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Communications Software Technical Committee - CommSoft

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IEEE CommSoft E-Letters

Vol. 5, No. 1, May 2016

CONTENTS

MESSAGE FROM COMMSOFT TC CHAIR

The Technical Committee on Communications Software (TC-COMMSOFT) examines methods and techniques devoted to advancement of the formal methods and tools, use of system analysis and design, methodology for development of communications protocols as well as application of general Software Engineering approaches for the purpose of development of communications applications. The issues addressed by the TC-COMMSOFT include domain-specific languages and practices of using them. Developing of "middleware" between networks and applications and the usefulness and usability of it is also a topic.

In this volume, we have selected 2 papers on three various subjects: vehicular cloud computing and routing protocols for mobile AdHoc networks .

Event computation for CIT-S through the cloud

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Abstract: ”Connected vehicles” is a very hot challenge since many years. Usual communications could be ensured through wireless local area networks (over ITS-G5 for example) or through cellular networks (over 3G, LTE, etc.). ITS-G5 is not enough deployed. For this reason, its coverage is quite low. Then, the need to have efficient solutions using cellular networks is required. Indeed, we propose in this paper a solution to trigger automatically some events after collecting messages from mobile nodes. The triggered events are those related to traffic congestion which could be combined with a notification about alternative routes. The contribution consists of a deployment of an application over smartphones embedded in vehicles which are connected to a server which takes care of management of vehicle location as well as traffic congestion management. The deployment of the application during some weeks has provided a mobility model which has been used as an input in a simulator. Many simulations have been undertaken and some indicators have been measured as latency and packet loss rate. Keywords: C-ITS, VANETs, Cellular Networks, Safety Road Applications

Keywords: WSN, ITS, car detection, magnetometer

1. Introduction

The deployment of connected vehicles is an interesting challenge since a decade. The connectivity is one of the most important issue to solve. Indeed, a dedicated Wifi has been designed for connected vehicles: IEEE 802.11p (denoted also ITS-G5). However, the deployment of ITS-G5 hotspots (denoted Road Side Units) needs to be generalized. In this paper, we intend to use a cellular network in order to ensure the collection and the delivery of messages to and from vehicles. The remainder of this paper is organised as follows: Section II describes the related works. Section III details the architecture of the system proposed. Section IV presents our solution results and section V concludes

2. Related works

[10] proposes an evaluation of vehicular communications networks through car sharing scenarios. The authors have investigate the study of three parameters. They adapted a specific mobility model which has been imported to a simulator. They have worked on a grid network representing manhattan and they observed some performance parameters as delays, packet loss. The most important objective of the study is to show that vehicular communication is feasible and realistic under some conditions. [9] studies throughput over VANETs system along a unidirectional traffic for different traffic conditions and transmission ranges of wireless equipments. All studied vehicles are randomly connected. The paper gives a results of simulation studies achieved on NS-2 toolbox. They have measured performances indicators in case of congestion. A comparison of the obtained results to the expected connectivity results has been done and have shown that the throughput over simulation is lower due to packet losses caused by collisions. 2 [6] gives an overview of how research on vehicular communication evolved in Europe and, especially, in Germany. They describe the German field operational test sim TD. The project sim TD is the first field operational test to evaluate the effectiveness and benefits of applications based on vehicular communication in a setup that is representative for a realistic deployment environment. It is, therefore, the next necessary step to prepare for an informed deployment decision of cooperative systems. [12] presents a detailed study on performance evaluation of IEEE 80211.p networks versus LTE vehicular networks. The authors analyse some performance indicators like end-to-end delay for both networks in different scenarios (high density, urban environments, etc.). Many important issues have been measured as network availability and reliability. The authors have proved through simulations that LTE solution meets most of the application requirements in terms of reliability, scalability, and mobility but EEE 802.11p provides acceptable performance for sparse network topologies with limited mobility support. [14] gives an efficient solution for routing messages over VANETs by using the vehicle’s heading. [13] is dedicated to routing over

VANETs in a urban environments. [11] is a study about movement prediction of vehicles. Indeed, an adapted routing algorithm is proposed. [8] gives an overview of strategies to use for routing on VANETs. [15] reviews much more actual strategies on vehicular networks. In this paper, we analyse performances of VANETs using cellular network as a unique communication medium. We measure especially the end-to-end delay and compared it with ITS-G5 performances

