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Quality of Service Based Routing in Manet Using Route Handoff

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Abstract: In wireless mobile ad hoc networks (MANETs), packet transmission is impaired by radio link fluctuations. This paper proposes a novel channel adaptive routing protocol which extends the Ad hoc On-Demand Multipath Distance Vector (AOMDV) routing protocol to accommodate channel fading. Specifically, the proposed Channel-Aware AOMDV (CA-AOMDV) uses the channel average nonfading duration as a routing metric to select stable links for path discovery and applies a preemptive handoff strategy to maintain reliable connections by exploiting channel state information. Using the same information, paths can be reused when they become available again, rather than being discarded. Using this method CA-AOMDV has greatly improved network performance over AOMDV.

Key words: Mobile ad hoc networks · Routing protocols · Channel adaptive routing

INTRODUCTION

Wireless mobile ad hoc networks (MANETs) are selfconfiguring dynamic networks in which nodes are free to move. A major performance constraint comes from path loss and multipath fading .Many MANET routing protocols exploit multihop paths to route packets [1]. The probability of successful packet transmission on a path is dependent on the reliability of the wireless channel on each hop. Rapid node movements also affect link stability, introducing a large Doppler spread, resulting in rapid channel variations .Routing protocols can make use of prediction of channel state information (CSI) based on a priori knowledge of channel characteristics, to monitor instantaneous link conditions. With knowledge of channel behaviour, the best links can be chosen to build a new path, or switch from a failing connection to one with more favorable channel conditions. Several channel adaptive schemes that have been developed for MANETs to maintain connection stability can be found in the literature. In this paper, we introduce an enhanced, channel-aware version of the AOMDV routing protocol. The key aspect of this enhancement, which is not addressed in other work, is that we use specific, timely, channel quality information allowing us to work with the ebb-and-flow of path availability. [2] This approach allows reuse of paths which become unavailable for a time, rather than simply regarding them as useless, upon failure and discarding them. We utilize the channel average nonfading duration (ANFD) as a measure of link stability, combined with the traditional hop count measure for path selection [3]. The protocol then uses the same information to predict signal fading and incorporates path handover to avoid unnecessary overhead from a new path discovery process. The average fading duration (AFD) is utilized to determine when to bring a path back into play, allowing for the varying nature of path usability instead of discarding at initial failure [4].

Mobile-to-Mobile Channel Model: In MANETs, potentially all nodes are in motion, so it is appropriate to use the mobile-to-mobile channel model to characterize the channel between any two nodes. It is practically difficult to find the relative speeds between mobile nodes, so this channel model has the advantage of only using the individual node speeds. It incorporates large-scale path loss and small-scale flat fading. For transmission over a distance, d, in the presence of flat fading, the received signal power is exponentially distributed with mean $G_0d^{-\alpha}$, where G_0 is proportional to the transmitted signal power and α is the propagation loss coefficient, typically between two and four.

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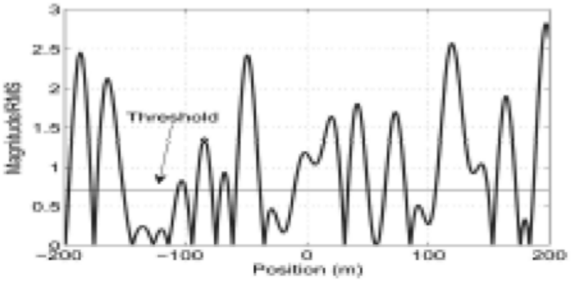


Fig. 1: Fading Waveform With Threshold Indicated.

Average Nonfading Duration: The average nonfading duration is affected by both the physical propagation environment (e.g., obstacles such as trees and buildings) and the node velocities. A typical fading waveform is shown in Fig. 1. The ANFD, average length of time that the signal envelope spends above a network-specific threshold, Rth

$$v = \frac{1}{\rho \text{fT} \sqrt{2\pi(1+\mu^2)}} = \frac{c\sqrt{\text{G0}}}{\text{Rthd}^{a/2}\text{f0}\sqrt{2\pi(2\text{vT}^2 + \text{vR}^2)}}$$

where ρ is the ratio between the transmission threshold and the root-mean-square power of the received signal ($\rho = Rth/Rrms$) where $Rrms = \sqrt{G0d^{-a}}$, fT= f0VT is the maximum Doppler shift of the transmitter, f0 is the transmitter signal carrier frequency, c =3 *10^8ms^{-1} is the speed of electromagnetic radiation,and μ= vR/vT is the ratio of the receiver velocity to that of the transmitter where vR and vT are the receiver and transmitter node velocities, respectively [5].

