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Message from the General Chairs

On behalf of the Organizing and the Executive Committee, it is our privilege to welcome you to the 9th IFIP/IEEE Wireless Days Conference (WD' 17) taking place in the beautiful city of Porto, recently elected best European destination in 2017. The Conference venue is the Faculty of Engineering of the University of Porto, located in walking distance from the yellow line of the Porto underground network heading to downtown.

The Wireless Days 2017 program features three distinguished keynote speakers that are international leaders in their respective research areas: Prof. Falko Dressler, Full Professor for Computer Science and Chair for Distributed Embedded Systems at the Heinz Nixdorf Institute and the Dept. of Computer Science, University of Paderborn, Germany, on Wednesday; Prof. Edward Knightly, department chair of Electrical and Computer Engineering at Rice University in Houston, USA, on Thursday; Prof. Christian Wietfeld, Full Professor and head of the Communication Networks Institute (CNI) of TU Dortmund University, Germany, on Friday.

We are honored to have these world-class guests as keynote speakers, who will definitely add special value to the technical program. The conference committee has also prepared an exciting social program with the aim of making your stay in Porto unforgettable.

Many people did an outstanding job to make Wireless Days 2017 a reality. First, we would like to thank all the authors who submitted their works to the Conference, which were of utmost importance to enable the design of a high quality technical program. A special thanks goes to the Technical Program Chairs and Track Chairs who, along with the TPC members, did an outstanding job in reviewing and selecting the conference papers. We also thank IFIP and IEEE for their technical sponsorship, as well as for their contribution in keeping the reputation of Wireless Days high.

We are very grateful to our sponsors and supporting institutions, especially the Faculty of Engineering of the University of Porto, INESC TEC, and the Luso-American Development Foundation, for all the support provided. Finally, we would like to express a very special thanks to the Steering Committee of Wireless Days, namely to Nadjib Achir, for all their help and positive suggestions.

We sincerely hope that you find the conference a good opportunity for new experiences both at research and personal levels. We expect that WD' 17 creates a fruitful environment for sharing experiences and fostering cooperation.

Welcome to Porto, and enjoy the IFIP/IEEE Wireless Days 2017 program. We are looking forward to seeing you back soon!

Prof. Manuel Ricardo, FEUP/INESC TEC

Dr. Rui Campos, INESC TEC

General Chairs, IFIP/IEEEWireless Days 2017

Message from the TPC Chairs

On behalf of the Technical Program Committee, we would like to welcome you to Wireless Days 2017 in Porto, Portugal.

The Technical Program Committee of Wireless Days 2017 received 78 paper submissions from 38 different countries. Out of these, 26 full papers and 16 short papers were selected for oral presentation. The overall acceptance ratio for full papers was 33.3%. In addition, 11 papers were accepted for poster presentation.

Each paper was peer-reviewed by at least three different researchers from academia or industry, assigned by the 5 track co-chairs from a list of approximately 140 TPC members.

The Conference has 11 technical sessions that address recent and novel research results in wireless communications and networking, as well as 2 poster sessions. Given the interesting set of topics of the technical sessions, we are confident that this will be an opportunity for students, engineers and researchers to present and discuss their work, from which new ideas may sparkle.

The program of Wireless Days 2017 would not have been possible without the strong commitment of the Technical Program Committee. We thank the track co-chairs, TPC members, and the reviewers who were able to complete the peer-review process on schedule and helped to the success of the Conference.

Finally, we are sincerely grateful to all authors who submitted their manuscripts to WD’17 and thus contributed to the high quality of the program. We are certain that the program is compelling to the WD’17 participants and hope it will raise new research challenges to the wireless communications and networking community.