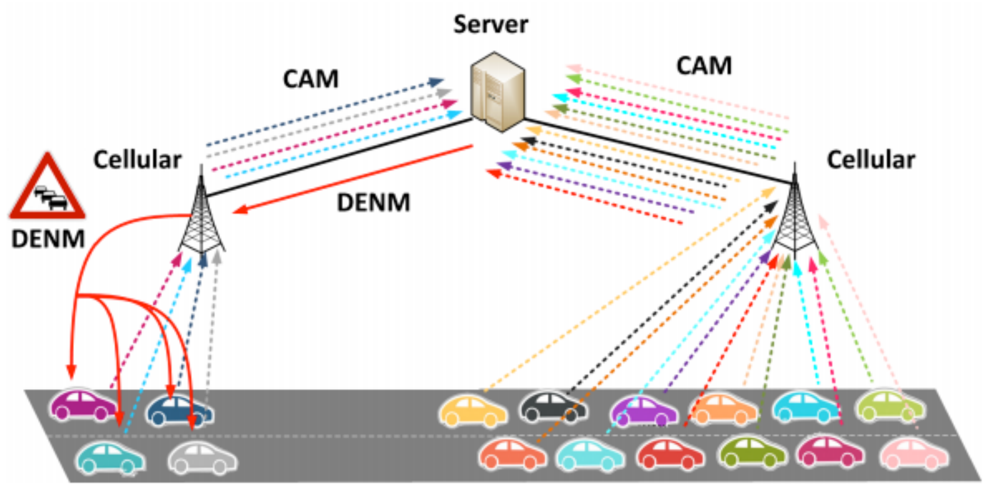
3. System architecture

A. Preliminaries

In the area of C-ITS (Cooperative Intelligent Transportation System), a protocol stack has been defined and standardized by the ETSI. Over the Transport-Networking layer (defined as geonetworking layer), The facilities layer has been designed in order to be an efficient interface between the application layer (close to the driver and the vehicle sensors) and the transport-networking layer. The facilities layer handles 2 main messages : CAM (Cooperative Awareness Message) [5] and DENM (Decentralized Event Notification Message) [7]. The aim behind sending CAM messages is to give dynamic information about the vehicle (position, speed, heading, etc.). However, the aim of exchanging DENM message is to notify about any event (accident, traffic jam, etc.). The system presented here is divided principally into two components. The first component is the Client described in the section III-C, that has to be executed in every connected vehicle. The second component is the Server described in the section III-D, that has to be installed on the Cloud. We assume that every vehicle is equipped with an OBU integrating a cellular communication module. This OBU manages to keep the link available between the Client and the Server using the cellular network. Whenever the vehicle moves, it sends CAMs to other vehicles in Vehicle-to-Vehicle (V2V) communications. Depending on the speed of the vehicle, the frequency of CAM messages changes from 1 Hz to 10 Hz. In our proposition, all the CAMs are also sent simultaneously to the Server through the cellular network. Since CAMs are light (the average size is about 100 Bytes), the throughput consumed by such communication is not very high. Then, the Server could track every vehicle and estimates the average speed in every part of the road network. The Server has the knowledge of the traffic condition over the whole network in realtime. When it detects for example a traffic jam, it computes the list of vehicles that will arrive at the congested sections. Then, it sends a DENM to the interested vehicles through the cellular network. The objective of such message is to prevent from the collision and avoid crashs. Since the communication range of a vehicle is about 300m, networks using only V2V links are sparse and the connectivity could not be guaranteed, especially with a weak penetration rate as it is the case now. Therefore, the cellular network could counterbalance this lack of connectivity. They allow to reach vehicles that are far away from the event since the network coverage is almost complete. The subsection below will describe an example of such system.

B. Detailed scheme

To better understand our system, the Figure 1 presents an example of one use-case of our system. This use-case is the traffic jam warning



In this example, the vehicles in the front are stationary since they are in a traffic jam. They continue sending CAM messages to the server at a rate of 1 message every second. When the server will receive all the messages from these vehicles, it will conclude that there is a traffic jam in this area. This information is then useful for vehicles moving in the direction of this area. The server, then, computes all the vehicles that could be interested in this event. After that, he will prepare a DENM message including all the data about the event (time, localisation, duration, etc.) and will push it automatically to the list of potentially interested vehicles. When they receive the information, the vehicle will notify the driver in order to be aware and to prepare the deceleration to avoid collision with the stationary vehicles. Moreover, if these vehicles have the information previously, they can take an alternative route. So, they will avoid the congested zone and hence reduce the travel time. This will improve the efficiency of the transportation systems, reduce the cost of mobility and enhance the environment quality by reducing the greenhouse gas emission.

