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Link Stability Decision Based Routing Protocol for MANET Using HMM Model

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Abstract: Link stability is a challenging aspect while configuring a routing protocol for dynamically changing topology of Mobile Ad hoc Networks (MANET). The frequent mobility of the nodes causes partitioning the network, path lost and dropping of transmitted packets. In order to achieve reliable and stable link, Link Stability Decision Based Routing Protocol (LSBR) which addresses link quality of intermediate mobile nodes in the MANET is proposed. The parameters like residual energy and SNR of the individual nodes are considered to estimate the stability of the route while transmission of data packets by Hidden Markov Model (HMM). This prediction model is associated with Congestion and Energy Aware routing protocol (CAERP) for improving the link stability as well as energy delay trade off in the MANET. This proposed LSBR protocol compared with existing DSR based routing protocols and this protocol provides better performance metrics in a optimal way.

Key words: MANET, routing protocol, link stability, energy, delay, Markov model

INTRODUCTION

MANETs are attractive in the decisive medium of current day to day communications due to easy deployment and infrastructure-less architecture. There is no centralized coordinator to control the nodes in the network. The communicating devices in the MANET are allowed to move freely within the network premises. Generally, the nodes are self configuring in nature. The movement of the nodes is having autonomous behavior, i.e., the direction of movement; velocity and the location are independent from its neighbor. Due to the mobility of the nodes, the topology of the network changed frequently. It causes the recurrent path changes between the sources to destination. The distraction of the path induces the packet loss during the data transmission. The retransmission of the data packet and the new route discovery is indirectly affecting the energy utilization of the nodes.

The mobile nodes are act as a transceiver as well as router for packet transmission. Hence, every node have to identify the path changes is necessary to achieve the link stability in order to ensure the reliable delivery of data packets. However, link stability issues are more important in many characteristics for the selection of route to destination in MANETs.

In the phase of routing process the route discovery and route maintenance are major function performed by the mobile nodes. Due to the frequent movement of the nodes the transmitted data packets are dropped and it is over come by achieving the link stability and finding neighbor node mobility. The quality of the link also varied due to the nodes movement, it pretense the difficulty to find the reliable and stable multi-hop route path for successful transmission of data packets.

After the path change, finding the new path is a challenging task. Hence the routing protocols already implemented have to be redesigned carefully. In such a way that, these implementations can adopt with the dynamic environment effectively to achieve the continuous data transmission without any packet loss.

The main application areas of the MANETs are particularly appropriate for critical situations such as, military, smart homes and different types of disasters management. The MANET reveal dynamic topology, bandwidth constraint, link capacity, attack vulnerability and energy constraints. The nodes in the multi-hop environment spend their energy for its own transmission and reception; apart from that energy also consumed for transmissions of neighbors' data packets. Because of the shared environment the packets are sent from source to destination through multi-hop paths. Hence, the reliable transmission of data packets depends on the energy of the individual nodes in the network. Thus by implementing a routing protocol along with the link stability yields better energy utilization, packet delivery ratio, delay and throughput.

Literature review: Moussaoui *et al*. (2014) proposed a mechanism associated with the Optimized Link State

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Routing Protocol (OLSR) to select stable and sustainable Multipoint Point Relay (MPR) nodes. It reduces greatly the recalculation of MPR and routing table updating process. It uses stability function as important criteria to the path selection. It is based on the mobility degree of the intended node neighbor. This implementation assures the quality of service requirements like response time and pocket loss.

Song *et al.* (2012) described the link stability in MANETs which having dynamic network topologies. A novel scheme has been implemented to estimate the link stability which is based on the frequent changes of links in the network. The network layer parameters alone are used to monitor the network change without use of lower layer parameters. The estimation scheme is adoptable to all the mobility models and irrespective of topologies. Then the proposed routing protocol adjusts its mode based on the link stability estimated. This scheme can able to provide precise estimation in both scenarios stationary and non-stationary.

Sridhar and Chan (2005) presented a routing protocol for MANET, based on stability and hop count. The stability metric is measured by means of the residual lifetime of a link. First, it inspects how the residual link life time is affected by the parameters, like speed and mobility pattern. According to the Associativity Based Routing (ABR), the older links are considered as more stable compared to the newer one. It proposes the stability and hop count based routing. The histogram estimator is used to calculate the stability of the path.