José Ruela, INESC TEC

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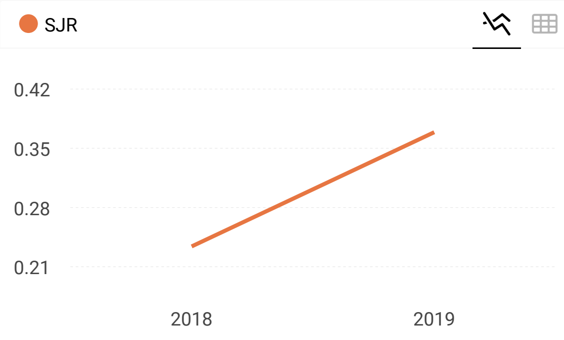
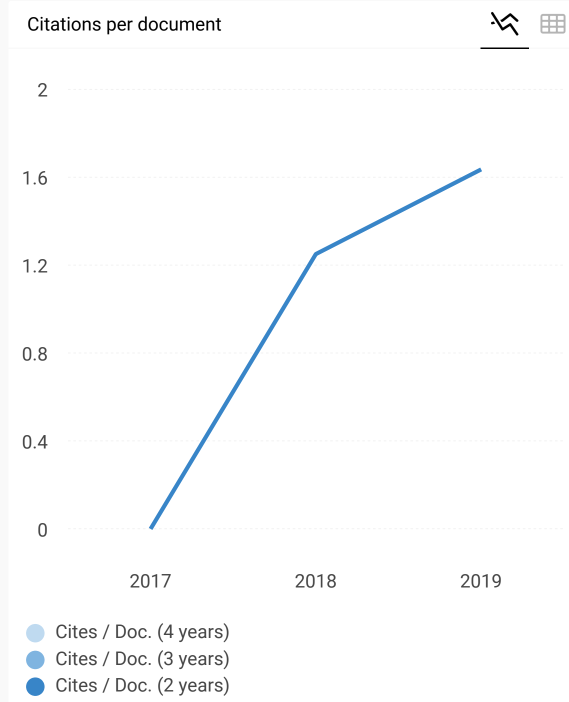
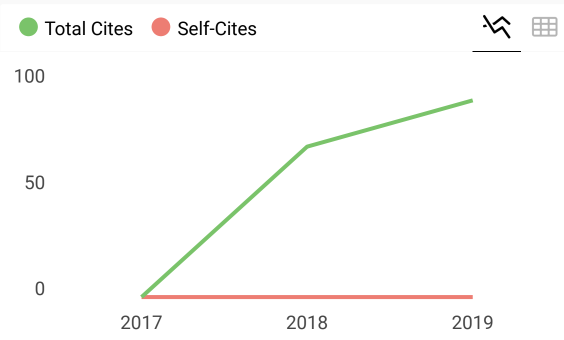
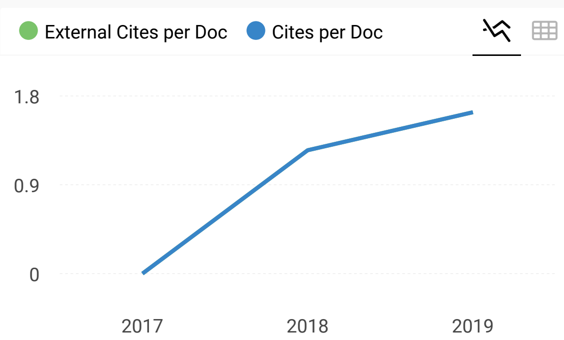
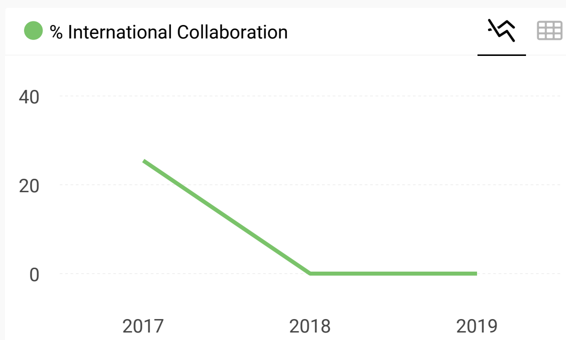
The Wireless Days Conference is a major international conference which aims to bring together researchers, technologists and visionaries from academia, research centers and industry, engineers and students to exchange, discuss, and share their experiences, ideas and research results about theoretical and practical aspects of wireless networking. Wireless Days 2017 is technically co-sponsored by IEEE Communications Society and IFIP. After the successful editions of 2008 in Dubai, UAE (44% acceptance ratio), 2009 in Paris, France (38% acceptance ratio), 2010 in Venice, Italy (33% acceptance ratio), 2011 in Niagara Falls, Canada (35% acceptance ratio), 2012 in Dublin, Ireland (35% acceptance ratio), 2013 in Valencia, Spain (34% acceptance ratio), 2014 Rio de Janeiro, Brazil, 2016 Toulouse, France (35% acceptance ratio), the ninth edition of Wireless Wireless Days will be held in Porto, Portugal, on March 29-31, 2017. Wireless Days 2017 will include presentations of both theoretical and experimental achievements, innovative wireless systems, prototyping efforts, case studies and advances in technology related to wireless networking and communication infrastructures. The Wireless Days 2017 program will be split into the following 5 conference tracks: Track 1: 5G and Beyond Track 2: Wireless Communications Track 3: Ad Hoc, Sensor, Vehicular and Delay Tolerant Networks Track 4: Wireless Models and Simulations Track 5: Mobile Networking and Computing