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Enhanced Predictive Preemptive Multipath Routing Protocol for Mobile Ad hoc Network

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***Abstract*—In Ad Hoc networks, route failure may occur due to less received power, mobility, congestion and node failures. Many approaches have been proposed in literature to solve this problem, where a node predicts pre-emptively the route failure that occurs with the less received power. However, these approaches encounter some difficulties, especially in scenario without mobility where route failures may arise. In this paper, we propose an improvement of AOMDV protocol called E-PPAOMDV (Enhanced Predictive Preemptive AOMDV). We propose a cross-layer networking mechanism to distinguish between both situations, failures due to congestion or mobility, and consequently avoiding unnecessary route repair process. The E-PPAOMDV was implemented using NS-2. The simulation results show that our approach improves the overall performance of the network. It reduces the average end to end delay and the routing overhead of the network.**

***Index Terms*— Ad-Hoc networks, Multipath Routing, PPAOMDV, MAC, Cross layer.**

1. Introduction

An ad hoc network consists of mobile nodes, which communicate with each other through multi-hop routes. Nodes cooperate with their neighbors to route data packets to their final destinations. In ad hoc networks, network topology is changing continuously because of the node movement. To maintain the communication between nodes, many routing protocols have been proposed, which are classified under two categories: table-driven and on-demand routing protocols.

On-demand routing protocols discover routes only when the source needs to send packets. Therefore, there is almost no route maintenance overhead, whereas the route discovery before data transmission increases the delay. However, if the link failure happened, nodes should inform the sources to change the existing route and retransmit the packets that were lost due to link failure. Therefore, on-demand routing protocols increase delay and decrease the successful packet arrival ratio. This causes the reduction of the packet delivery ratio.

Several approaches have been proposed [3],[4],[11] to flexibly anticipate link failure by adding a function that predicts the link failure in one of the popular on-demand routing protocols which is Ad hoc On-demand Distance Vector (AODV) [1],[2].

Previous approaches encounter some difficulties, especially in scenario without mobility. The problem is that these approaches predict link failures based of the Received Signal Strength (RSS) information and interpret that it happened due to node mobility, where actually it was due to congestion. Therefore, the process of route repair should not be performed since it increases even more the congestion, decreasing the overall performance of the network.

Transmitting information to a neighboring node in MAC layer is preceded by the exchange of Request To Send (RTS)/Clear To Send (CTS) frames. If this communication fails, the MAC layer waits (back off time) and retries later. After several failed attempts, the MAC layer informs the routing layer using a cross layer interaction. In our approach, the cause of that unsuccessful communication is sent to the routing layer. If the last received power of the destination node indicates that it is reachable, the routing layer is informed, using the variable xmit_reason with the value XMIT_REASON_HIGH_RSS. Depending on this information a node will decide whether it performs a route repair or not.

In this paper, we propose an Enhanced Predictive Preemptive Ad hoc On-Demand Multipath Distance Vector (E-PPAOMDV), it is an on-demand routing protocol based on a cross-layer networking mechanism to distinguish between both situations, failures due to congestion or mobility, and consequently avoiding unnecessary route repair process, where we use a "Route Failure Prediction Technique" based on the Lagrange interpolation for estimating whether an active link is about to fail or will fail.

The rest of the paper is organized as follows. Section 2 describes related works; section 3 describes an overview of AOMDV; the proposed protocol is presented in section 4 and its performance is evaluated and compared with that of PPAOMDV in section 5. Some conclusions are given in section 6.

2. Related Works

2.1 Link failure prediction methods

In [3], a Predictive Preemptive AODV (PPAODV) was proposed which predicts the link failure using the Received Signal Strength (RSS) has been proposed. The prediction method uses Lagrange interpolation, which approximates the process of RSS by means of n-dimensional function with information of past RSS. PPAODV [3] discovers a new route before the active route becomes obsolete and changes the route smoothly by predicting a RSS of data packets at the Predict Time t_{PT} from the past information of RSS. PPAODV [3] sets Discovery Period T_{DP} as the minimum time that a node can exchange one data with the neighboring node.

