# POSTER: Traffic-Adaptive Packet Relaying in VANET

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## ABSTRACT

It was noticed that in highway scenarios co-directional traffic consists of a collection of disconnected clusters. Since end-to-end connectivity between the sender and receiver is not guaranteed to exist, a car that stores a packet may have to carry it for a while, acting as a "data mule", before a suitable next hop can be identified. We begin by offering a very simple analytical expression for the expected size of a cluster in co-directional traffic as a function of traffic density and radio transmission range. We then to develop a Traffic-Adaptive Packet Relaying protocol (TAPR) where each car uses a simple strategy to decide whether to use co-directional or oncoming traffic based on local traffic conditions. The performance of TAPR was evaluated by extensive simulation.

## Categories and Subject Descriptors

C.2.3 [**Computer Communication Networks**]: Network Operations—*Routing*; C.2.1 [**Computer Communication Networks**]: Network Architecture and Design—*Vehicular Ad hoc Networks,Wireless communication*

## General Terms

VANET Routing

## Keywords

Vehicular ad hoc networks,Routing

## 1. INTRODUCTION AND MOTIVATION

The past decade has witnessed the emergence of Vehicular Ad-hoc Networks (VANET) specializing the well-known Mobile Ad Hoc Networks (MANET) to Vehicle-to-Vehicle and Vehicle-to-Roadside wireless communications. VANETs have a number of specific characteristics that set them apart from MANET. First, while most MANET networks are deployed in support of special-purpose operations including disaster relief, search-and-rescue, law-enforcement and multimedia classrooms, all of which are short-lived and involve a small number of players, ' VANETs involve potentially thousands of fast-moving vehicles over tens of miles of roadways and streets. Second, and more importantly, while MANETs may experience *transient* periods of loss of connectivity, in VANET, especially under sparse traffic conditions, extended periods of disconnection are the norm rather than the exception. It has been argued that MANET routing protocols either do not work or else are inefficient in VANET [12, 25].

### 1.1 Related work

Several routing protocols have been recently published like . The Directional Propagation Protocol (DPP)[25] utilizes the directionality of data and vehicles for packet propagation. DPP considers real traffic scenarios in which vehicles form clusters on the road and these clusters may be disconnected from each other. It uses co-directional clusters, clusters that run on the same direction as the packet direction, to propagate a packet so that the packet speed is the sum of the communication speed and the vehicle travel speed. when disconnection occurs between two co-directional clusters, clusters in the other direction may be used as bridges to the next co-directional cluster.

### 1.2 Evaluating the expected size of a cluster

Since we know that co-directional traffic is *inherently* partitioned into equivalence classes, each consisting of all the cars enjoying end-to-end connectivity, an interesting question is to estimate the expected size of a cluster. The goal of this subsection is to provide an answer to this natural question. For this purpose, we find it convenient to inherit the notation and terminology above.

As we saw, the probability $p$ that a given bin contains at *least* $d+1$ balls is $p = \binom{m+n-d-3}{m-2}\binom{m+n-2}{n}^{-1}$. Let $X$ be the random variable that counts the number of "gaps" (i.e., the number of bins containing at least $d+1$ balls). Since $X$ is binomial, the expected value $E[X]$ of $X$ is

$$\begin{aligned} E[X] &= (m-1)\cdot p \\ &= (m-1)\cdot \binom{m+n-d-3}{m-2}\binom{m+n-2}{n}^{-1} \quad (1) \end{aligned}$$

Once we have the expected number of gaps in co-directional traffic, the expected number of clusters becomes $1+E[X] = 1+(m-1)\cdot\binom{m+n-d-3}{m-2}\binom{m+n-2}{n}^{-1}$. Thus, and the expected size of a cluster is

$$E[cluster\_size] = \frac{m \cdot \binom{m+n-2}{n}}{\binom{m+n-2}{n} + (m-1) \cdot \binom{m+n-d-3}{n}}. \quad (2)$$

**Figure 1: *Illustrating the expected cluster size.***

Figure 1 provides a side-by-side comparison of the expected cluster size predicted by (2) and the value obtained by simulation. As an illustration, imagine a two-lane road of 1Km and 10 cars distributed uniformly at random per lane of traffic. By virtue of (1) we expect to see about 2.47 clusters; by (2) the expected cluster size is between 4 and 5 cars.