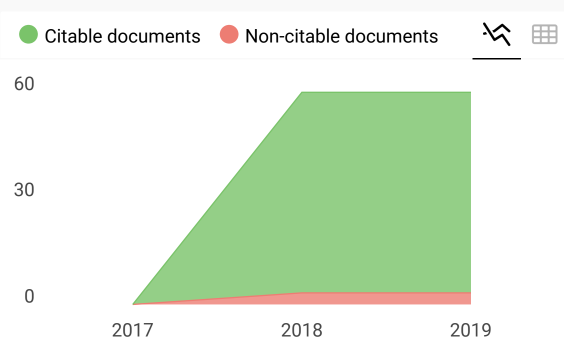


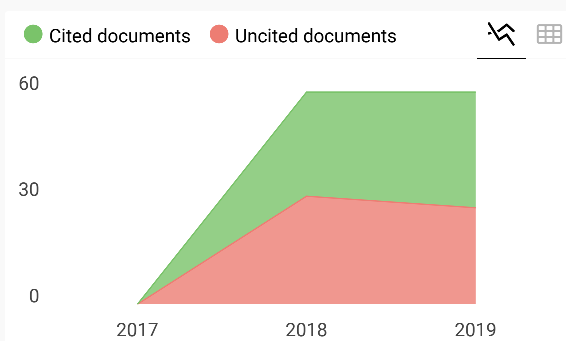












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Evaluation of Inter-vehicle Connectivity in Three-dimensional Cases

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***Abstract*—Packet forwarding decisions in communications among vehicles are important due to their high mobility. Further, road topologies are expected to contribute to more occurrences of out-of-range transmissions, which lead to frequent disconnections. The current method to overcome such complex road environments (*i.e.*, in a three-dimensional scenario) is through the introduction of relative angles as a weighting value applied to the forwarding scheme in Vehicular-to-Vehicular Urban Network (V2VUNet). This scheme avoids unnecessary participating vehicles and selects the proper vehicle as a relay. In order to show the performance of a V2VUNet, this paper analyzes and evaluates various communication models in several three-dimensional cases.**

***Index Terms*—Relative angle, V2VUNet, inter-vehicular communication, three-dimension scenario.**

I. Introduction

One challenge of maintaining a reliable communication in Vehicular Ad-hoc Networks (VANET) is the frequent communication topology changes, which leads to respective disconnections. The case of a three-dimensional environment with some common objects such as high rise buildings and overpasses [13], are a rarely investigated issue in VANETs [2]. These objects determine practical instances that apply the altitude factor. The altitude factor (*z*-axis) in the location coordinate contributes to frequent disconnections [1], thus, vehicles will have to search for a new communication path in order to substitute the "broken" path, particularly at different altitudes.