In [4], the authors have proposed a High Precision - PPAODV (HPPPAODV) which is an amelioration of PPAODV. HPPPAODV can improve the prediction accuracy ratio by 1) using the Newton interpolation, 2) adding the chance of acquisition of RSS to reduce the error margin of RSS that is affected by the influence of the thermal noise and fading and 3) predicting the value of the Discovery Period T_{DP} by the number of hop in a route.

In [11], Authors propose The Predictive Preemptive AOMDV (PPAOMDV) , an approach that uses the "Route Failure Prediction Technique" for estimating whether an active link is about to fail or will fail . To evaluate this approach to route failure prediction, they have added it to Ad Hoc on- Demand Multipath Distance Vector Routing Protocol (AOMDV).

3. AOMDV Overview

AOMDV is an extension of AODV [1],[2] protocol where it computes multiple disjoint loop-free paths in a route discovery [10]. Authors assume that every node AOMDV shares several characteristics with AODV. It is based upon the distance vector concept and uses hop-by-hop routing approach. Moreover, AOMDV also finds routes on demand using a route discovery procedure. The main difference is in the number of routes found in each route discovery. In AOMDV, RREQ propagation from the source to the destination establishes multiple reverse paths both at intermediate nodes as well as the destination. Multiple RREPs traverse these reverse paths back to form multiple forward paths to the destination into the source and intermediate nodes routing tables.

4. The Proposed E-PPAOMDV

4.1 The Proposed Mechanism For Congestion Control

In E-PPAOMDV we implemented a cross layer approach that tracks the RSS of received data packet from each neighbouring node in order to know when an adjacent node is near enough for a successful transmission.

We use a "Route Failure Prediction Technique" based on the Lagrange interpolation (1) for estimating whether an active link is about to fail or will fail, and it can distinguish between both situations; link error at MAC layer was due to congestion and due to mobility of nodes to avoid the unnecessary route repair process. The Predict Time (t_{PT}) is calculated as (2) and the Discovery Period T_{DP} can be calculated as (3).

$$P\,(t_{PT}) = \left(\frac{(tPT-t2)(tPT-t3)}{(t1-t2)(t1-t3)}\times P1\right)+\frac{(tPT-t1)(tPT-t3)}{(t2-t1)(t2-t3)}\times P2)+\left(\frac{(tPT-t1)(tPT-t2)}{(t3-t1)(t3-t2)}\times P3\right) \quad (1)$$

Where P (t_{PT}) is the value of RSS at t_{PT}, P1 −P3 and t1−t3 are 1st −3rd RSS and their received time respectively.

$$t_{PT} = t3 + T_{DP} \quad (2)$$

$$T_{DP} = T_{warning}\times n_{A\text{-}S}+TRREQ \times n_{S\text{-}D}+TRREP \times n_{S\text{-}D} \quad (3)$$

Where, Twarning, TRREQ and TRREP represent the transmission time of warning packet, RREQ packet and RREP packet, respectively. Also n_{A-S} and n_{S-D} represent the number of hops between node "A" to node "S" of the active route and number of hops between node S to node D of a new route, respectively.

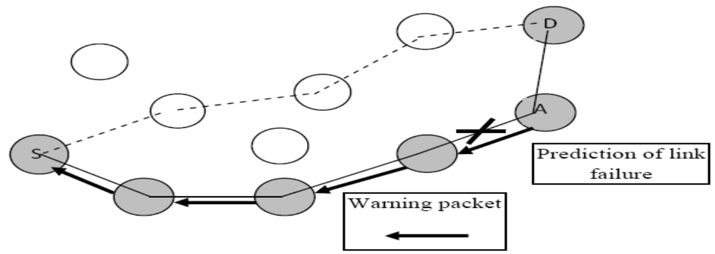

Figure. 1 Node A predicts link failure

4.1.1 Extension of MAC Layer

AOMDV [10] interprets a link failure (in MAC layer) as a broken link, even when it was caused by congestion at the receiver. The sender node should know why communication was impossible. We implemented an approach that tracks the RSS of received data packet from each neighbouring node in order to know when an adjacent node is near enough for a successful transmission. If lost packets were due to congestion and high traffic, AOMDV triggers route repair, and this can affect the network performance. If lost packets is due to low signal quality or misrouted packets, then route repair is needed because the receiver is not reachable.

