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TSR-AODV: A Reliable Routing Mechanism for Wireless Mesh Networks

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Abstract— Since wireless mesh networks are ad-hoc in nature, therefore routing protocols used for ad-hoc networks like AODV are also used for WMNs by considering only the shortest path to destination. In WMNs data is transferred to and from APs, and due to this, certain problems such as congestion on routes and overloading the APs are taken place. To obtain a reliable routing path, we have proposed a reliable routing mechanism in this paper. In this paper, we propose a fuzzy logic based, routing algorithm for finding a reliable routing path in WMNs. In this routing technique for each node, we calculate two parameters, signal power value and trust value, to find out the lifetime of routes. Each node along route discovery, stores its signal power value and trust value in RREQ message. In the destination with the help of fuzzy logic mechanism, a new parameter reliability value is determined from inputs signal power value and trust value of each route. The path having highest reliability value is selected as a stable route from source to destination.

Keywords— Wireless Mesh Networks, Fuzzy rules, Fuzzy logic, STR-AODV, Trust value, Signal Powers

I. INTRODUCTION

A wireless mesh network represents a series of peer-to-peer transmissions where each node functions as a router and repeater. Wireless Mesh Networks (WMNs) are one of the key technologies which will dominate wireless networking in the next decade. They will help to realize the long-lasting dream of network connectivity anywhere anytime with simplicity and low cost. Accordingly they will play a major role within the next generation Internet. Their capability for self-organization significantly reduces the complexity of network deployment and maintenance, and thus, requires minimal upfront investment. These networks consist of simple mesh routers and mesh clients, where mesh routers have minimal mobility and form the backbone of WMNs. They provide network access for both mesh and conventional clients [1]. To select a routing path in WMNs, the routing algorithm needs to consider possible unreliable network topology due to the multi-hop wireless environment. In addition, the routing path selection is intertwined with resource allocation, interference avoidance and rate adaptation across multiple hops. A routing protocol for WMNs can be *proactive* or *reactive*. For proactive routing, a routing path between two nodes is established before any traffic flow is initiated between them. A reactive routing starts to set up a routing path for two nodes only after traffic is generated between these two nodes. Based on its routing algorithm, a routing protocol can be executed in a centralized, distributed, or hybrid manner. AODV and DSR are the reactive routing protocols, in which RREQ (Route REQest) messages packets are used for route discovery purposes. AODV is distributed and tree-based routing protocol in which routing is centralized. DSDV is the proactive routing protocol [1]. In some application scenarios, reliability is more important than other performance objectives. In this case, multipath routing is a preferred approach, in which multiple routing paths are available to improve the reliability. With multiple routing paths available, they can be used to send traffic simultaneously, or only the best routing path is used and all other paths are for backup only. The former method can achieve better traffic distribution over the entire network, while the latter method is easier for protocol maintenance since only one routing path is used at a time. In some reliability aware routing protocols, multiple copies of a packet are sent to several routing paths from a client to the destination gateway [1].

Most of the works, regarding routing protocols have been done only on energy aware, bandwidth efficient, min hop -count, minimum cost. But less attention has been focused in making the routing protocol to select a more reliable route. In critical applications, like military operation, data packets are forwarded to destination on the basis of reliable nodes. In this paper, we propose a reliable routing mechanism TSR-AODV (a routing scheme) based on fuzzy logic. In this scheme, for each and every node, we have to calculate two parameters trust value and signal power value, to find out the lifetime of route paths. During route discovery, every node adds its trust value, signal power value in RREQ message. In the destination, based on 'reliability value' is decided which route have to be selected. The route having higher reliability value is selected from source to destination [2].