Several studies have shown that the degree of successful transmission defined by Packet Delivery Ratio (PDR) is influenced by different levels of road topology, particularly in three-dimensional environment [9], [10], [12]. One important component for the packet forwarding decision is the consideration of a vertical angle measurement [10], which is produced by the coordinate of sender and receiver node at different altitudes.

This paper recalls the importance of Horizontal Relative Angle (HRA) and Vertical Relative Angle (VRA) and its potential implementation in complex three-dimensional scenarios. Here, the VRA is introduced as the solid angle of a cone, analog to a shape made by the omni-antenna radiation [3]. Applying the VRA on the aforementioned scenario with altitude-applied roads provides improvements on the routing performance.

The remainder of this paper is organized as follow, Section II describes related work of various inter-vehicle communication models in terms of the type of mobility. Section III introduces the key idea of the VRA forwarding scheme being part of a V2VUNet. The evaluation of such a V2VUNet is discussed in Section IV, followed by the summary and future work in Section V.

II. Related Work

A connection process is described as the connectivity that is built for exchanging basic information (*i.e.,* location coordinate, speed, and direction) or even more complex information (*e.g.,* text or image content). As a real experiment, Fig. 1, shows how signal loss occurs, when the vehicle equipped with Global Positioning System (GPS) is located under an overpass. Participating vehicles operate as a sender *S*, a receiver *R*, or a relay *I*. During packet transmissions, vehicles located at random position are moving also in random speeds. Thus, the communication amongst vehicles can be modeled as: (1) Static-to-dynamic (S2D) communication model, (2) Dynamic-to-dynamic (D2D) communication model.

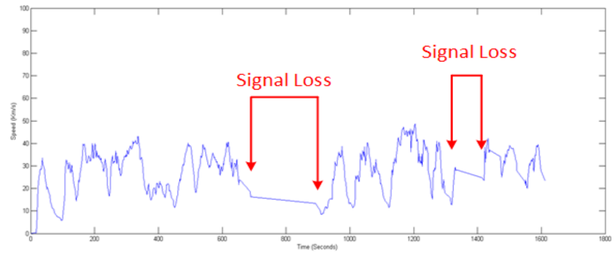

Fig. 1. GPS Connection Lost Occurs Under the Overpass [16]

A three-dimensional environment may lead to less duration for connectivity to occur [10]. In order to investigate this issue, two models are introduced: (1) *Cross overpass model,* represents a typical overpass which is located in the middle of road, and (2) *Parallel overpass model,* represents different road levels without a chance that vehicles will be located at the same z-axis coordinate (cf. Fig. 2).

The angle-based forwarding scheme (AFS) is a forwarding method that takes into account angle measurements between *S* and *R* [5], [9], [14]. AFS is the basic idea of implementing HRA and VRA that will be described in Section III.

III. V2VUNet Approach

V2VUNet approach introduces the concept of selecting a proper relay node *I* [9], [10]. V2VUNet indicates the transmission range depending on angle measuring factors both on the same road level, *i.e.,* HRA measurement and different road levels, *i.e.,* VRA measurement.

