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An Efficient AODV Routing Protocol for Vehicular Ad hoc Network

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Abstract*: Vehicular Ad-hoc Network (VANET) is considered as a sensor network with special characteristics and some advance features. For VANET nodes treated with high mobility and fast topology change. These nodes can sense its neighboring area to provide various services like traffic monitoring, speed of vehicle and some environmental parameters monitoring. One of the advance reactive routing protocol is Ad Hoc on-demand Distance Vector (AODV) is most commonly used routing protocol in topology based routing. This paper is presenting improved AODV protocol, in order to consider different parameters like node mobility, sent packet rate, delay and throughput. Results are implemented using Network Simulator-2.

Index Terms*: Cooperative Communication, Intelligent Transportation System (ITS), Packet combining, VANET.

I. INTRODUCTION

One of the basic objectives of Vehicular communication network is to provide improved road safety and ease with Intelligent Transportation Systems (ITS).Different researchers developing new technologies and protocols for enhanced data transmission between two vehicles (nodes) to a vehicular network. Like Mobile Ad hoc Network (MANET), VANET presents rapid intelligent and challenging technology. In both each node acts as a data terminal and a router [3]. VANETs considered as distributed, self organizing network to provide communication for moving vehicles. Many researchers trying to develop Vehicular Ad-hoc network because of its flexibility and free network communications.

II. SYSTEM MODEL AND ASSUMPTIONS

VANET architecture can be divided into three different parts as Mobile, Infrastructure and Generic [1-3]. Relays are being introduced in cellular networks to improve coverage to mobile users in the cell and the overall network capacity. Correct placement of relays in the cell area is necessary for ensuring that maximum improvement in the performance of the network due to the introduction of relays. Some papers like [4] have analyzed this issue but in very primitive scenario. Shadowing and fading has not been considered in the relay placement analysis in this paper. Another paper [5] designs channel partitioning and relay placement schemes for GSM cellular networks. It uses the number of users supported by the system as a performance metric for system design.

We consider a channel model with shadowing and cellular OFDMA air interface case which has not been analyzed in this paper.

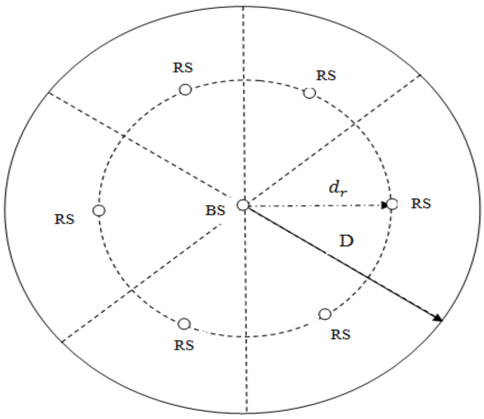

Fig.1. Relays are arranged symmetrically in a single ring around the base station

The probability of successful decoding for a transmission between the base station (BS) and the mobile station (MS), is chosen as the performance metric. We determine the optimal position of relays which maximizes this metric [6,7]. Resources such as power and bandwidth are shared between the BS and RS. With a limit of total resources, we also address the issue of optimal resource allocation to relays coupled with relay placement. Optimal relay placement is analyzed for two cases. Firstly, Global System Multiplexing (GSM) cellular systems which use a single carrier frequency for packet transmission and secondly cellular OFDMA systems with multiple subcarriers used for a single point to point packet transmission [8] .

III. SYSTEM MODEL

1. Description of relays

Consider a cellular system with 6 relays placed symmetrically in a single ring around the base station, as shown in Fig.4. The relays are assumed to be decode-and-forward transparent relays [10, 16]. Transparent relays do not transmit any control signals to the mobile and hence the mobile is unaware of the existence of such relays. Transparent relays act as slaves to the base station which centrally schedules the relay transmission. The relay overhears packet transmission to or from the mobile without communicating directly to the mobile, and forwards this packet on the downlink or uplink when scheduled by the BS [11].

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We also assume that the BS always chooses the relay closest to a mobile for forwarding that mobile's packets. Thus the coverage area of each relay becomes a sector of angle Π/3 as shown in Fig. 4. Thus, each relay is responsible for forwarding the data for mobiles in its own sector.

2. Topology used for analysis

With the relay selection method described in the previous section, it is sufficient to consider the problem of optimal relay placement in just one sector of the cell as shown in Fig.2.