II. LITERATURE SURVEY

In [3] Nen-chung Wang et al, propose a stable weight-based on-demand routing protocol (SWORP) for MANETs. The proposed scheme uses the weight-based route strategy to select a stable route in order to enhance system performance .The weigth of a route is decided by three factors: the route expiration time, the error count, and the hop count. Route discovery usually first finds multiple routes from the source node to the destination node. Then the path with the largest weigh value for routing is selected. In [4], Nen-Chung Wang and Shou-Wen Chang also propose a reliable on-demand routing protocol (RORP) with mobility prediction. In this scheme, the duration of time between two connected mobile nodes is determined by using the global positioning system (GPS) and a request region between the source node and the destination node is discovered for reducing routing overhead. The routing path with the longest duration of time for transmission is selected to increase route reliability. In [5], Neng-Chung Wang etal, propose a reliable multi-path QoS routing (RMQR) protocol for MANETs by constructing multiple QoS paths from a source node to a destination node. The proposed protocol is an on-demand QoS aware routing scheme. They examine the QoS routing problem associated with searching for a reliable multi- path (or uni-path) QoS route from a source node to a destination node in a MANET. This route must also satisfy certain bandwidth requirements. They determine the route expiration time (RET) between two connected mobile nodes by using global positioning system (GPS). Then use two parameters, the route expiration time and the number of hops, to select a routing path with low latency and high stability. Some other proposed protocols are considering energy and trust evaluation as a factor of reliability. In [6], an approach has been proposed in which the intermediate nodes calculate cost based on battery capacity. The intermediate node takes into consideration whether they can forward RREQ packet or not. This protocol improves packet delivery ratio and throughput and reduces nodes energy consumption[8].In [7], Gupta Nishant and Das Samir had proposed a method to make the protocols energy aware .They were using a new function of the remaining battery level in each node on a route and number of neighbors of the node. This protocol gives significant benefits at high traffic but at low mobility scenarios [8].

III. PROPOSED ROUTING MECHANISM

In this section we propose our novel reliable routing mechanism. Trust value and signal power capacity value are the two main parameters in this method that make the routing algorithm more reliable.

A. Fuzzy logic controller

To solve hard optimized problems, fuzzy logic is a useful tool. Here, fuzzy logic has been used for routing and management of a wireless mesh network. In fuzzy logic, values of different criteria are mapped into linguistic values that characterize the level of satisfaction with the numerical value of the objectives. The numerical values are chosen typically to operate in the interval [0, 1] according to the membership function of each objective. The proposed mechanism takes into account of two input variables, signal power value and trust value. The absolute value of each of these parameters can take a large range at different points on the network. We have considered the normalized values for each parameter. Now 'crisp' normalized values are being converted into fuzzy variables. For this, two fuzzy sets have been defined for each variable. For the input variable signal power, the set, low (from 0 to 0.4), medium (from 0.2 to 0.8) and, high (from 0.6 to 1.0) have been used. For the input variable, trust value, the set poor (from 0 to 0.4), average (from 0.2 to 0.8) and excellent (from 0.6 to 1.0) have been used.

The normalized value of each parameter is mapped into the fine sets. Each value will have some grade of membership function for each set. The memberships that have been defined for each of the fuzzy set for any particular input variable are triangular in shape.

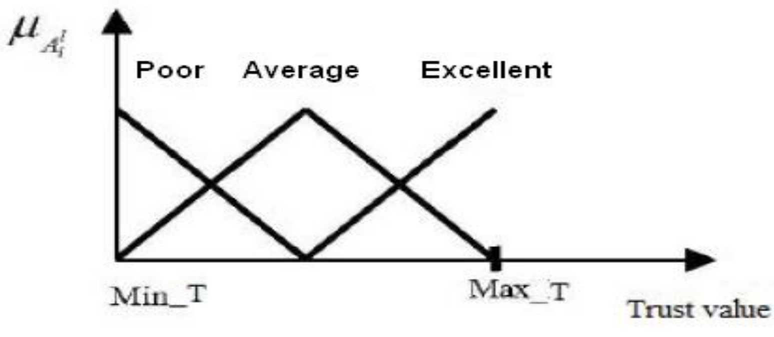

Fig.1 Membership function for trust value.

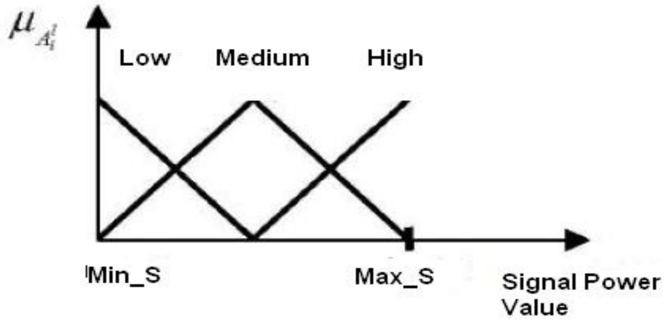

Fig.2 Membership function for signal power value.