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A. Vertical Relative Angle Measurement

A VRA measurement aims to discover the real distance in three-dimensional cases. When the angle measurement is calculated within the same road level topology, it is called as HRA. In contrast, VRA is a term that refers to an angle measurement in different road levels. The VRA defined as θ_z shows the distance of a transmission range between two communicating vehicles. The vehicle's orientation is included in a relative angle measurement in order to obtain such a precise angle which refers to a vector calculation of vehicle's directions. The relative angle is measured based on the *S*'s coordinate frame (cf. Fig. 3.) and can be expressed as in Eq. 1.

$$\theta_S = atan2(\|\vec{v_S} \quad \vec{v_R}\|, (\vec{v_S} \bullet \vec{v_R})) \qquad (1)$$

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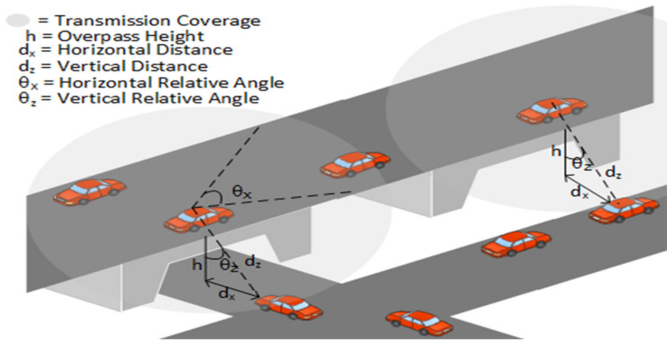

Fig. 2. HRA and VRA Schemes

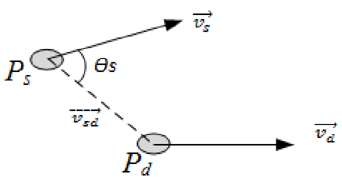

Fig. 3. Relative Angle Calculation

B. Packet Forwarding Scheme Using Filtering Out Concept

The concept of V2VUNet shows the AFS that includes real location coordinates (*e.g.*, provided by GPS) of the participating vehicles. The V2VUNet is applicable for vehicle's location coordinates on top of other vehicle's location coordinates. Using distances between vehicles at planar positions will influence the parameters of V2VUNet such as mobility information, *i.e.*, speed and direction, and non-planar position information, *i.e.*, angle. It is obvious that the higher the overpass, the larger the distance between two communicating vehicles becomes. Therefore, the height of an overpass leads to another impact factor with respect to a transmission coverage. Both HRA and VRA are implemented in the V2VUNet. The principal of filtering out concept in V2VUNet is to select the relay node *I*, which fulfills HRA and VRA requirements.

The two steps of filtering out concept are: (1) *HRA execution* and (2) *VRA execution*. The HRA focuses on the participating vehicles located on the same z-axis coordinate as shown in Fig. 2. Based on the AFS concept, the θ_x angle is the maximum transmission area in order to reduce the unnecessary participating vehicles. The HRA is executed whenever there is a participating vehicle that fulfil the AFS requirement. In VRA, the term solid angle, *i.e.*, θ_z, defines the transmission range in three-dimensional scope. VRA executes a participating vehicle that satisfying the AFS. Once the HRA and VRA decisions have been made, the next step is to execute the packet forwarding.

IV. SIMULATIONS AND RESULTS

The simulation is conducted in two scopes, *i.e.,* the communication model scope and the three-dimensional case scope. In order to apply a realistic city environment, typical parameters for influencing factors are chosen as shown in Table I. The Network Simulator 3 (NS-3.25) [15] is used to simulate wireless technologies, (*i.e.*, IEEE 802.11p), the routing protocol (*i.e.*, Greedy Perimeter Source Routing (GPSR) [8]), the mobility, the road topology, and the network density.

TABLE I: PARAMETER SETTINGS

Parameter	Unit
Transmission Range IEEE 802.11p	up to 300 m
Routing Protocols	GPSR
Number of Nodes	10 - 100
Simulation Area	500 m x 500 m x 20 m
Upper Road Height	10 m
Vehicle Velocity	0 -70 km/h
Packet Size	512 Byte
Simulation Time	200 s
Number of Driving Lanes	2

