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Automatic Tuning Of OLSR Routing Protocol Using IWD in VANET

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Abstract: Vehicular adhoc network (VANET) provides wireless communication among vehicles without any underlying Network Infrastructure. In such Network Quality-of-service (QoS) is difficult because the network topology may change constantly and the available state information for routing is inherently imprecise. However, due to the vehicle movement, limited wireless resources and the lossy characteristics of a wireless channel, providing a reliable multihop communication in VANETs is particularly challenging. Therefore, offering an efficient routing strategy is crucial to the deployment of VANETs. In this paper, we propose Intelligent Water Drops (IWD) algorithm to optimize the parameter setting in optimized link state routing protocol (OLSR). IWD Algorithm harmonizes the parameters in OLSR for better Qos. The QoS versions of the IWD tuned OLSR routing protocol do improve the Packet Delivery Ratio, reduce the communication cost and network traffic load in the high speed movement scenarios.

Keywords: Quality-of-service, Multipoint Relay, Vehicular Ad Hoc Network

I. INTRODUCTION

Vehicular ad hoc networks (VANETs) have emerged as one of the most successful commercial applications of mobile ad hoc networks. One major goal of VANET deployment is to increase road safety and transportation efficiency. Most VANET research has focused on analyzing routing algorithms in a highly dense network topology under the oversimplified assumption that a typical vehicular network is well connected in nature. Another phenomenon that could lead to network fragmentation in VANET is the low penetration ratio of the DSRC technology at the initial stages. This case implies that, even during rush hours, the number of cars that are equipped with DSRC radios could be extremely small due to the low penetration ratio of the DSRC technology. This disconnected network problem poses a crucial research challenge for developing a reliable efficient routing protocol that can support safety applications in highly diverse VANET topologies. The objective of this paper is to optimize the OLSR protocol by selecting proper Multipoint Relays (MPR) and effective tuning of OLSR parameters.

Along with the recent developments in the VANET field, a number of attractive applications, which are unique for the vehicular setting, have emerged. VANET applications include onboard active safety systems that are used to assist drivers in avoiding collisions and to coordinate among them at critical points such as intersections and highway entries. Safety systems may intelligently disseminate road information, such as incidents, real-time traffic congestion, high-speed tolling, or surface condition to vehicles in the vicinity of the subjected sites. This helps to avoid platoon vehicles and to accordingly improve road capacity. With such active safety systems, the number of car accidents and associated damage are expected to be largely reduced. In addition to the aforementioned safety applications, IVC communications can also be used to provide comfort applications. The latter may include weather information, gas station or restaurant locations, mobile e-commerce, infotainment applications, and interactive communications such as Internet access, music downloads, and content delivery. In this paper, our focus is more on the provision of such entertaining applications. The design of effective vehicular communications poses a series of technical challenges. Guaranteeing a stable and reliable routing mechanism over VANETs is an important step toward the realization of effective vehicular communications.

Existing routing protocols, which are traditionally, designed for MANET, do not make use of the unique characteristics of VANETs and are not suitable for vehicle-to-vehicle communications over VANETs. Indeed, the control messages in reactive protocols and route update timers in proactive protocols are not used to anticipate link breakage. They solely indicate presence or absence of a route to a given node. Consequently, the route maintenance process in both protocol types is initiated only after a link-breakage event takes place. When a path breaks, not only portions of data packets are lost, but also in many cases, there is a significant delay in establishing a new path. This delay depends on whether another valid path already exists (in the case of multipath routing protocols) or whether a new route-discovery process needs to take place. The latter scenario introduces yet another problem. In addition to the delay in discovering new paths, flooding required for path discovery would greatly degrade the throughput of the network as it introduces a large amount of network traffic, especially if the flooding is not locally directed, as in the case of location aided routing (LAR) protocols [7]. However, if the locations of destination nodes are unknown, Omni directional flooding is inevitably the only option. In a highly mobile system such as VANET, where link breakage is frequent, flooding requests would largely degrade the system performance due to the introduction of additional network traffic into the system and interruption in data transmission.