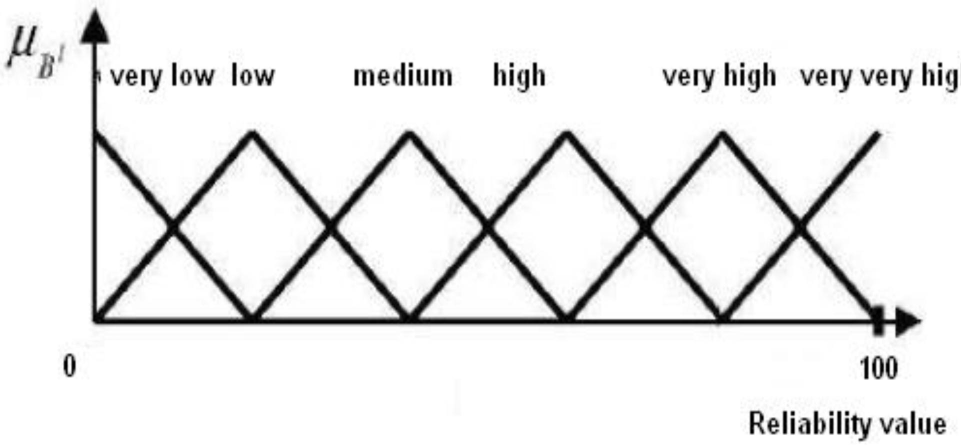

Fig.3 Membership function for Reliability value.

B. Reliability Evaluation

Reliability factor take different values based on rules of inference that dependent upon varied input values i.e. trust value and signal power value. The rules of inference have been written. A fuzzy system takes decision for two inputs variables which variables values appear in output;

$$f(x) = \frac{\sum_{i=1}^{6} \bar{y}^{l} \left(\prod_{i=1}^{2} \mu_{A_i^l}(x_i) \right)}{\sum_{i=1}^{6} \left(\prod_{i=1}^{2} \mu_{A_i^l}(x_i) \right)} \qquad (1)$$

In equation X_i represents crisp input ith (trust value, signal power value). $\mu_{A_i^l}(x_i)$ represents fuzzy membership function for input ith , and $\bar{y}^{l}$ is center average of output fuzzy set 1$^{st.}$.The fuzzy inference rules are as follows:

Rule 1: If trust value is excellent and signal power value is high then reliable value is very- very high.
Rule 2: If trust value is average and signal power value is high then reliable value is very high.
Rule 3: If trust value is excellent and signal value is medium then reliable value is high.
Rule 4: If trust value is average and signal power value is medium then reliable value is medium.
Rule 5: If trust value is poor and signal power value is medium then reliable value is low.
Rule 6: If trust value is anything and signal value is low then reliable value is very low.

The crisp value of input variable was given and a defuzzified crisp value for selected variable was calculated from the proposed routing mechanism. An output linguistic variable is used to represent the reliability value. The grade of membership function can be any where between 0 and 1 for each fuzzy set.

C. Route Discovery Process

- A source node S broadcasts RREQ messages to its neighbouring nodes in WMNs until they arrive at their destination node D. Each RREQ message have several fields such as source ID, destination ID, trust value, signal power value of nodes within the route.
- If the intermediate node Z receives a RREQ message and it is not the destination D, then the detail about the node Z is included to the RREQ message which is appended to message fields. Next, node Z again re-forwards the message to all the neighbouring nodes of itself.
- If node Z receives a RREQ message and node Z is the destination D, it waits a period of time, hence the destination D may receive a lot number of different RREQ messages from the source S. after this, it obtained the reliability value for every route path from source S to the destination D using the information in each RREQ message. In the final stage, destination node D sends a route reply message i.e. RREP along the route path having a maximum reliable value.

IV. SIMULATION SETUP AND RESULTS

For the performance analysis of the routing protocol extensions, the experimental setup is done using Matlab R2010b. The simulation for the performance evaluation may be done using *NS-2.34 network simulator*. Research has been taken out for the evaluation performance of the routing protocols in Wireless Mesh Networks. The main goal is to reduce the end-to-end delay and improve the PDF and throughout. The same parameters are used here for the simulation of both routing algorithms i.e. AODV and TSR-AODV. The following parameters are set for the simulation purposes as shown in table 1

Table1: Mesh topology simulation parameters

Parameter	**Value**
Number of Nodes	100
Packet Size	127 bytes
Data Rate	100k
Operational Frequency	2.4 GHz
Simulation Time	600 sec
Pause Time	100s, 200s, 300s, 500s, 700s
Topology Used	Mesh Topology
Mobility Strategy	Random Way Point
Transmission Radius of each node	20 m
Type of traffic	CBR
Domain	100m*100m*100m
Max Speed	1,5,10,15,20 m/s
Burst Time	200 m/s
Random Noise	0

Here, results are shown for performance of AODV routing algorithm and TSR-AODV routing mechanism. We analyze then using the metrics:

***EED (End-to-End Delay)*:** Refers to that the time taken for a packet to be transmitted across a network from source to destination [9].