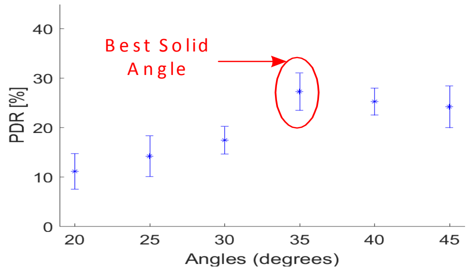

Fig. 4. Solid Angles Evaluation in D2D Communication Model

In addition, *S*, *R*, and *I* are placed randomly both on two different road levels and followed the predefined driving lane. The number of *S* and *R* are generated linearly, which means a 10-nodes network contains 5 senders and 5 receivers. During 200 s of simulation time, each vehicle is expected to run a distance with (a) moving under and on the overpass, and (b) moving on different road levels.

Fig. 4 describes the solid angles that have been evaluated in the D2D communication model due to its realistic traffic. The pattern of a best solid angle of 35° shows about 30% of the maximum PDR. Thus, this best solid angle is applied for further simulations. The reason of selecting the best solid angle is to obtain the maximum PDR in an extreme case, which is also affected by the width of road that fits the transmission range of θx and θz (VRA and HRA).

The first set of results is shown in Fig. 5 to Fig. 8 which indicates the PDR of the two connection models, *i.e.*, S2D and D2D. Overall, the ratio of successful connections in both S2D and D2D models are less than 50% due to the road topology and overpass construction. Thus, communicating vehicles located outside the antenna coverage obviously cannot establish good connections, *i.e.,* less than 5% of those. PDR in S2D show lower percentages compared to PDR in D2D. The lower PDR in S2D is caused by static vehicles mainly in the status, where these vehicles cannot search for a new path. This occurs particularly in the cross road scenario. The static vehicle is located under the overpass construction. However, both in the parallel and the cross road scenarios, and both in the S2D and the D2D communication models clearly indicate that the forwarding scheme with the V2VUNet has a 10% better performance compared to a forwarding scheme without the V2VUNet.

The second set of results is shown in Fig. 9 to Fig. 12, which indicates the end-to-end (e2e) delay of each communication model. Overall, the higher e2e delays in the V2VUNet are caused by the searching for the new path mechanism, where the current path is broken due to the vehicle's mobility. In the cross and parallel scenarios, both e2e delays indicate a significant value. In the cross scenario, the e2e delays reach more than 1000 ms. This delay occurs due to the overpass construction, which causes the vehicle to require more time to find the new path. In the parallel scenario the maximum e2e delay never reaches more than 250 ms. However, the overall e2e delays in any case never reach more than 10% of the e2e delay without the V2VUNet.

