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# AODV Routing Algorithm with Link Prediction Model

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**Abstract:** Due to the high mobility nature, transportation of message in the network is challenging. Mobility is the main reason of frequent link breaks. The frequent change in routes adversely affects the QoS in the network. QoS can be improved by knowing the probable availability of future routes. The statues of the routes, can be determined if the availability of links between the nodes can be predicted. In this paper, we introduce an analytical model for link predication. Since, the exact distribution of link availability is unknown, we have applied Laplace distribution. Epoch length and rate of change in velocity of nodes have been considered two parameters of the distribution. We have incorporate link availability model in AODV Routing algorithm. With simulation, various network scenarios were analyzed to prove the model's correctness and characteristics.

## 1. Introduction

Mobile Ad hoc Network (MANET) is co-operative collection of mobile computers communicating with each other through wireless links, without requiring any supporting infrastructure. In MANET all the nodes can connect dynamically in an arbitrary manner due to their mobility. The nodes in the network behave both as autonomous nodes and as routers. In MANET, node mobility affects the quality of service requirement of applications by causing frequent link failures. Quality of service can be assured by achieving, a more deterministic network behavior. In MANET because of the random mobility of the nodes, network behavior is not deterministic mostly. Therefore probabilistically approach can help in predicting the network behavior and thus providing QoS.

In this paper, a probabilistic approach is used that can help in finding the availability of future routes. Availability of a route in future mainly depends on the availability of links between the nodes forming the route. Therefore, it is important to predict the future availability of a link that is currently available. Here, we have introduced an analytical model for link predication using Laplace distribution. Since, the exact distribution of link availability is unknown, we have applied Laplace distribution considering epoch length and rate of change in velocity of nodes as two parameters of the distribution.

The paper is organized as follows. In section 2, related work is introduced. Section 3, gives the details of link predication model proposed for estimation of link availability for a given period. The simulation results based on the proposed model with AODV routing algorithm are discussed in section 4. Finally, section 5 summarizes the work.

## 2. Related Work

Damla Turgut, Sajal K. Das and Mainak Chatterjee [12], present an algorithm that predict the expected lifetime of the link which is independent of speed and direction of nodes in the networks for different mobility model. Predication of route life time they used transmission range of node. Some mobility model which are used by author in the literature are Deterministic, Partially deterministic and Brownian motion. In Deterministic model, movements of all nodes are completely defined so it is easy to calculate the time when they will move away to each other transmission range. Partially deterministic mobility model have movement of all nodes with certain probability. But in Brownian motion, motion of all nodes is random between 0 to $2\pi$ and velocity is random at any given time.

Shengming Jiang, Dajiang He and Jianqiang Rao [10] have proposed a prediction based link availability estimation model, for MANET. This model predicts the probability of an active link between two nodes being continuously available for a predicted period based on the current node's movement. They used exponential distribution for prediction of link availability. In this model authors considered the change of node movement, but did not consider the rate of change that may effect the prediction.

Min Quin, Roger Zimmermann and Leslie S. Liu [11] develop a model predicting the availability of link between mobile peers for support multimedia streaming. The authors have presented a mathematical framework for analyzing the link predictability for a short duration.

Dario Pompili and Marco Vittucci [14], proposed a probabilistic predictive multicast algorithm for ad hoc networks. This algorithm predicates the next position of node. This way routing algorithm gets the stable link in the network. For the link predication authors used the power of node for link predication and given an analytical model for link predication.

K´aroly Farkas, Theus Hossmann, Lukas Ruf, Bernhard Plattner [13], proposed an approach to predict link quality variation based on pattern matching which is affected by mobility of node. This approach called XCoPred. Author used SNR (Signal to Noise Ratio) for link predication. When network need to prediction of link, node tries to detects the pattern similar to the current situation in the history of the SNR values of its link by applying the normalized cross-correlation function.

## 3. Link Predication Model

In this section, we introduced model to estimate the future status of link availability using Laplace distribution. In this model, we assume that the mobility epoch lengths are exponentially distributed with mean $\mu$, and the rate of velocity change is b. An epoch is considered a random variable and defined as a random length interval during which a node moves in a constant direction at a constant speed. The probability of epoch length lesser than equal to x is given as

$$F(x) \square \ \mathrm{P}\,\{\text{Epoch length} \leq x\}$$

F(x) is cumulative distribution function for Laplace distribution and is given below :

$$F(x) \square \frac{1}{2b}\int_0^{\mu} e^{\frac{(x-\mu)}{b}}\,dx + \frac{1}{2b}\int_{\mu}^{tp} e^{-\frac{(x-\mu)}{b}}\,dx$$

The parameter b represents the effects of variance such that probability of link availability changes rapidly for higher value of b. For an active link between two nodes at time $t_0$, the availability of this link, $L(T_p)$, is defined as

$$L(Tp) \square \ \mathrm{P}\,\{\, t_0 \leq t \leq T_p \,\big|\, \text{Link is available at } t_0 \,\}$$