## 2. TAPR: OUR TRAFFIC-ADAPTIVE PACKET RELAYING PROTOCOL

We assume that vehicles are DSRC-compliant. In particular, every 300 ms, each vehicle sends a beacon message with a range of about 200-300 m. these beacons contain information that allows vehicles to handshake and to exchange information. In TAPR, every vehicle has to maintain information like position and current speed about the head and the tail vehicles of its cluster. So, a vehicle that detects no other vehicles in front of it, declares itself as the head of the cluster and sends that to other vehicles in the back. The same technique is applied to detect and propagate information about the tail of the cluster.

Lets define clusters that are co-directional with the destination as co-directional clusters and clusters in the other direction as oncoming clusters.

In TAPR, we have two modes of operations, the disconnected mode and the connected mode. Suppose that the source vehicle at figure 1 has some packet to send to the destination as shown in the figure. The disconnected mode means that the source can not send the packet to the next oncoming clusters through any co-directional cluster. In this case, the source will simply route the packet to the head of its cluster. The head vehicle in turns will wait until it either meets the destination or it can send the packet to next oncoming cluster through co-directional clusters. The connected mode means that there exist a co-directional cluster that overlaps the sources cluster and the next oncoming cluster. In this case, the source can choose the shortest path to send the packet to the farthest oncoming cluster that it can reach. Thus, the basic idea of TAPR is to switch between muling and routing according to current traffic conditions.

## 3. PERFORMANCE ANALYSIS

The main goal of this section is to provide a performance evaluation of TAPR obtained by extensive simulation. Our simulation compares the proposed TAPR with DPP. We assume a 2 km stretch of undivided road, with one lane of traffic in each direction. In each lane, vehicles are deployed uniformly at random and for simplicity we ignored the size of a vehicle. Figure 2 shows a comparison between TAPR and DPP in terms of number of messages sent by both protocols to route a packet over the 2 km stretch of road. For low traffic densities, we expect to have clusters that may not overlap. So, TAPR sends fewer numbers of messages than DPP because TAPR chooses to mule whenever there is no connection to next oncoming cluster on the road. By contrast, DPP does not detect this fact and sends the message over a co-directional cluster that ends up at the same oncoming cluster again which waste resources.

As the traffic becomes denser, clusters will overlap with high probability and both DPP and TAPR choose to route over the connected clusters. Thus, for high density DPP and TAPR behave almost in the same way.

## 4. CONCLUDING REMARKS AND FUTURE WORK

Somewhat surprisingly, the vast majority of routing papers in VANET assume end-to-end connectivity between the sender and receiver. Recently, [25] suggested that this assumption may be be always valid. In this paper we have proved, using a probabilistic argument, that the empirical findings of [25] are valid. Indeed, we proved that even in reasonably dense traffic, the probability of establishing an end-to-end route consisting entirely of co-directional cars is rather small. Motivated by the result, we have developed a Traffic-Adaptive Packet Relaying protocol (TAPR) that makes adaptive packet relaying decisions. Every car running TAPR uses a simple strategy to decide whether to use co-directional or oncoming traffic based on local traffic conditions. We proved that TAPR is time-optimal in the sense that no other protocol can deliver a packet faster. The performance of TAPR in terms of packet relaying time and overhead was evaluated by extensive simulation.

A possible extension, that will be reported in the journal version of the paper, involves adapting TAPR to a multi-lane scenario where traffic in each lane has its own probability distribution.

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