Afterward, the signal strength of neighboring nodes can be used to detect the reason for lost packets, distinguishing between congestion and broken links due to mobility, because in the last case, the receiver is unreachable and its signal strength is now available. The implementation is divided into two parts; the first part keeps the last three received signals from a node in an array, and computes RSS using Lagrange Interpolation (from the received data packets) if the signal is weak enough and the node moving away, the MAC layer sends a Request To Send (RTS) and the second part decides the kind of message (link failure, either due to errors or due to congestion using signal strength of neighbouring nodes) to be sent to the upper layer, whenever the communication is impossible but the destination node is in the transmission range of the sender.

Transmitting information to a neighbouring node in MAC layer is preceded by the exchange of Request To Send (RTS)/Clear To Send (CTS) frames. If this communication fails, the MAC layer waits (back off time) and retransmits later. After several unsuccessful attempts, the MAC layer informs to the routing layer that communication failed. In our approach, the reason for that unsuccessful communication is sent to the routing layer. If the last received power (the result of Lagrange interpolation) of the destination node indicates that it is reachable, the routing layer is informed, using the variable xmit_reason with the value XMIT_REASON_HIGH_RSS. In this case, the routing layer should interpret that communication to destination was impossible, not because of a broken link but rather congestion, therefore, route maintenance is not needed. If that is not the reason delivered to the routing layer, a route maintenance process is required.

4.1.2 Extension of AOMDV

When a node tries to communicate with a neighboring node and this communication failed (after several attempts, MAC layer sends an error to the routing layer). AOMDV interprets that the neighboring node is not present anymore and communication failure was due to mobility.

In a scenario without mobility communication failures may arise, but AOMDV will interpret that it was due to mobility, where actually, it was due to congestion. Therefore, the process of route repair should not be performed since it increases even more the congestion, decreasing the overall performance of the network. The proposed amelioration will make AOMDV capable to distinguish between both situations, avoiding the route repair process when the link error at MAC layer was due to congestion and not due to mobility of nodes. In our approach, when a node is not able to communicate with a neighbouring node, MAC layer informs to the upper layer that there was a problem including whether the neighbouring node is still reachable or not (see Fig. 2). Therefore, the sender node does not perform route maintenance if it was informed that the neighbouring node is still reachable.

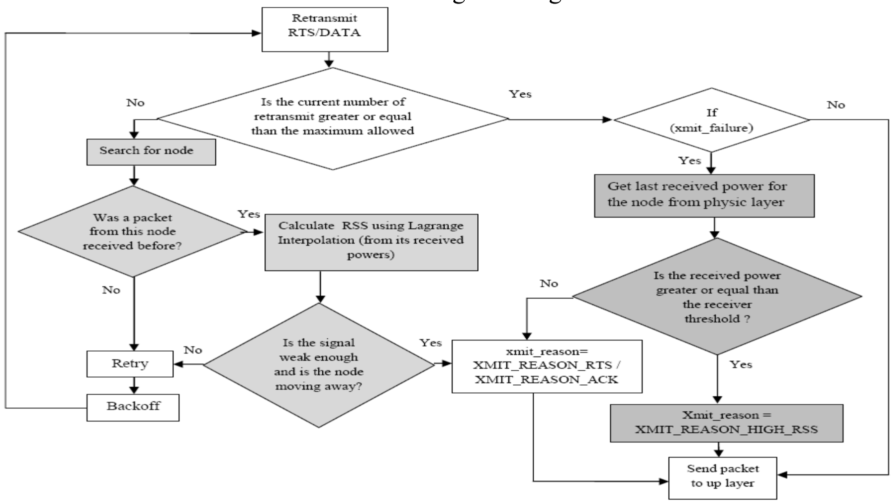

Figure. 2 The proposed mechanism that uses the Lagrange interpolation is shown here, this diagram shows also how MAC layer informs to the routing layer, when several attempts to communicate to the receiver node failed

5. Simulation and Performance Results

We have used the implementation of AOMDV [10] in the NS simulator version 3.35 [5]. Our results are based on the simulation of 50 wireless nodes forming an ad hoc network moving about in an area of 1500 meters by 300 meters for 200 seconds of simulated time. Two Ray Ground reflection model was adopted. Nodes positions were generated randomly.