PDF (Packet Delivery Ratio): The ratio of the number of delivered data packet to the destination [9].
This illustrates the level of delivered data to the destination.

Σ *Number of packet receive/*Σ *Number of packet send*

The greater value of packet delivery ratio means the better performance of the protocol.

Average Throughput: Throughput or network throughput is the average rate of successful message delivery over a communication channel. It is expressed in kilobits per second [9].

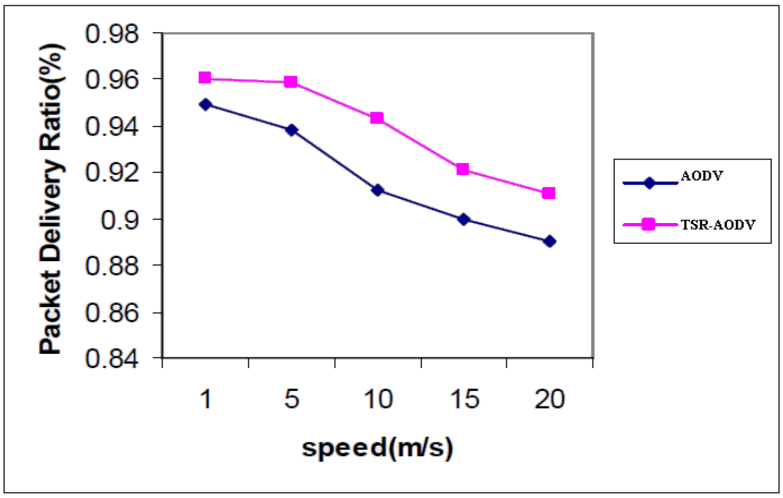

Fig.4 packet delivery ratio at different speed.

Fig.4 indicates the packet delivery ratio with different mobility speeds. When nodes moved at higher mobility speeds, both algorithms decreased the packet delivery ratio. The reason is that the routing path was easy to break when the mobility speed increased, but we can see that TSR-AODV transmits and receives more data packets than AODV. This is because TSR-AODV always chooses the most stable route for transmission packets along the path instead of choosing the shortest path.

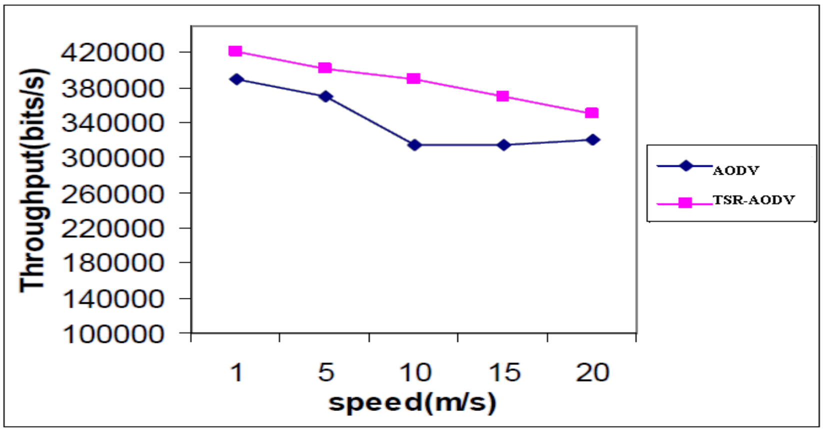

Fig.5 Throughput at different speed.

In Fig.5 result shows that throughput of both routing mechanisms reduces when the speeds increase. When the speed of the node increased, the routing path was more unreliable. Here, the reason is that there were more chances for routes to break when the speed of the node was faster. Thus, the number of rebroadcasts increased. Since TSR-AODV has chosen more reliable route than AODV, we can see that it has performed better at all speeds.

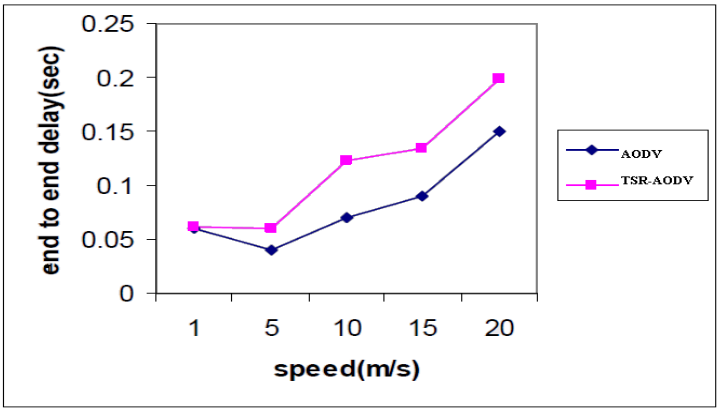

Fig.6 End to End delay at different speed.