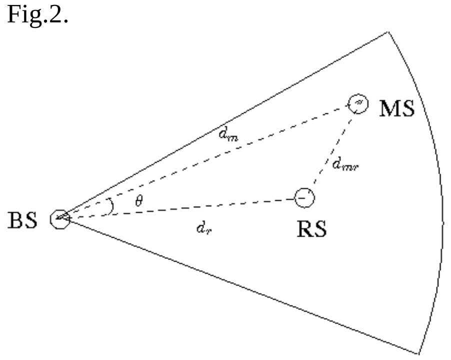

Fig. 2: The RS which closest to the MS is used for it for relaying the data between the BS and the MS. Thus, it is sufficient to consider the probability of success for MS positions in a sector of angular width Π/3.

Let the radial distance of the relay from the base station be d_r Mobiles are assumed to be uniformly distributed over the area of the cell. For the purpose of analysis we consider mobile station located at a distance of dm from the base station and at an angle $cos\theta$ from the radial line between relay and base station. Thus the distance between relay and mobile is

$$d_{m,r} = \sqrt{d_r^2 + d_m^2 - 2d_r d_m}\ cos\theta \qquad \ldots\ldots\ldots\ldots (1)$$

3. Automatic Repeat request (ARQ)

It is assumed that the ACK and NACK packets are always received correctly. The data packets are decoded correctly if the signal to noise ratio at the receiver is above a given threshold Based on this criterion, the probability of correct decoding is defined in the next section and used for the determining the best relay placement in cellular networks.

IV. RELAY PLACEMENT FOR CELLULAR OF DMA:

Consider a cellular OFDMA system in which each wireless transmission uses multiple subcarriers [15]. We assume that inter-cell interference is negligible, that is the set of subcarriers in a cell are not reused in the neighboring cells. We evaluate the probability of success in this case.

1. Definition of probability of correct decoding

Now let us obtain an expression of probability of correct decoding of a point to point transmission from node x to node y, where node x and node y denote any MS, any relay or the BS in a cell. Node x uses M subcarriers for this transmission. The rate achieved at the receiver y is

$$R = \sum_{i=1}^{M} \frac{1}{2} log_2\left(1 + \frac{SNR^i_{X\to Y}}{\Gamma}\right) \qquad \ldots\ldots\ldots\ldots (2)$$

Where i is the index of the subcarrier and $SNR^i_{X\to Y}$ is the signal to noise at the receiver on the i^{th} subcarrier. A quantity called the average SNR. $SNR^i_{X\to Y}$ has been defined in [18]. It is obtained from the expression of rate in (equation 2) as follows.

V. EFFECTIVE COMMUNICATION

Since non-transparent relays have all the capabilities of a BS, they also support handover of MS to or from the BS or other relays. But handover with a relay will be much more complicated than inter-BS handover [19]. the main reason behind this is the absence of a backhaul directly connected to the relay. Lets us consider three possible cases of handover - BS to relay, relay to BS, and relay to relay. Suppose the BS is in an active call with the MS. Now if the MS hands over to a relay, the current packet queue and ARQ state have to be communicated to the relay.

$$10log_{10}\overline{SNR^i_{X\to Y}} = \frac{\sum_{i=1}^{M} 10log_{10}\, SNR^i_{X\to Y}}{M} \qquad \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

$$= \frac{1}{M}\sum_{i=1}^{M} p_x^i\ 10\eta\, log_{10}(d) - N + s^i \qquad \ldots\ldots\ldots(4)$$

$$= \overline{P_X} - 10\log_{10}(d) - N + \bar{S}$$

$$P_{success} = P_{BS\to MS} + (1 - P_{BS\to MS}).P_{BS\to RS}.P_{RS\to MS} \ldots\ldots(5)$$

This is straightforward since all the current and future packets will be sent to the relay which will transmit it to the MS. However relay to BS and relay to relay handovers pose a problem. In case of hop-by-hop ARQ, the BS clears packets from its buffer after it receives an ACK from the relay. Thus, the packets remaining in the relay's queue at the time of handover have to communicated to the BS and if handover target is another relay, then from the BS to the relay. This causes a lot of signaling overhead, especially for relay to relay handovers. We need to devise better methods to perform this type of handover. A scheme has been discussed in [13]. It suggests that the BS would multicast the packet to a set a candidate relays. Thus, during a relay to relay handover, the handover target relay will already have the packets present in the current serving relay's queue [17]. But this scheme is not practically feasible because it involves too many unnecessary packet transmissions by multicasting. Better schemes shall be worked upon in the future.

VI. SIMULATION EVALUATION

For evaluation and simulation of routing protocols various tools have been used in VANET. To enlighten the issues in the network, which is essential to assess performance simulations provide outcome to real-world observations. Simulation tools, for example, Network Simulator-2 (NS-2) and Network Simulator-3(NS-3) have been used for the same. To build these simulators TCL script and C++ programming languages are used.