Further, $L(T_p)$ can be calculated in two parts. First, the link availability $L_1(T_p)$ is calculated when the velocities of the two nodes keep unchanged between $t_0$ and $t_0 + T_p$. Second case $L_2(T_p)$ represents the condition when both the nodes change the velocity. Therefore, $L(T_p)$ is calculated

$$L(T_p) = L_1(T_p) + L_2(\phi) \qquad (1)$$

$L_1(T_p)$ can be easily calculated as the nodes are not changing velocity. It will be equal to the P{epoch > $t_0$ +$T_p$ l link is available at $t_0$} and is given as

$$L_1(Tp) = [1 - F(Tp)]^2$$

$$= \frac{\left(e^{-\frac{\mu}{b}} + e^{-\frac{(t_p-\mu)}{b}}\right)^2}{2} \qquad (2)$$

Let Φ is a random variable that denotes variable time interval $t_0 < \Phi < T_p$ during which one or both node change velocity. We assume that $t_0 < \phi$ is time interval in which nodes are not changing their velocity. After $t_0 + \phi$ time, nodes change their velocity. $P\{\phi < \Phi < Tp\}$ denotes the probability that both the nodes do not change their velocity between $t_0$ and $t_0 + \phi$ and either of them or both change velocity after $t_0 + \phi$. Therefore, $P\{\phi < \Phi < Tp\}$ is given as

$$P(\phi < \Phi < Tp) = 2[F(T_p) - F(\phi)][1 - F(T_p)] + [F(T_p) - F(\phi)]^2$$

$$= \left[ e^{-\frac{\phi}{b}} - e^{-\frac{T_p}{b}} + e^{-\frac{(T_p+\phi-2\mu)}{b}} + e^{-\frac{2(T_p-\mu)}{b}} \right] \quad (3)$$

$l_2(\phi)$ is calculating the estimate of link availability, when nodes are changing their velocity after $\phi$ time interval This is given as

$$l_2(\phi) = \frac{\phi + (T_p - \phi) p L_1(T_p - \phi)}{T_p} + \varepsilon = \frac{\phi + (T_p - \phi)\frac{p}{4}\left(e^{-\frac{\mu}{b}} + e^{-\frac{(T_p-\phi-\mu)}{b}}\right)^2}{T_p} + \varepsilon \quad (4)$$

Where p represents the probability that two nodes move closer to each other after changing their velocity. $\varepsilon \geq 0$ is an adjustment to the link availability.

Now $\overline{l}_2$ denotes the average $l_2(\phi)$ over $\phi$, and is used to estimate $L_2(T_p)$. $\overline{l}_2$ is given as

$$\overline{l_2} = \int_0^{T_p} l_2(\phi) f(\phi) d\phi \qquad (5) \qquad (5)$$

where $f(\phi) \geq 0$ is given by

$$f(\phi) = \lim_{\Delta\phi \to 0} \frac{P\{\phi \leq \Phi < T_p\} - P\{\phi + \Delta\phi \leq \Phi < T_p\}}{\Delta\phi}$$

$$= -\frac{-dP\{\phi \leq \Phi < T_p\}}{d\phi}$$

$$= -\frac{1}{2b}\left(2e^{-\frac{\phi}{b}} - e^{-\frac{2(\phi-\mu)}{b}} - e^{-\frac{(T_p+\phi-2\mu)}{b}}\right) \quad (6)$$

By substitute $l_2(\phi)$ and $f(\phi)$ in Eq.5 with Eq. 4 and 6, respectively, we obtain the following.

$$\overline{l_2} = \int_0^{T_p} L_2(\phi) f(\phi) d\phi$$

Therefore, $L(T_p)$ is estimated as follows:

$$L(T_p) \approx L_1(T_p) + \overline{l_2}$$

## 4. Simulation Results

We have incorporate link availability model in AODV [7] Routing algorithm for simulation. Various network scenarios were analyzed to prove the model's correctness and characteristics. We choose GlomoSim [39], because is a scalable simulator that was designed especially to large radio networks. It maintains thousands of nodes, utilizing the parallel environment and distributed. Every plot was taken as an average of ten different runs. In the simulation experiment, we tested networks from 20 up to 100 mobile nodes. In all the simulations, we used standard parameters of the channel and radio model: channel capacity of 2MB/s, free space propagation model and radio propagation range of 100 meters.

The IEEE 802.11 protocol was used as the medium access control protocol. The mobile nodes use the random waypoint as the movement model. The range of the speed is from 1 to 20 m/s. The traffic was produced using a traffic generator, which made randomly constant bit rate (CBR) sessions. The data packet size was 512 Bytes.

Modified AODV have less link break then AODV in simulation. Due to the less link failure network delivery rate improves because there is no packet loss and end-to-end delay decreases as source node avoid searching new route to continue transmission after link failure.