Nair and Muniraj (2012) proposed the Prediction based Link Stability Scheme (PLSS) for MANETs in order to achieve the link stability. To extend the network lifetime it makes the balance between the path stability, link, nearer node and total mobile nodes. The proposed scheme optimally reduces the packet loss and yields reliable stability. It consists of four phases such as stability of nearer node, link, route path, mobile nodes and calculation of the entire network lifetime. It assures better performance ratio such as delay, energy consumption, network life time and packet delivery ratio.

Rekha Patil presented the QoS aware routing protocol based on the link stability. The main task of the QoS routing is to optimize the resource utilization as per the application requirements. In order to overcome the system degrades due to the mobile nodes, a concentration should be focused on the link quality. Hence, the authors implementing the link quality prediction based on mobility estimation for further routing decision. Upon the implementation of the link stability estimation and cost matrix the system provides best in class QoS support.

Jenn-Hwan Tarng proposed the radio link stability based routing protocol for MANETs. The proposed Ad hoc on demand Stability Vector (AOSV) routing protocol posses the link stability prediction and novel path selection algorithm to ensure the stability of the frequently changing network. The prediction of the radio link stability is computed by stochastic mobile to mobile propagation model. It is also ensures the stability of the multi hop route path. Then the path finding algorithm explores the stable path with biggest route stability for the defined transmitter to receiver pair.

Wu *et al.* (2011) presented the AODV based routing protocol for MANETs. It addresses the link stability and bandwidth efficiency in a considerable manner, in order to avoid the frequent link changes. This scheme utilizes the distributed Q-learning to gather the network information. The information such as link stability and bandwidth efficiency are taken into consideration for selecting the appropriate stable route path for communication. If efficiently handles the mobility in the network and efficiently switches the new route when the current route fails.

Dana *et al.* (2011) proposed a reliable routing algorithm for MANETs based on fuzzy logic for Ad hoc networks. In this scheme for each node they solve two parameters namely trust value and energy value, for calculating the lifetime of transmission route. Each and every node along to the route discovery process, records its trust value and energy capacity in route request packet. In the receiver with the help of fuzzy interference system, a new parameter reliability value is generated in order to select the more reliable path from sender to receiver.

MATERIALS AND METHODS

LSBR protocol implementation: In this proposed scheme the hidden Markov model has been used to predict the nodes state whether it has included in the best path or optimum path. The optimum link is considered for current transmission path via this justification. The parameters SNR and the residual energy are used to predict the output. The residual energy is one of the important parameter which is used to define the current status of the node itself. If the residual energy goes beyond a threshold value, it is very difficult to send the information without any loss and it has some limitations concerned with distance. The second parameter SNR is also one of the parameter which is used to justify the nodes signal level with respect to path loss. By input this two parameters to the Markov model, It is confined that the output is in three modes like best link, optimum link and link to be avoided. Residual energy calculation per node is as follows:

$$E_{Un} = E_{Td} + E_{Rd} \quad (1)$$

$$E_{Re} = T_E - E_{Un} \quad (2)$$

Where:

T_E = The initial energy of the node
E_{un} = Energy utilization of the node
E_{td} = Energy transmitted
E_{rd} = Energy received
E_{re} = And residual energy

SNR calculation: The parameter d is the distance between the nodes and d_0 is a reference distance. The parameter β is called path loss exponent and is determined by the physical environment. Some typical values of β can be found for simulation β = 4 was chosen which is a typical value observed in obstructed in building environments. The SNR measurements of an example link with taking only the path loss into account. The second part of the shadowing model is an added random variable which is used to model different effects on the received signal strength when the nodes of the link are in motion:

$$\frac{P_r(d)}{P_r(d_0)} = 10\beta\log^{d}_{d0}\,[dB] \quad (3)$$

The distance between the intermediate nodes to sink is calculated by Friss transmission formula. X_{dB} has a Gaussian distribution with zero mean and standard deviation σdB is called shadowing deviation and is also determined by the physical environment.

Hidden Markov Model of LSBR protocol: Figure 1 shows the state transition diagram of prediction principle of finding output states based on hidden and observed states of Markov process. In this state transition, higher priority is given to SNR attribute of the nodes rather than residual energy. Probability of SNR and residual energy should be always one for predicting the next state. If the value of SNR and residual energy is higher than last observed one, the state of the machine is remains same. The state machine observes three types of prediction like best link, optimum link and link to be avoided, respectively.

```
States = ('SNR ','Res_energy' )
Observations = ('Link to be avoid',' Optimum link',' Best link')
Start Probability = {'SNR ':0.6,'Res_energy ':0.4}
Transition Probability={
    'SNR' : {'SNR ':0.7,'Res_energy ':0.3},
    'Res_energy ': {'SNR ':0.4,'Res_energy ':0.6},
}
Emission Probability={
    'SNR': {'Link to be void':0.1,'Optimum link':0.4, 'Best link':0.5},
    'Res_energy ': {'Link to be avoid':0.6,'Optimum link':0.3, 'Best link':0.1}
}
```