Fig.6 represents average End to End Delay with speed as a function .As result shows that AODV has fewer delays than TSR-AODV. Higher delay in the proposed routing mechanism is because of the time it has wasted for discovering the route with longer life, so the packets would in the meanwhile stay in the buffer until a valid route is found. This takes some time and will, therefore, increase the average delay while AODV chooses the shortest path as a valid path.

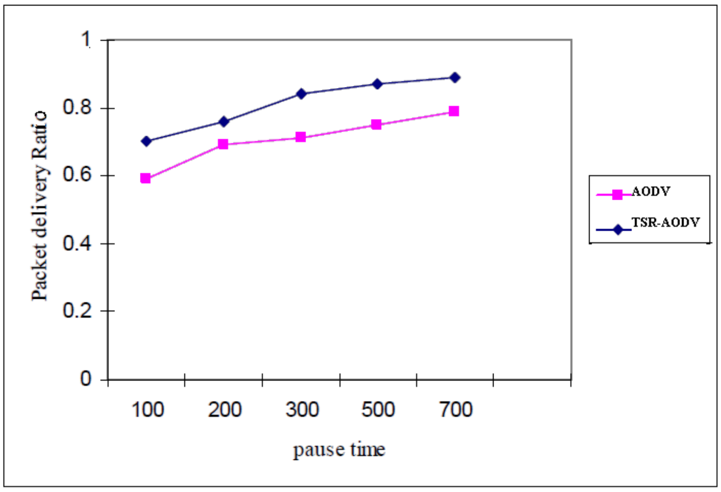

Fig.7 Packet Delivery Ratio at different pause time.

Fig.7 represents the performance of packet delivery ratio under various 100s, 200s, 300s, 500s, and 700s pause times. The results indicates that packet delivery ratio in TSR-AODV is better as compared to AODV.

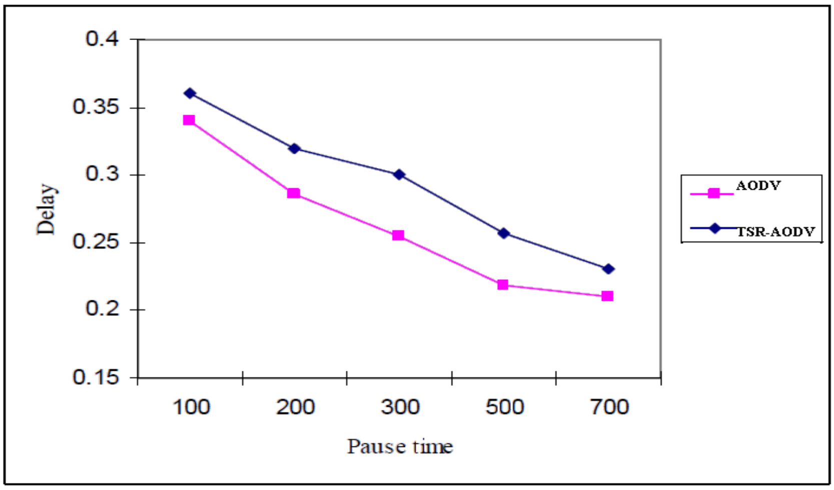

Fig. 8 End to End delay at different pause time.

The results in Fig. 8 indicate that TSR-AODV obtains a high end to end delay. In TSR-AODV, route selection is based on trust value and signal power value not on the minimum number of hops as in AODV.

V. CONCLUSION

Wireless mesh network is most popular technology as compared to other wireless technologies as its initial infrastructure cost is low. One of the most important issues influencing performance of WMN is the routing protocol used. Existing routing protocols such as DSR, AODV changes their route based on their length. To maximize the performance of WMN, a reliable routing mechanism TSR-AODV using fuzzy logic is proposed in this paper. In this routing technique, we calculate three parameters/variables trust value, signal power value and reliability value that are used to find out a reliable route from source to destination. During route discovery, each node stores its trust value in RREQ message. On the basis of reliability value, the destination node decides which routes have to be followed. The routing path having highest reliability value is selected for the communication from source to the destination. The simulation results represents that the proposed routing mechanism has significant reliability improvement as comparison to AODV. For simulation results have been compared using the metrics packet delivery ratio, throughput and end to end delay. Using the propose scheme, we can obtain a reliable routing path for WMNs.

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