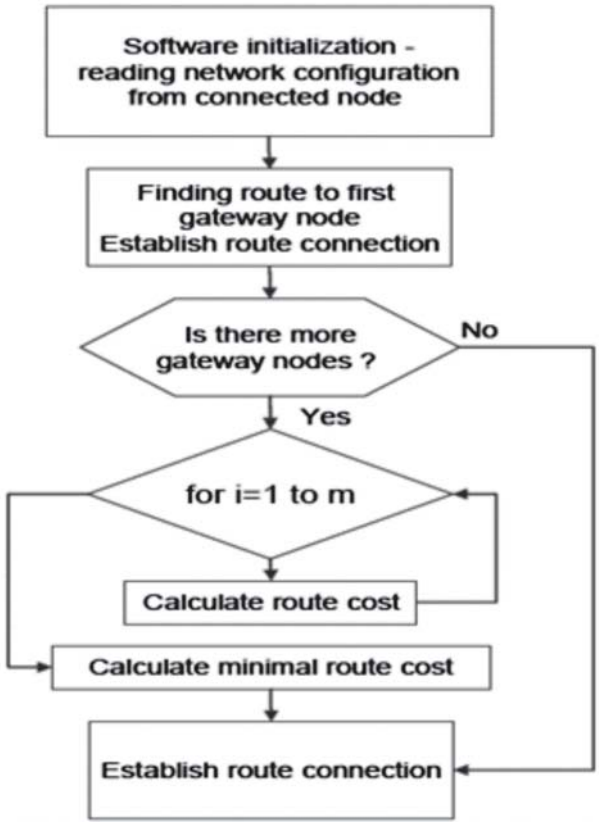

Figure 3. Proposed Routing Algorithm.

In Fig.3, algorithm of proposed routing protocol is represented. After routers initialization, based on information in routing tables, neural network finds the route to the first (nearest) gateway in the observed network topology.

Mobile device is going to be connected to this gateway. If there is more than one gateway, proposed algorithm will start the process of routing recalculations in order to find more suitable gateway and appropriate route to it. In this case, the criteria are number of hops, link capacity and link occupancy. These criteria should use network resources as optimally as possible. If such gateway and route is found, algorithm should perform the rerouting.

- Link status changes have to be detected and observed by neural network. After recalculation, traffic can be rerouted if there is a better solution. This sub procedure starts every time when these changes are detected.

VI. SIMULATION RESULTS

The proposed routing algorithm in wireless mesh network is realized in Matlab 7.0. We used dynamically created network topology based on arbitrary number nodes. One of the networks topology based on 15 nodes is shown here. All links are bi-directional with different parameters (explaining the links status and network topology) for different directions. Network topology, connectivity and number of nodes are changeable and user can define them through appropriate Graphic User Interface. Each link is described with three parameters: distance, capacity and traffic density. All values for all parameters are randomly generated and scaled to the interval [0-1].

If we assume that the nodes numbered as 11 12 and 13 are gateways, and the new user is connected to the router 1, our algorithm has to find first route as in Fig.5. Gateway.

12 has been chosen because this path is the shortest distance. This first phase is realized, and user is connected to Internet

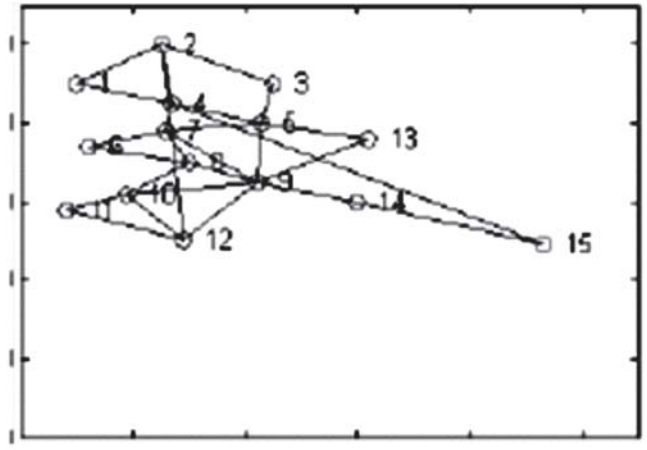

Figure 4. Network Topology based on 15 Nodes.