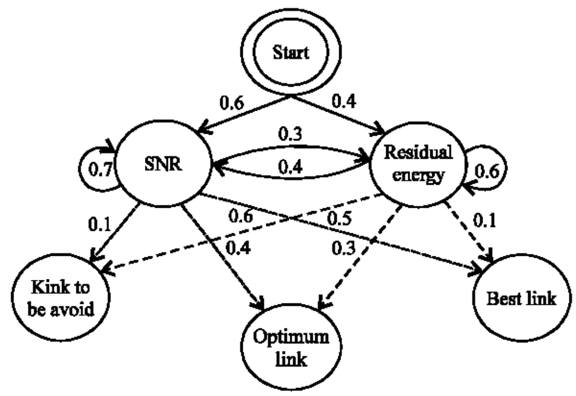

Fig. 1: Hidden Markov model of LSBR protocol

The state machine prediction is to be best link when the probability of the SNR and residual energy is high. In this prediction model, the SNR is computed along with distance metrics. If the SNR is said to be high value in behind the distance between the sources to sink is also low, it implies very low noise on the link. Although, the residual energy is less compared to the threshold, it is considered as best link because of the distance metric (i.e., the node consumes minimum energy for short distance).

The observation state is optimum link, only when the probability of the SNR and residual energy is closer to the threshold values. The value of the SNR should be slightly higher than the residual energy to achieve the link quality.

The state machine observation is link to be avoided, when the probability of the SNR is low and Residual energy is high. Even though the residual energy is high compared to the threshold, it is considered to be avoided link because of the SNR value is too low. It means the noise level of the link higher than the signal level, in behind reducing the link stability.

RESULTS AND DISCUSSION

Performance evaluation: The performance characteristics of the proposed LSBR compared and evaluated with DSR and RRAF routing protocols.

The metrics like energy utilization, delay, throughput and packet loss are measured and compared with the existing one. Table 1 shows the simulation settings of the proposed system. The LSBR implemented with the NS2 simulation environment, the numeric results are illustrated in Table 2.

Figure 2 and 3 demonstrates the metrics pockets load in Kbs versus energy consumption and delay. From the Fig. 3, it shows that the average energy utilization of the proposed system gradually increases when the number of nodes increases above half of the total number of nodes deployed. However, that the energy consumption is reduced the number of nodes is minimal. From the Fig. 3, it shows that the delay of the proposed system is getting contradicted when the number of nodes increases. The delay is reduced when the number of nodes is minimal.

According to Fig. 3, the delay difference between the above said two is very minimal deviation. Figure 4 is plotted between packet loads in Kbs versus number of packet dropped. It shows that the proposed system reduces the packets drop in a considerable amount, since proposed system uses the new prediction mechanism.

Figure 5 and 6 are plotted between loads in different data rates versus number of packet dropped, throughput respectively. It shows that the proposed system reduces the packets drop compared to the existing stated technique. In Fig. 6 the throughput metric of LSBR getting improved minimal compare to the existing system. The overall numeric simulation results show that the proposed technique enhances the parameters like energy utilization, delay, drop and throughput.