In this paper, we define an optimization problem to tune the OLSR protocol, obtaining automatically the configuration that best fits the specific characteristics of VANETs. An optimization problem is defined by a search space and a quality or fitness function. The search space restricts the possible configurations of a solution vector, which is associated with a numerical cost by the fitness function. Thus, solving an optimization problem consists of finding the least-cost configuration of a solution vector. In spite of the moderate number of configurable parameters that govern OLSR [7], the number of possible combinations of values that they can take makes this task very hard. Due to the high complexity that these kinds of problems usually show, the use of automatic intelligent tools is a mandatory requirement when facing them. In this sense, metaheuristic algorithms [11] emerge as efficient stochastic techniques able to solve optimization problems. Indeed, these algorithms are currently employed in a multitude of engineering problems showing a successful performance.

Optimized link state routing (OLSR) is a proactive protocol, wherein each node maintain routing information to every other node in the network. OLSR [8] is a point-to-point routing protocol based on the traditional link-state algorithm. To update topology information, Link-state messages are periodically exchanged by the nodes. Multipoint replaying (MPR) strategy is used to minimize the flooding during each route updates. This is made possible by retransmitting the packets only to a set of neighboring nodes called the multipoint relays of that node. The MRP set is so selected that it connects to all nodes that are two hops away from it. Hello messages are used to get the one hop neighbors, and each node forms a subset of one hop neighbors, which connects to all of its two hop neighbors. A "shortest hop path algorithm" is used for selecting optimal route to a destination using topology information in the routing table. The optimal route information is stored in a routing table. Thus, routes to every destination are immediately available during data transmission. MPR selection is important for efficient performance of OLSR, as smaller the MPR set, less overhead is introduced in the network. Various studies have been conducted to reduce the control traffic overheads by adapting the existing OLSR routing protocol. Routing performance is improved by traffic shaping based on priority of the data packet. In this paper, it is proposed to modify OLSR using swarm intelligence, Intelligent Water Drops (IWD) algorithm, to reduce end to end delay and improve throughput in the network by traffic shaping at the network layer. Rest of the paper is organized as follows: section II deals with literature reviews related to this research; section III introduces all the techniques used in the research; section IV discusses the simulation results and section V concludes the paper.

II. PROTOCOL OVERVIEW

In this section, we discuss the functions of the OLSR protocol. We also consider the studies of selecting MPR in flooding the messages.

A. OLSR protocol factor: OLSR periodically exchange different messages to maintain the topology information of the entire network in the presence of mobility and failures. The core functionality is performed mainly by using three different types of messages: HELLO, Topology Control (TC) and multiple interface declaration (MID) messages. HELLO messages are exchanged between neighbor nodes (one-hop distance). They are employed to accommodate link sensing, neighborhood detection, and MPR selection signaling. OLSR is a type of classical link-state routing protocol that relies on employing an efficient periodic flooding of control information using special nodes that act as multipoint relays (MPRs). The use of MPRs reduces the number of required transmissions. These messages are generated periodically, containing information about the neighbor nodes and about the links between their network interfaces. TC

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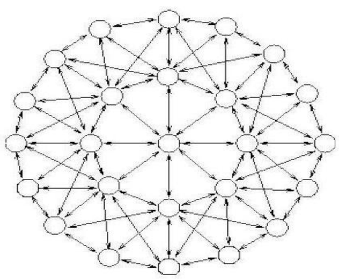
messages are generated periodically by MPRs to indicate which other nodes have selected it as their MPR. The information is stored in the topology information base of each network node, which is used for routing table calculations. Such messages are forwarded to the other nodes through the entire network. Since TC messages are broadcast periodically, a sequence number is used to distinguish between recent and old ones. MID messages are sent by the nodes to report information about their network interfaces employed to participate in the network. Such information is needed since the nodes may have multiple interfaces with distinct addresses participating in the communications.

B. Multipoint Relays (MPRs): The idea of multipoint relays is to minimize the overhead of flooding messages in the network by reducing redundant retransmissions in the same region. Each node in the network selects a set of nodes in its symmetric 1-hop neighborhood which may retransmit its messages. This set of selected neighbor nodes is called the "Multipoint Relay" (MPR) set of that node. In Fig. 2 black circles represents the MPR's. Selection of MPR reduces the number of re-transmissions.