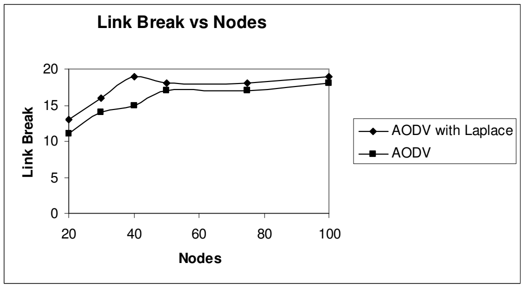

Fig 1 Link Breaks vs Nodes

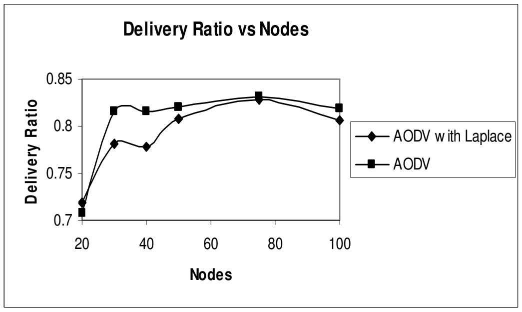

Fig 2 Delivery Ratio vs Nodes

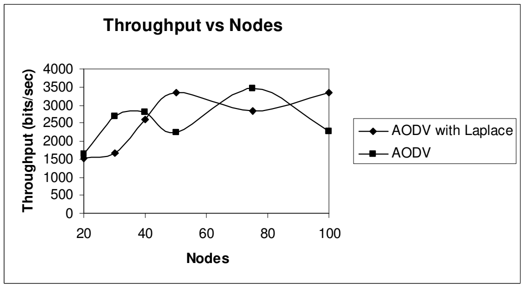

Fig 3 Throughput vs Nodes

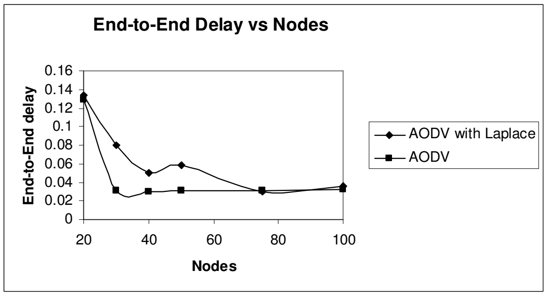

Fig 4 End-to-End Delay vs Nodes

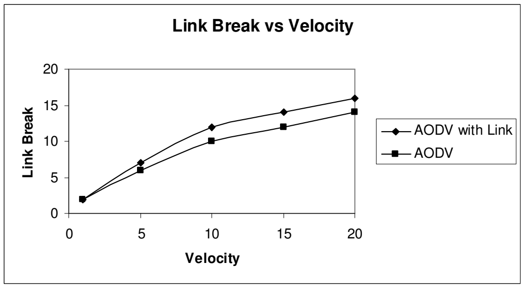

Fig 5 Link Break vs Velocity

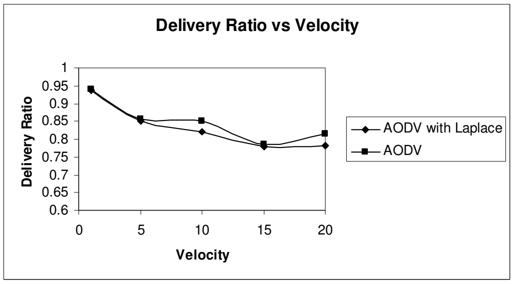

Fig 6 Delivery Ratio vs Velocity

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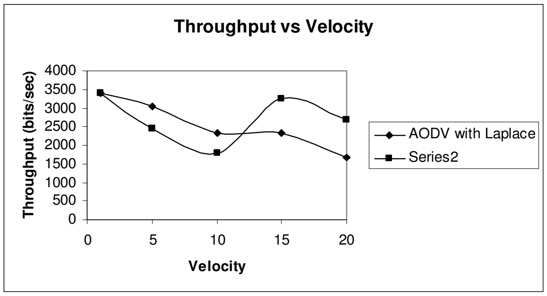

Fig 7 Throughput vs Velocity

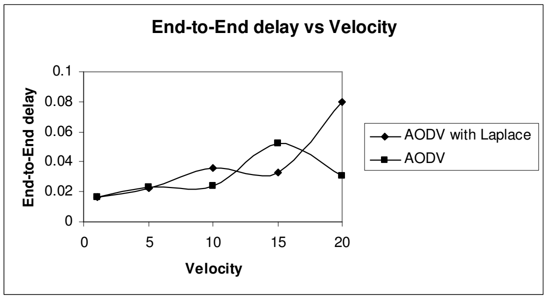

Fig 8 End-to-End delay vs Velocity

## 5. Conclusion

In this paper, we have presented an analytical model for link predication in mobile ad hoc network using Laplace distribution. Simulation results show the improvement of AODV algorithm. Work can be extended with incorporation of link availability model with other routing algorithm.

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