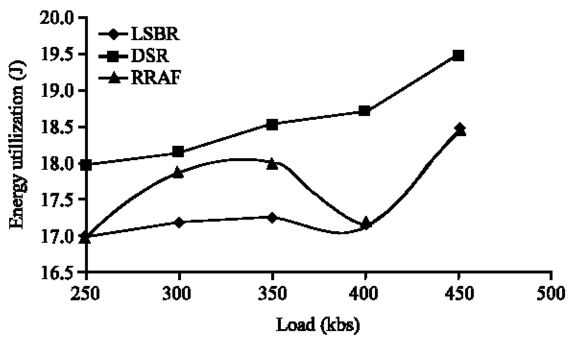

Fig. 2: Load vs. energy utilization

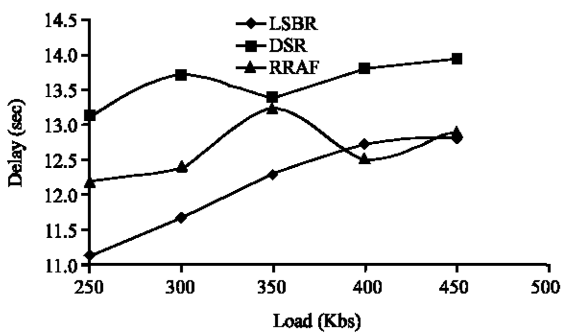

Fig. 3: Load vs. delay

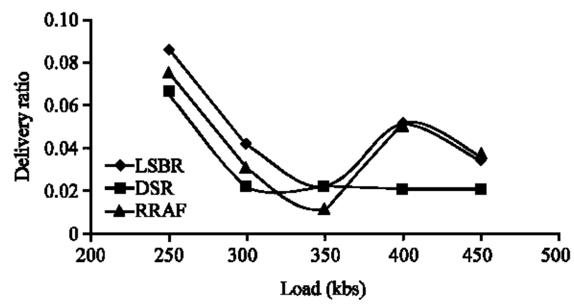

Fig. 4: Load vs. drop

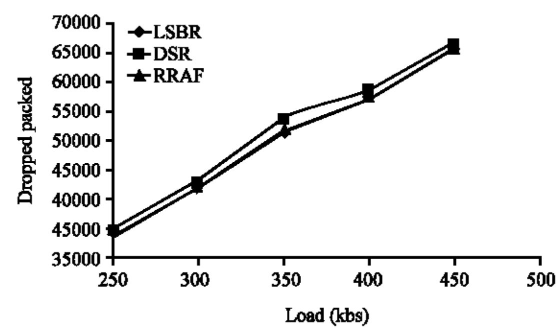

Fig. 5: Load vs. drop

Table 1: Simulation settings

Parameters	Values
No. of nodes	20, 40, 60, 80 and 100
Area	1250×1250 m
MAC protocol	IEEE 802.11 DCF
Radio range	250 m
Simulation time	90 s
Routing protocol	LSBR
Packet size	512 B
Speed	10 m sec^{-1}
Pause time	5 sec
Rate	250-Kb/s
Mobility model	Random kay point
Tx power	0.660 W
Rx power	0.395 W
Initial energy	14.1 J

Table 2: Numerical results

Load	Energy			Delivery ratio			Delay			Drop			Throughput		
(Kbs)	LSBR	RRAF	DSR	LSBR	RRAF	DSR	LSBR	RRAF	DSR	LSBR	RRAF	DSR	LSBR	RRAF	DSR
250	16.9671	16.9681	17.9687	0.08595	0.07590	0.0659	11.1382	12.1982	13.1340	38325	38720	39320	0.1358	0.1028	0.1248
300	17.1727	17.8798	18.1567	0.04217	0.03117	0.0221	11.6737	12.4042	13.6987	45317	45345	46327	0.2204	0.2104	0.2100
350	17.2296	18.0096	18.5389	0.02191	0.01171	0.0219	12.2904	13.2150	13.4120	53566	53998	55569	0.2121	0.2020	0.1821
400	17.0820	17.1720	18.7290	0.05073	0.05073	0.0209	12.7118	12.5118	13.7868	58758	58762	59780	0.2315	0.2510	0.1795
450	18.4843	18.4645	19.4860	0.03495	0.03875	0.0207	12.8295	12.9000	13.9297	65832	65992	66898	0.2541	0.2649	0.1549

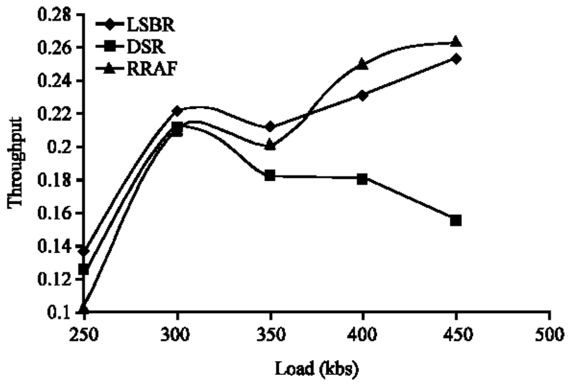

Fig. 6: Load vs. throughput

CONCLUSION

The proposed LSBR implemented with NS2 event driven simulator and compared with existing DSR and RRAF routing protocol. In this protocol, the node selection is predicted based on the Hidden Markov Model. The parameters SNR and residual energy are fed as input to the model and the output defines whether the link is taken into account or not. Further the pocket transmission can be performed in the newly predicted link. It leads link stability, reduced energy utilization and improved throughput in the network. The numerical results of the performance parameters like energy utilization, delay, throughput, packet drop of the proposed system are analyzed. It shows that the LSBR outperforms existing stated routing protocols.

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