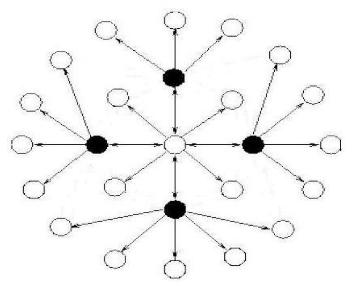


Fig. 1 flooding a packet in a wireless network

Fig. 2 Flooding a packet using MPR

The neighbors of node N which are not in its MPR set receive and process broadcast messages but do not retransmit broadcast messages received from node N. Each node selects its MPR set from among its 1-hop symmetric neighbors. This set is selected such that it covers (in terms of radio range) all symmetric strict 2-hop nodes. The MPR set of N, denoted as MPR (N), is then an arbitrary subset of the symmetric 1-hop neighborhood of N which satisfies the following condition: every node in the symmetric strict 2-hop neighborhood of N must have a symmetric link towards MPR (N). The smaller a MPR set the less control traffic overhead results from the routing protocol. Each node maintains information about the set of neighbors that have selected it as MPR. This set is called the "Multipoint Relay Selector set" (MPR selector set) of a node. A node obtains this information from periodic HELLO messages received from the neighbors. A broadcast message, intended to be diffused in the whole network, coming from any of the MPR selectors of node N is assumed to be retransmitted by node N, if N has not received it yet. This set can change over time (i.e., when a node selects another MPR-set) and is indicated by the selector nodes in their HELLO messages.

C. Protocol Core Functioning: The core functionality of OLSR specifies the behavior of a node, equipped with OLSR interfaces participating in the VANET and running OLSR as routing protocol. This includes a universal specification of OLSR protocol messages and their transmission through the network, as well as link sensing, topology diffusion and route calculation. Packet Format and Forwarding a universal specification of the packet format and an optimized flooding mechanism serves as the transport mechanism for all OLSR control traffic. Link Sensing is accomplished through periodic emission of HELLO messages over the interfaces through which connectivity is checked. Given a network with only single interface nodes, a node may deduct the neighbor set directly from the information exchanged as part of link sensing: the "main address" of a single interface node is, by definition, the address of the only interface on that node. MPR Selection and MPR Signaling The objective of MPR selection is for a node to select a subset of its neighbors such that a broadcast message, retransmitted by these selected neighbors, will be received by all nodes 2 hops away. The MPR set of a node is computed such that it, for each interface, satisfies this condition. The information required to perform this calculation is acquired through the periodic exchange of HELLO messages. Topology Control Message Diffusion Topology Control messages are diffused with the purpose of providing each node in the network with sufficient link-state information to allow route calculation. Route Calculation Given the link state information acquired through periodic message exchange, as well as the interface configuration of the nodes, the routing table for each node can be computed.

III. RELATED WORK AND BACKGROUND

OLSR daemons periodically exchange different messages to maintain the topology information of the entire network in the presence of mobility and failures. The core functionality is performed mainly by using three different types of messages: HELLO, Topology Control (TC) and Multiple Interface Declaration (MID) messages.

HELLO messages are transferred between fellow nodes in the network (one-hop distance). They are used to accommodate neighborhood detection and MPR selection signaling. These messages are generated and transferred periodically between the nodes in the network. TC messages are generated periodically by MPRs to indicate which other nodes have selected it as their MPR. This information is stored in the topology information of each node, which is used for routing table calculations.

TABLE 1
MAIN OLSR PARAMETERS AND RFC 3626 SPECIFIED VALUES

Parameter	Standard Configuration	Range
HELLO_INTERVAL	2.0 s	R ε [1.0, 30.0]
REFRESH_INTERVAL	2.0 s	R ε [1.0, 30.0]
TC_INTERVAL	5.0	R ε [1.0, 30.0]
WILLINGNESS	3	Z ε [0,7]
NEIGHB_HOLD_TIME	3 × HELLO INTERVAL	R ε [3.0, 100.0]
TOP_HOLD_TIME	3 × TC_INTERVAL	R ε [3.0, 100.0]
MID_HOLD_TIME	3 × TC_INTERVAL	R ε [3.0, 100.0]
DUP_HOLD_TIME	30.0 s	R ε [3.0, 100.0]

Then those messages are forwarded to other nodes in the network. The TC messages are differentiated by assigning sequence number. MID messages contains the information about the nodes network interfaces which are employed to participate in the network communication. Such information is needed since the nodes may have multiple interfaces with distinct addresses participating in the communications. The OLSR mechanisms are regulated by a set of parameters predefined in the OLSR RFC 3626 (see Table 1). These parameters have been tuned by different authors without using any automatic tool and they are the timeouts before resending HELLO, MID, and TC Messages. The "validity time" of the information received via these three message types, which are NEIGHB_HOLD_TIME (HELLO), MID_HOLD_TIME (MID), and TOP_HOLD_TIME (TC); the WILLINGNESS of a node to act as an MPR and DUP_HOLD_TIME, which represents the time during which the MPRs record information about the forwarded packets. Various metaheuristic methods are applied to tune the OLSR, but still the communication cost is high in these cases.