It can be surmised from that the value of the ANFD is high for low-transmission threshold (low ρ) and decreases with an increase of μ or ρ . Further, increased node mobility (captured by vR and vT) would cause a corresponding decrease in the ANFD due to the increased rate of signal fluctuations and that an increased link distance (via d) would cause a decrease in ANFD due to a greater path-loss influence.In MANETs, choice of stable links for route establishment ensures reliable packet transmission. Link stability can be represented by the distance between the nodes forming the link and their mobilities. Thus, any measure of how stable a link is should include these factors. The ANFD is inversely proportional to link length, d and node velocities vT and vR. The ANFD of a link between two highly mobile or separated nodes will be shorter than that of a link between two slow moving and/or close nodes. In short, a link with a high ANFD will have a relatively long lifetime. Thus, using the ANFD as a metric will result in choosing more stable links. There is minimal extra calculation required to determine ANFD. The parameter Rrms can be garnered from received packet signal strengths and fT can be calculated via fT= f0VT. Thus, to calculate nodes simply need to include speed and location in the header of each packet.

Average Fade Duration: The average fading duration, is the average length of time that the signal envelope spends below Rth. Transmission is not considered possible while the signal envelope for a link is below the threshold. The AFD for the mobile-to mobile channel is given by

$$\aleph = \frac{e^{\rho^2} - 1}{\rho \text{fT}\sqrt{2\pi(1+\mu^2)}}$$

The AFD metric is used in CA-AOMDV to determine for how long a faded link will be unavailable and is recorded in the route cache.

Route Discoveries in CA-AOMDV: Route discovery in CA-AOMDV is an enhanced version of route discovery in AOMDV, incorporating channel properties for choosing more reliable paths. We defined the ANFD for one link of a path, according to the mobile-to-mobile channel model. CA-AOMDV uses the ANFD as a measure of link lifetime.The duration D, of a path is defined as the minimum ANFD over all of its links.All node inserts its current speed into the RREQ header.

$$D = \min_{1 \le h \le H} \text{ANFD}$$

where h is link number and H is number of links/hops in the path.

Route Maintenance in CA-AOMDV: In mobile environments, it is necessary to find efficient ways of addressing path failure. Using prediction and handoff to pre-empt fading on a link on the active path, disconnections can be minimized, reducing transmission latency and packet drop rate. Route maintenance in CA-AOMDV takes advantage of a handoff strategy using signal strength prediction, to counter channel fading. When the predicted link signal strength level falls below a network specific threshold, the algorithm swaps to a good-quality link. The fading threshold is chosen so as to

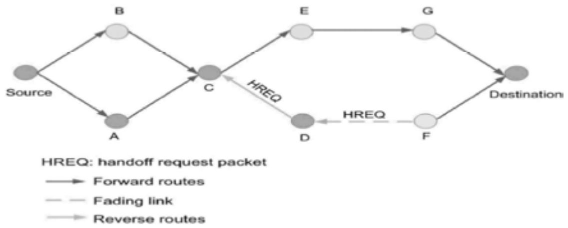


Fig. 2: Handoff Process

provide robustness to prediction errors. The presence of multiple users experiencing independent channel fading means that MANETs can take advantage of channel diversity.

All nodes maintain a table of past signal strengths, recording for each received packet, previous hop, signal power and arrival time. Ideally, there will be M packets However, this will depend on the packet receipt times compared with the specified discrete time interval, Δt. If packets are received at time intervals greater than Δt, sample signal strengths for the missed time intervals can be approximated by the signal strength of the packet closest in time to the one missed. If packets are received at intervals of shorter duration than Δt, some may be skipped. An example of how handoff occur in CA-AOMDV is shown Figure 2.

The handoff process is implemented via a handoff request (HREQ) packet. The CA-AOMDV handoff scheme is described below.It consists of prediction length,handoff trigger,handoff table, Forwarding The Hreq.