The movement scenario files used for each simulation are characterized by a pause time. Each node begins the simulation by selecting a random destination in the simulation area and moving to that destination at a speed distributed uniformly between 0 and 10 meters per second. It then remains stationary for pause time seconds. This scenario is repeated for the duration of the simulation. We carry out simulations with movement patterns generated for 5 different pause times: 0, 20, 40, 80 and 200 seconds. A pause time of 0 seconds corresponds to continuous motion, and a pause time of 200 (the length of the simulation) corresponds to limited motion. Constant bit rate (CBR) sources are used in the simulations. The packet rate is 4 packets/sec when 10, 20, 30 and 40 sources are assumed. The performance metrics used to evaluate performance are:

Average end-to-end delay of data packets: This includes all possible delays caused by buffering during route discovery, queuing at the interface queue, retransmission delays at the MAC layer, and propagation and transfer times. This should be minimized.

Normalized routing load: The number of routing packets transmitted per data packet delivered to the destination. This should be minimized.

We report the results of the simulation experiments for the Predictive Preemptive AOMDV protocol (PPAOMDV) and for E-PPAOMDV.

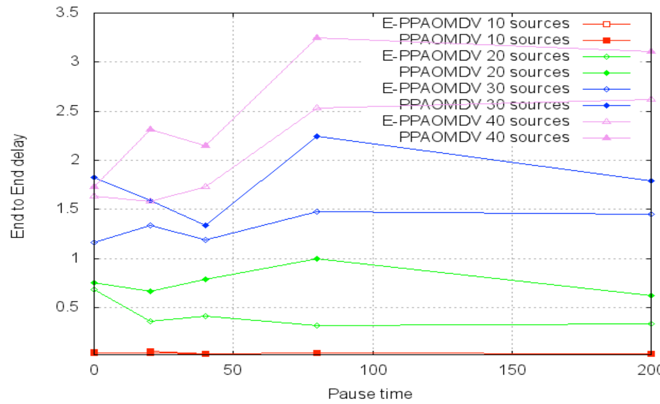

Figure. 3 Average End to end delay

In Fig. 3 the results obtained for the end-to-end delay metric are presented. We observe that the end-to-end delay increases significantly when the number of sources increases. The delay is affected by the route repair procedure because data packets are buffered until an alternative route is found. The results show that E-PPAOMDV outperforms PPAOMDV significantly when the number of sources increase and the motion is low. Fig. 3 shows a gain of about 20% of E-PPAOMDV over PPAOMDV, for 40 sources in the pause time 200s.

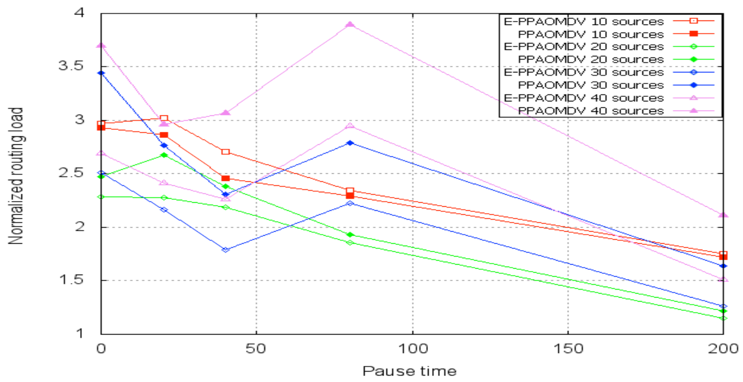

Figure. 4 Normalized routing load

Fig. 4 shows how mobility and number of sources affect the communication overhead. The overhead is high when node motion is high; this is due to the fact that it is difficult to obtain an alternative link to replace a broken one when motion is high. It is also observed that the overhead is low when the number of sources is low. This results from the fact that many sources may share one or more paths, which decreases the communication overhead. It can be observed from Fig. 6 that the biggest gains of E-PPAOMDV over PPAOMDV is of 45% and happen with 80s of pause time and 40 sources. This has a good impact on energy because the number of control packets generated is low.

6. Conclusion

Multipath routing can be used in on-demand protocols to achieve faster and efficient recovery from route failures in highly dynamic Ad-hoc networks. In this paper, we have proposed a Enhanced Predictive Preemptive Multipath Ad hoc On-Demand Distance Vector (E-PPAOMDV). The main contribution in this work is the proposition of a cross-layer networking mechanism to distinguish between both situations, failures due to congestion or mobility; by the usage of the "Route Failure Prediction Technique" based on the Lagrange interpolation for estimating whether an active link is about to fail or will fail.

Simulation results show that the average end to end delay of E-PPAOMDV is less than that of PPAOMDV. Also the normalized routing load of E-PPAOMDV is smaller than that of PPAOMDV, especially when the number of sources is superior to 10 sources.

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