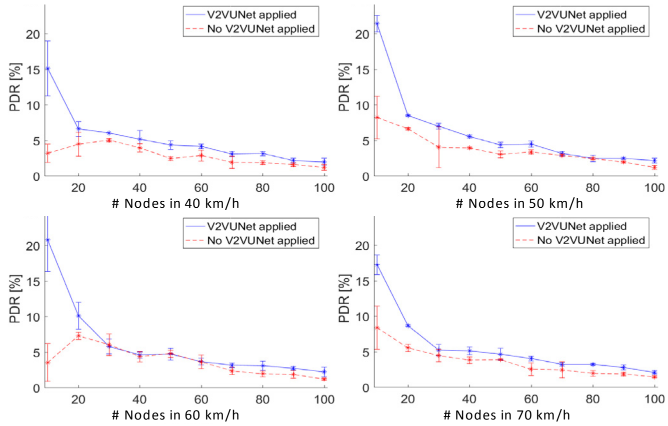

Fig. 5. S2D Communication Model in Cross Scenario

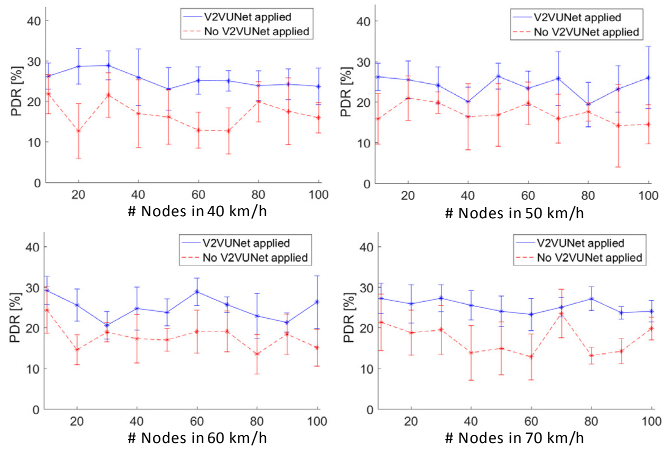

Fig. 6. D2D Communication Model in Cross Scenario

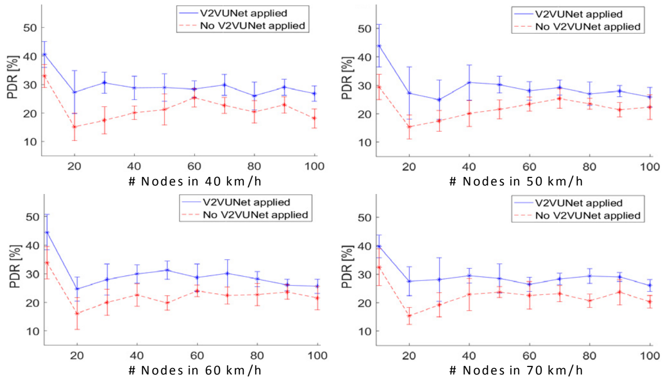

Fig. 7. S2D Communication Model in Parallel Overpass

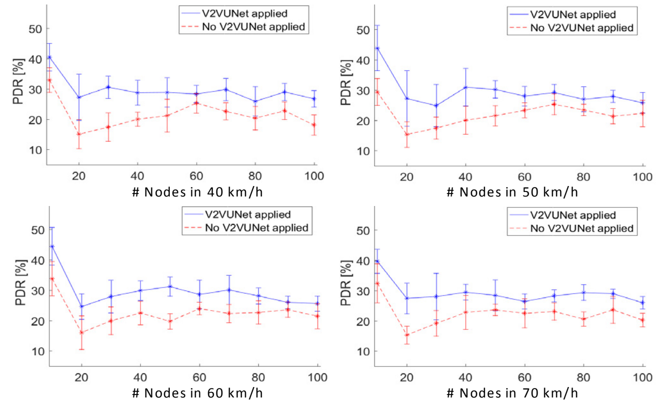

Fig. 8. D2D Communication Model in Parallel Overpass

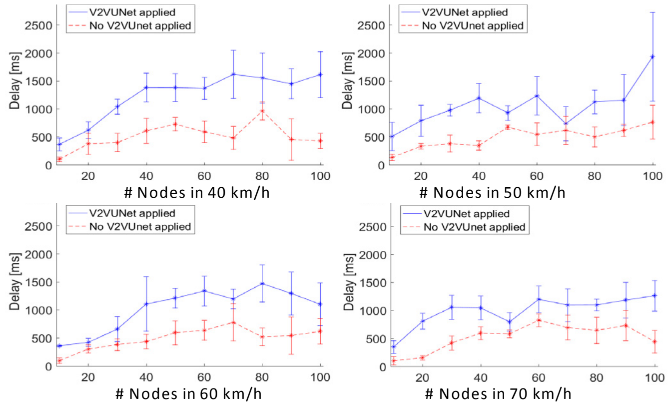

Fig. 9. e2e S2D Communication Model in Cross Overpass

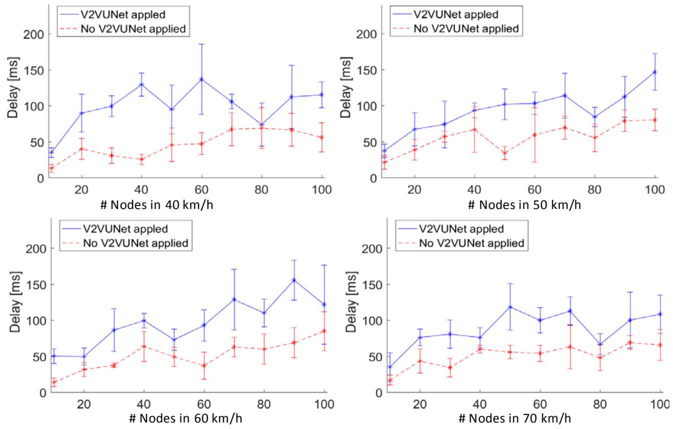

Fig. 10. e2e S2D Communication Model in Parallel Overpass

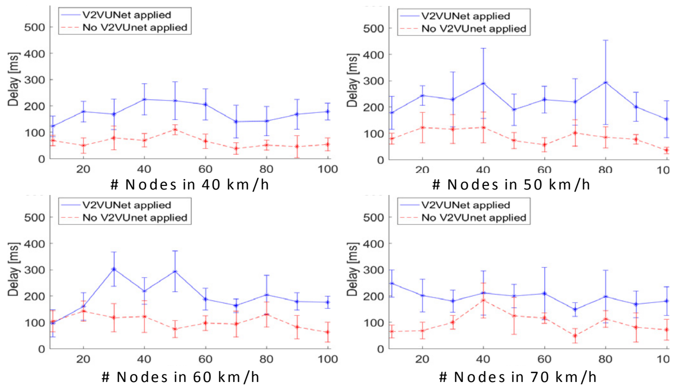

Fig. 11. e2e D2D Communication Model in Cross Overpass

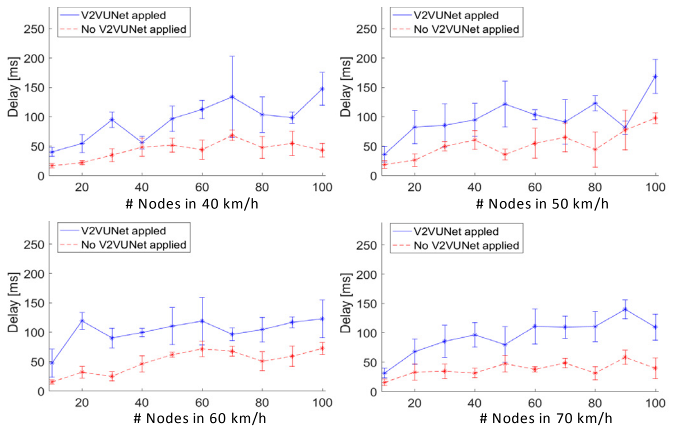

Fig. 12. e2e D2D Communication Model in Parallel Overpass

V. Summary and Future Work

This work evaluated inter-vehicle connectivity in three-dimensional cases. The V2VUNet as an approach with a filtering out concept maintaining a better inter-vehicle communication in three-dimensional large city environments. The V2VUNet is also evaluated in terms of its movement types, spanning from static to dynamic movements.

The evaluation concludes that the complexity of a three-dimensional road topology, such as with different heights of cross- or parallel overpass constructions, has a significant impact on inter-vehicle communication (*i.e.*, lower duration connectivity and fluctuating end-to-end delay).

The V2VUNet including additional weight values, *i.e.*, HRA and VRA, determines the next relay *I* in the communication path between two vehicles. Furthermore, it is shown that HRA and VRA metrics reduce unnecessary participants with a high chance of disconnection in the crossing overpass scenario and in the out-of-transmission range in the parallel overpass scenario. Additionally, the e2e delay becomes more stable through the approach proposed. Future work will include the evaluation of V2VUNet with a Multiple Input Multiple Output (MIMO) data dissemination in order to follow the modern approaches of information exchanges amongst vehicles.

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