Prediction Length: The LMMSE prediction algorithm performs quite poorly if not matched to the current channel conditions. Therefore, the prediction length should not be too long. In CAAOMDV, a given node may have multiple paths to the destination, each with a different next hop node. If an intermediate node has multiple paths to the destination, upon receiving an HREQ it can immediately switch from the active path to a good alternative one, without further propagating the hreq. Therefore, the time needed to implement a handoff in ca-aomdv is the duration, in terms of the discrete time interval Δt, for the hreq to be propagated to the fading link uplink node. For example, if ni and nj are neighbors in a given path and nj predicts a fade on link i-j, it will generate a hreq and forward it to ni.

Prediction length in corresponds to the number of discrete time intervals, Δt, for transmission of a hreq between nj and ni which can be approximated by using the data propagation time Tij from nj to ni.

$$\Psi = round\left(\frac{Tij}{\Delta t}\right)$$

where “round” is the integer rounding function. In addition to choosing a threshold with a suitable error margin, as described above, to enhance the robustness of the prediction process to errors in CA-AOMDV, the signal strength is predicted at $t0+\Psi$ and $t0+2\Psi$.

Handoff Trigger: Route handoff is triggered when a link downstream node predicts a fade and transmits a HREQ to the uplink node. Let TR be the transmission range, assumed to be the same for all nodes, let R^(t) be predicted signal strength at time t and Rth as the fade prediction threshold. If the prediction at $t0+\Psi$ is above Rth while that at $t0+2\Psi$ is below, the maximum transmitter velocity vmax ensuring signal strength above Rth at $t0+\Psi$ is determined. The HREQ registers the following fields: source IP address, destination IP address, source sequence number, AFD and vmax [6].

Handoff Table: All nodes maintain a local handoff table. This is used for avoiding duplicate HREQ. Each entry includes: source IP address, source sequence number, destination IP address and expiration timeout - indicates when a path is expected to be available again.

Forwarding The Hreq: Any node receiving a non duplicate HREQ checks for alternative paths to destination nd. Otherwise, if it has one or more “good” alternative paths to the nd, it marks the fading path indicated in the HREQ as dormant, setting the handoff dormant time in its routing table entry for that path to the AFD recorded in the HREQ. The HREQ is then dropped. If a fade is predicted on the active path, a nondormant alternative path to nd is then adopted. The dormant path is retained for use when the fade is over, reducing path discovery overhead.

RESULTS AND DISCUSSION

We now compare AOMDV and CA-AOMDV with respect to node mobility. The simulated network areas were 2200m× 600m and 2800m×600m. Fig. 3. Shows Throughput decreases with increased node mobility. The graph shows that CA-AOMDV outperforming AOMDV. Normalized routing control overhead is the ratio of number of routing control packets to delivered data packets. Overhead for both protocols increases with increasing node mobility because the more quickly

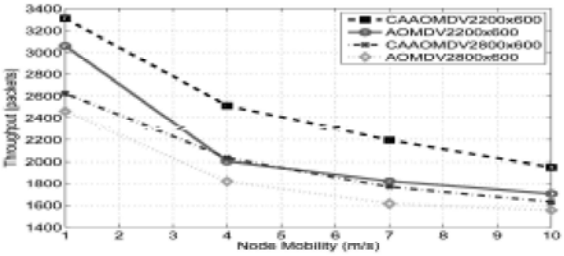


Fig. 3: Network throughput comparison between CA-AOMDV and AOMDV with increasing node mobility.

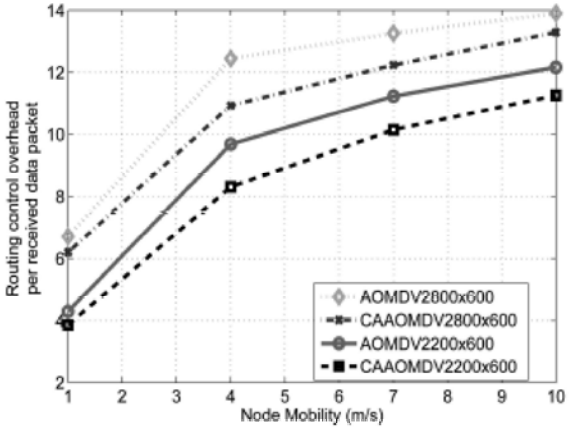


Fig. 4: Routing control overhead (normalized with respect to delivered data packets) comparison of CA-AOMDV and AOMDV with increasing node mobility.

changing network topology increases routing update frequency.Similarly CA-AOMDV maintains a lower routing overhead compared with AOMDV as shown in Fig. 4.