IV. PROPOSED SYSTEM

In this section we describe the routing operation of OLSR using automatic parameter tuning. It is performed using IWD algorithm. The IWD algorithm is a step in the direction to model a few actions that happen in natural rivers and then to implement them in a form of an algorithm. In the IWD algorithm, IWDs are created with two main properties:

- Velocity
- Soil.

Both of the two properties may change during the lifetime of an IWD. An IWD flows from a source to a destination. The IWD begins its trip with an initial velocity and zero soil. During its trip, it travels in the environment from which it removes some soil and it may gain some speed. An IWD is supposed to flow in discrete steps. From its current location

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to its next location, the IWD velocity is increased by the amount non-linearly proportional to the inverse of the soil between the two locations. Therefore, a path with less soil lets the IWD become faster than a path with more soil.
An IWD gathers soil during its trip in the environment. This soil is removed from the path joining the two locations. The amount of soil added to the IWD is non-linearly proportional to the inverse of the time needed for the IWD to pass from its current location to the next location. Thus, the time taken is proportional to the velocity of the IWD and inversely proportional to the distance between the two locations. It may be said that soil is the source material of information such that the environment and water drops both have memories for soil.

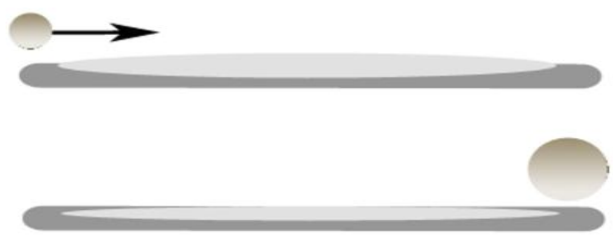

Fig. 3 the IWD on the left flows to the right side while removing soil from the river Bed and adding it to its soil (the soil on the bed is denoted by light gray color).

An IWD needs a mechanism to select the path to its next location or step. In this mechanism, the IWD prefers the paths having low soils to the paths having high soils. This behavior of path selection is implemented by imposing a uniform random distribution on the soils of the available paths. Then, the probability of the next path to select is inversely proportional to the soils of the available paths. Therefore, paths with lower soils have higher chance to be selected by the IWD.
IWD algorithm consists of two types of parameters:

- Static parameters
- Dynamic parameters

Static parameters are those that remain constant during the lifetime of the IWD algorithm. Dynamic parameters are reinitialized at the end of iteration of the IWD algorithm. The IWD algorithm is specified in the following steps:
Step 1: Initialization of static parameters. Initialize soil updating parameters as=1, bs=0.01 and cs=1 and velocity updating parameters av=1, bv=0.01, cv=1.
Step 2: Initialization of dynamic parameters. Every IWD has visited node of list Vc (IWD), which is initially empty. The IWDs velocity is set to InitVel and the entire IWDs are set to have zero amount of soil.
Step 3: Spread the IWDs randomly on the nodes of the graph as their first visited nodes.
Step 4: Update the visited node list of each IWD to include the nodes just visited.
Step 5: For the IWD in node i, select the next node j, which doesn't violate any constraints of the problem and make certain it is not in the visited node list Vc (IWD).
Step 6: For every IWD from node i to node j, updating its velocity Vel(t) by
$Vel (t+1) = Vel (t) + (av/ (bv + cv * soil^{2\alpha} (i, j))$
Step 7: Update the soils on the paths that form the current iteration-best solution TIB
Step 8: Update the total best solution TTB by the current iteration-best solution TIB
Step 9: Increment the iteration number by
Itercount = Itercount +1. Then, go to Step 2 if
Itercount < Itermax .
Step 10: The algorithm stops here with the total-best solution TTB.