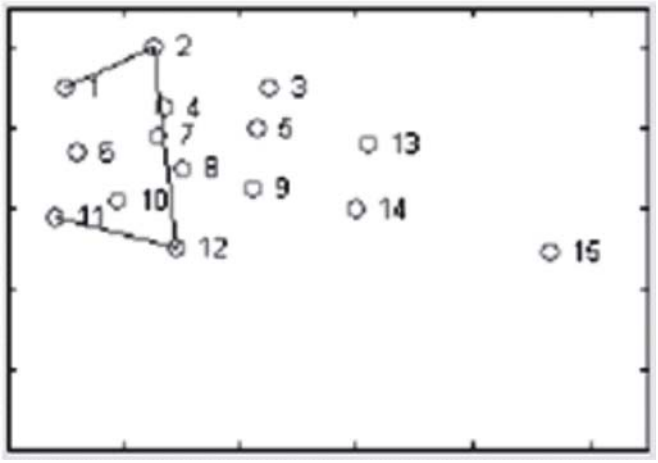

Figure 6. Route Based on Multicriteria Optimization When Wired Link Fromrouter 12 to Internet is Down.

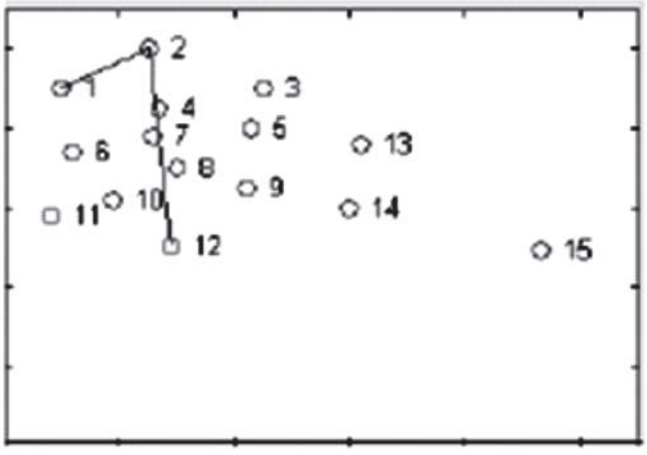

Figure 5. First Found Route from User' Connected Router to Gateway.

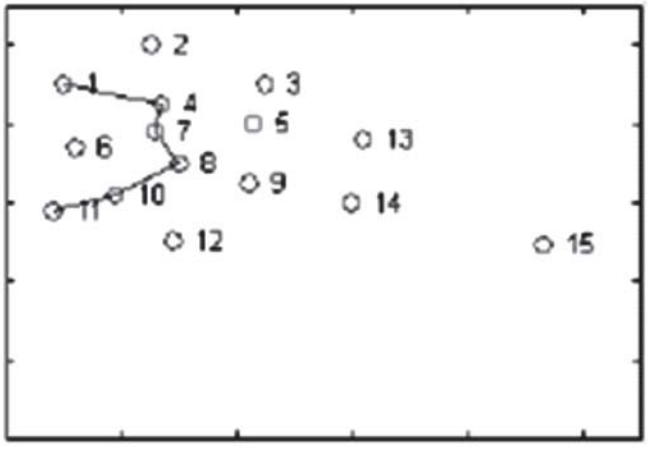

Figure 7. Route Based on Multi-criteria Optimization When Link 2-12 is Occupied by Another Connection.

through wireless mesh network. Second phase is finding of an optimal route based on multi-criteria optimization, including link capacity and traffic load or density.

Let us suppose the link between router 12 and Internet is down. This event needs immediate route recalculation, with minimal changes. New route is shown in Fig.6. Routing algorithm found the gateway 11 as the closest one, and made extension by link 12-11. Initially, link 2-12 is occupied by another connection, and the difference between link capacity and traffic density is too small. Neural network finds route 1- 4-7-8-10-11 as optimal for given input values, Fig. 7.

In this case, the user path is rerouted, and network is disburdened.

VII. CONCLUSION

In this paper, we propose an effective and efficient optimized route selection technique for wireless mesh network. This technique converges to a highly optimized path set very fast, and no message exchange overhead. The proposed routing technique can find the most optimized path set between any two nodes and there will be no need to discover new paths in the on-demand routing algorithm.

Here, a new multi criteria optimized route selection technique for WMN is presented. We have created new technique based on multi criteria optimization. We have analyzed a number of parameters to provide optimized usage of network resources. For this purpose, two techniques are used here, one is Hopfield neural network and second is mobile agent technology. Our proposed routing technique is scalable and it is adapted for dynamic network topology and real network environments.

VIII. REFERENCES

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