Here we obtain the path discovery and failure detection in ad hoc networking using ns2 simulator is shown in Figure 5-12.

Path Discovery:

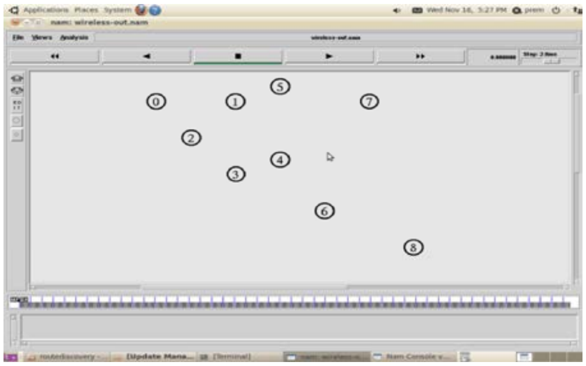


Fig. 5: Node Initialization

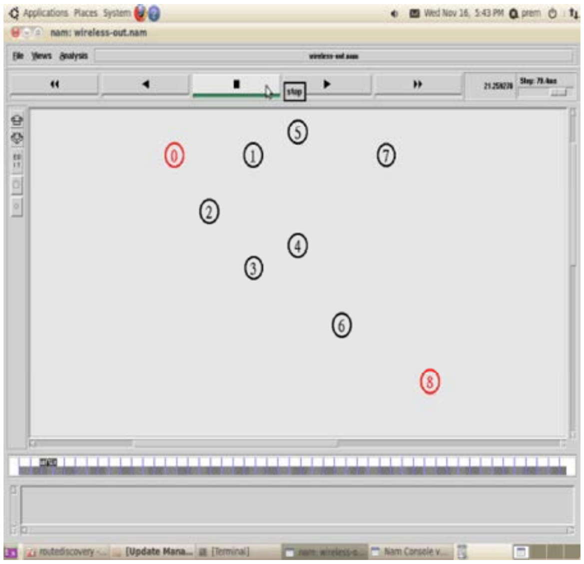


Fig. 6: Source and Destination

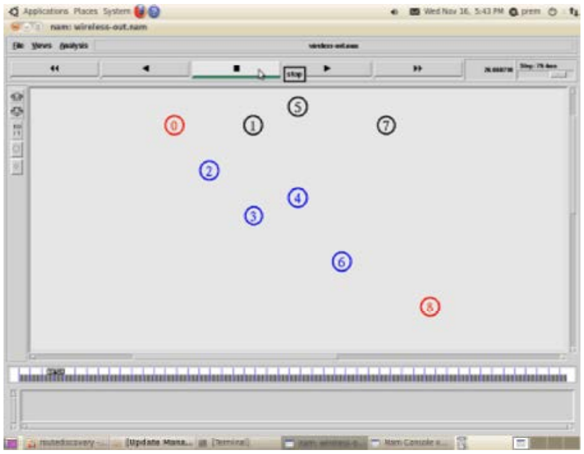


Fig. 7: Path Discovery

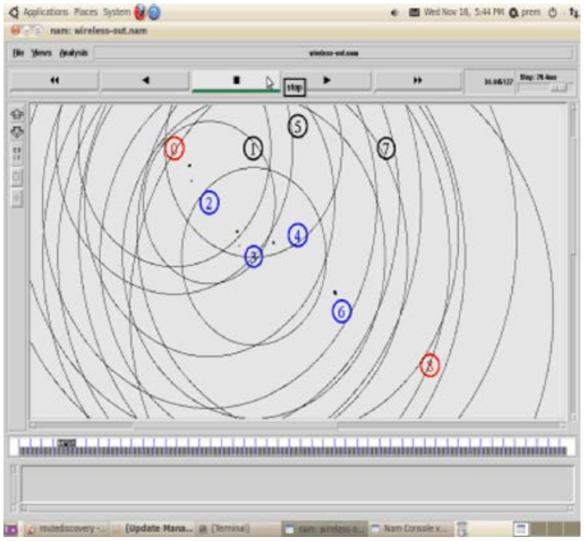


Fig. 8: Packet Transmission

Failure Detection

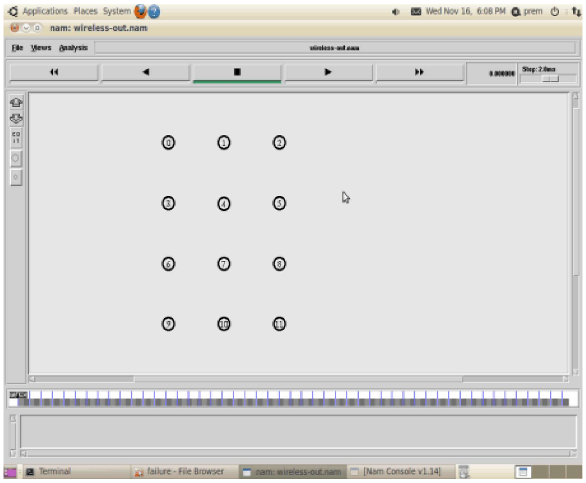
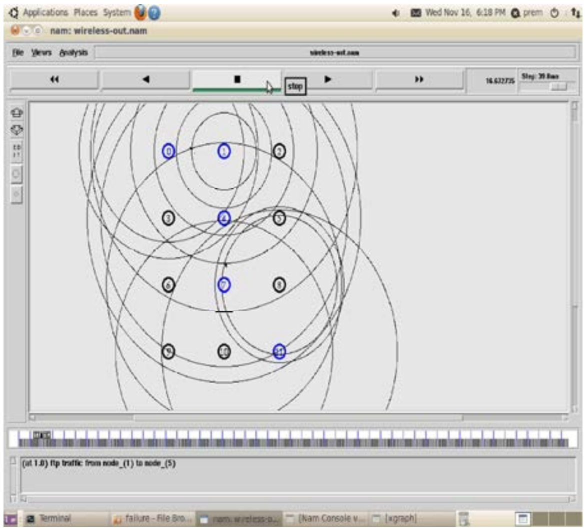


Fig. 9: Node Initialization



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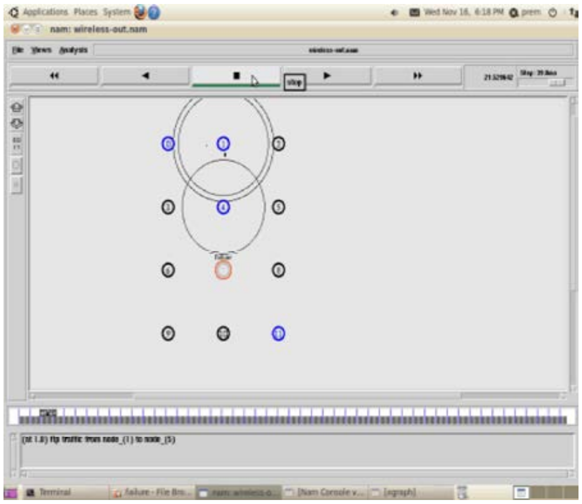
(at 1.0) ftp traffic from node_(1) to node_(5)
```

Fig. 10: Path Selection



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(at 1.0) ftp traffic from node_(1) to node_(5)