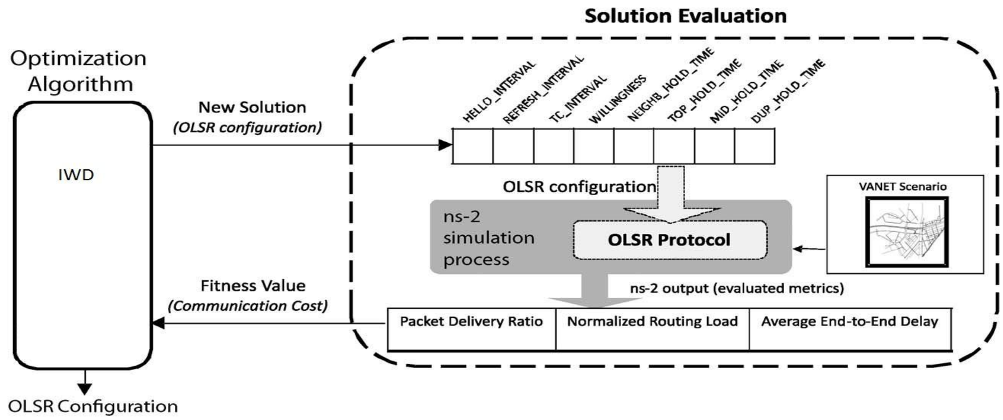

Fig. 4 Optimization framework for automatic OLSR configuration

A. Fitness Value:

As Fig. 4 illustrates, when the used metaheuristic requires the evaluation of a solution, it invokes the simulation procedure. This simulation gives the tentative configuration of OLSR over the defined VANET scenario. Then, ns − 2 is started and evaluates the VANET under the circumstances defined by the OLSR routing parameters generated by the optimization algorithm. After the simulation, ns − 2 returns global information about the PDR, the NRL, and the E2ED of the whole mobile vehicular network scenario, where there were some independent data transmission between the vehicles. The information is used to calculate the communication cost (comm_cost) function as follows:

$$comm\_cost = w \cdot NRL + w3 \cdot E2ED - w1 \cdot PDR.$$

The communication cost function represents the fitness function of the optimization problem addressed. To improve the QoS, the objective here consists of maximizing the PDR and minimizing both NRL and E2ED. As expressed in, it is used an aggregative minimizing function, and for this reason, PDR was formulated with a negative sign. In this equation, factors w1, w2, and w3 were used to weigh the influence of each metric on the resultant fitness value. These values were set in a previous experimentation, although resulting in poor solutions with low PDR and high NRL. It is observed that in VANETs (highly dynamic environments), the OLSR delivers a great number of administrative packets, which increases the NRL, hence damaging the PDR. Since interested issue is in promoting the PDR for the sake of an efficient communication of packets, it is decided in this approach to use different biased weighs in the fitness function, being w1 = 0.5, w2 = 0.2, and w3 = 0.3. The way, PDR takes priority over NRL and E2ED since first look for the routing effectiveness and second (but also important) for the communication efficiency.

V. SIMULATIONS AND RESULT

To increase the throughput and packet delivery ratio the IWD algorithm is used. The data are selected and transferred from the source to the destination. In this result we implemented the simulation of OLSR protocol and calculated its performance such as throughput and packet delivery ratio.

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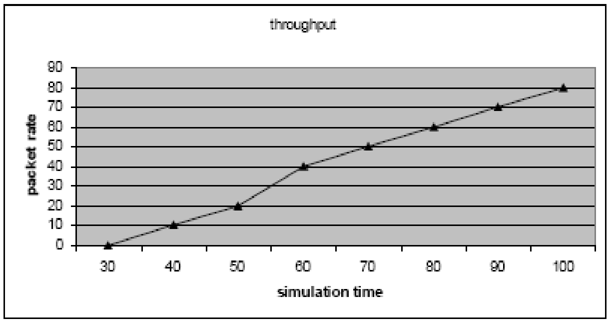

Fig. 5 Simulation Result

VI. CONCLUSION AND FUTURE WORK

In this paper, we presented a new algorithm to tune the parameters of OLSR protocol for routing Operations. The IWD algorithm finds the optimal paths and provides an effective multi-path data transmission to obtain reliable communications in the case of dense networks. Our study was concluded to evaluate the performance of IWD based algorithm and OLSR routing protocol in terms of packet delivery Ratio, average end-to end delay and Routing Load to be normalized. Our proposed algorithm can control the overhead generated and improved packet delivery ratio. The future work could be to examine different methods to more limits the traffic or load and compare the IWD based algorithm for other proactive and reactive routing protocols.

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