1. Network Simulator (NS2)

Network Simulator developed by University of California and VIN. NS-2 is discrete event and object-oriented simulator only designed for networking research [17].

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Various routing protocols in wireless network supported by NS-2 simulator tool [20]. NS2 simulator having limitations for type of antenna used. Only for bi-directional and Omni-directional antenna NS2 can support. NS-3 simulator is different from NS-2 in various features.

VII. RESULT AND DISCUSSION

Network performance can be analyzed with two parameters throughput, signal to noise ratio and Packet error rate for number of nodes in network. Simulation parameters used to evaluate AODV performance as shown in table.

Table 1. Simulation Parameters

PARAMETERS	VALUES
Routing Protocol	AODV
Simulation Time	3600s
Transmission Range	160m
MAC Layer Protocol	IEEE 802.11p
Number of Nodes	5,10,15
Traffic Type	Constant Bit Rate (CBR)
Packet Size	512 tes

1. Throughput and Average Signal to Noise Ratio (SNR)

The graph of throughput of received bits Vs Maximal end to end delay is shown in fig. 3. End to end delay is the time taken by a packet to travel from source to reach destination.

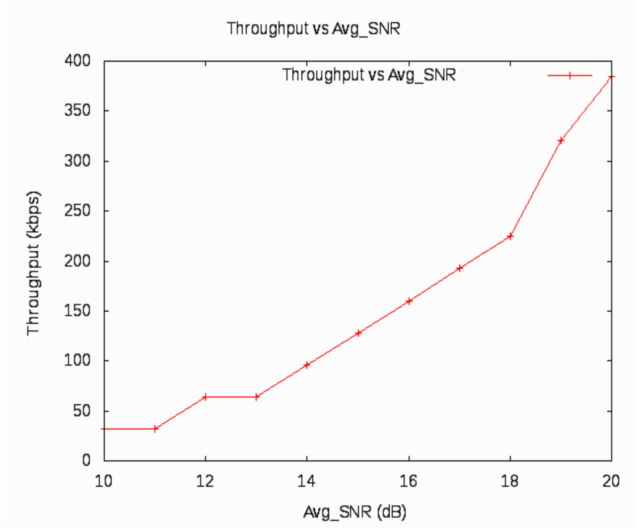

Fig. 3 Throughput Vs Avg. SNR

In Fig 4, Throughput of sending bits Vs Maximal simulation jitter. Jitter is the undesired deviation from true periodicity of an assumed periodic signal. Jitter period is the interval between two times of maximum effect (or minimum effect) of a signal characteristic that varies regularly with time.

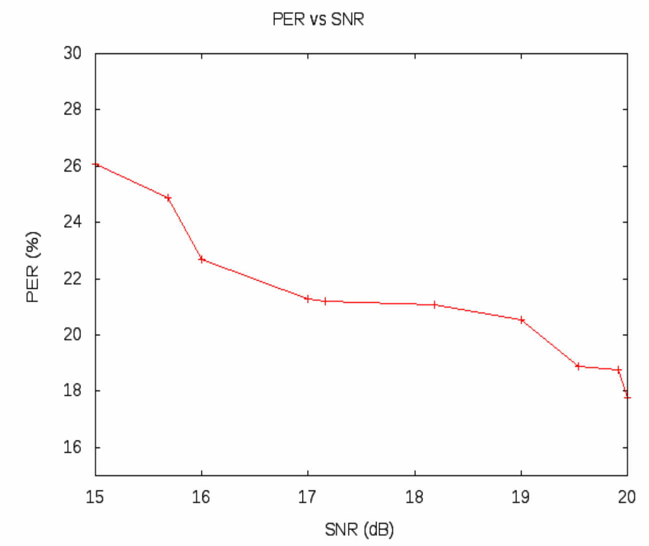

Fig. 4 PER Vs SNR

VIII. CONCLUSION

In this paper we pointed out the practical difficulties with using signal-level combining techniques like maximum ratio combining. Also we derived analytical expressions for the averaged probability of success. Other performance metrics like the supported capacity and delay will be analyzed in the future. A new ARQ protocol which facilitates seamless handover between two relays was devised. We are proposing changes in the IEEE 802.16 standard to incorporate this feedback of the AMS's ARQ state to the ABS. Contributions will also be made to the handover process. In case of scheduling also need to analyze effect of ARQ and HARQ. Practically by simulation on NS-2, AODV perform good by measuring End-to-End Delay and other parameters like PER and SNR. For VANET, End-to End Delay is important for notification and warning messages. Future work will involve developing a delay constrained scheduling policy for a transportation system and efficient routing protocol.

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