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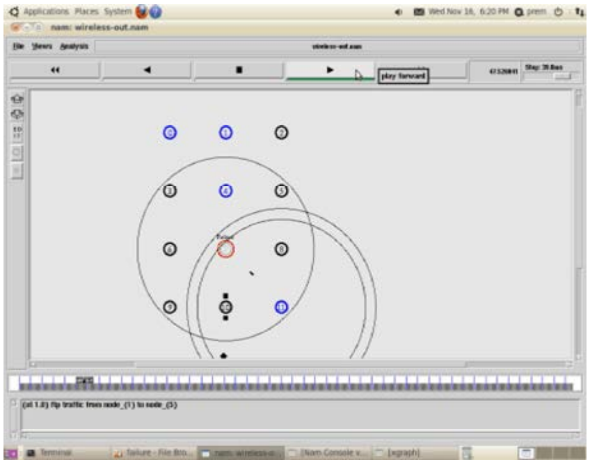
Fig. 11: Node Failure



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(at 1.0) ftp traffic from node_(1) to node_(5)
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Fig. 12: Packet Loss Indication

CONCLUSION

A channel-based routing metric is proposed which utilizes the average nonfading duration, combined with hop-count, to select stable links. A channel-adaptive routing protocol, CA-AOMDV, extending AOMDV, based on the proposed routing metric, is introduced. During path maintenance, predicted signal strength and channel average fading duration are combined with handoff to combat channel fading and improve channel utilization.Simulation results show that CA-AOMDV outperforms AOMDV in practical transmission environments [7-10].

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