Performance Evaluation of Video Dissemination Protocols Over Vehicular Networks*

Farahnaz Naeimipoor, Cristiano Rezende and Azzedine Boukerche
PARADISE Research Laboratory
University of Ottawa - Canada
Email: {fnaem040,creze019,boukerch}@site.uottawa.ca

***Abstract*—There are several outstanding services envisioned for Vehicular Networks that require the provision of video dissemination support. These services range from enhancing safety via the dissemination of video from an accident scene to advertisements of local services or events. This work considers the infrastructureless scenario of Vehicular Ad Hoc Networks (VANETS). The dissemination of video content over VANETs is extremely challenging mainly due to the network's dynamic topology and stringent requirements of video streaming. This paper studies the main approaches aimed towards an effective and efficient solution for video dissemination over VANETs. Furthermore, some of these solutions have been selected to discuss their techniques and suitability for video dissemination and compare their performance. This work describes in detail the process of video dissemination over VANETs and presents a thorough evaluation of existing solutions. This permitted us to summarize our observations and indicate the direction for the design of new solutions.**

I. Introduction

Vehicular networks is a prominent area as on-board technology is increasingly becoming available and deployed. Vehicles such as cars can actively participate in the communication aspect of this type of networks, as opposed to where they will remain as stand-alone passive nodes. Although roadside infrastructure might be needed in order to assist in the overall network connectivity, ad-hoc communication among nearby vehicles is crucial for any envisioned model of a vehicular network. This work focuses on the Vehicular Ad Hoc Network (VANET) model which mostly does not rely on roadside infrastructure and the majority of message exchanges are conducted in an ad-hoc manner between the cars.

VANETs can be extremely challenging to deal with as vehicles move intensively and at high speeds. Their network topology is highly dynamic, links do not last for more than a few seconds, and, constantly, new vehicles become within range of each other. Another aspect of VANETs' topology is that vehicles are not uniformly distributed through the network. Traffic congestion, road intersections, daily seasonality and routes popularity increase the concentration of vehicles in some regions whereas others are left unutilized. The wireless nature of the communication in VANETs is also a challenge as the medium for exchanging data is shared among all nearby vehicles. For all these mentioned reasons, there is a demand for the development of new suitable solutions for VANETs.

Many of the services and applications envisioned to be developed over VANETs either require the provision of video dissemination capability and/or its support. These services and applications will serve many different beneficial purposes. For example, law enforcement agencies could use live streaming from vehicles for surveillance or search purposes. Emergency response teams could be more effective if paramedics in ambulances or physicians at hospitals could have access to videos from the accident scene or from the first care provided in ambulances. Also, drivers could take better decisions in deciding which route to take if they could watch the current traffic conditions on the roads or highways that they are planning to take.

The main goal of this study is to analyze the existing works proposed for video content dissemination in terms of their efficiency and effectiveness for VANETs. Video content differs significantly from other data types such as alert messages, vehicles' information (e.g. speed, position, etc.) or services description (e.g. closest gas station). Video is constructed using large amounts of data and has stringent requirements in terms of delivery ratio and delay. Cisco has defined some of these requirements [1] for the exchange of video content. In the case of video-streaming, delay should not be higher than 4 to 5 seconds, while loss should not exceed 5 percent. Bandwidth requirements depend on applications and jitter imposes no significant requirements. The transmission of video over VANETs is expected to require the use of high amounts of network resources, but it cannot be too excessive. Therefore, video streaming solutions for VANETs have to fulfill all of these basic requirements while being limited to a reasonable occupation of the wireless medium. This paper emphasizes works that aim at the specific issue of video dissemination and discusses a number of solutions that have been proposed to tackle the aforementioned dissemination challenges.

In addition, the most effective and efficient layer-centric solutions for video dissemination over VANETs have been revised to investigate how these solutions tackle video dissemination challenges and how they perform based on video streaming requirements.

In this study, a Media Access Control (MAC) congestion control mechanism over Wireless Access in Vehicular Environ-

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ment (WAVE) [2] has been selected as a reliable approach on top of the link layer. This solution adopts a parameter known as Adoptive Offset Slots (AOS) to determine an optimal back-off time based on the network congestion.

Reactive, Density-aware and Timely Dissemination Protocol (REACT-DIS) is another selected solution that has been implemented over network layer. REACT-DIS is a receiving-based routing approach that avoid high packet delay and transmission overhead specially in denser areas.

Furthermore, Network Coding based Data Dissemination (NCDD) [3] approach has been choose as one of the best solution over the application layer. This approach take advantage of Network coding technique in the intermediate nodes to improve packet delivery ratio by broadcasting less number of video packets.

The rest of this paper is organized as follows: Section II presents the related works including the analysis and classification of comparative studies in video streaming over VANETs and Section III introduces a number of reliable and efficient techniques for video streaming as the main focus of this study. The performance evaluation of these approaches and simulation results are discussed and presented in section IV. Finally,Section V concludes this paper.

II. Related Work

To the authors' best knowledge, there are only a few number of works that have evaluated the performance of video streaming approaches over VANETs. Some of the comparative studies that were specifically aimed at layer-centric solutions have been surveyed in [4], [5]. A significant number of video streaming protocols in VANETs are tightly dependent on routing approaches [6], [7]. Most of these protocols are extensions of proposed routing schemes for video data dissemination in Mobile Ad Hoc Networks (MANETs) that have been redesigned based on the nature of VANETs [8]. Involved techniques in the routing protocols can be classified as network layer-centric techniques, since the main task of the network layer is the forwarding of data packets as well as providing routing for these packets. Fei Xie et al. in a performance study of live video streaming [9] have focused on the node selection methods in the network layer to find a reliable routing approach for forwarding video packets. In this work, data forwarding schemes have been divided into two major categories: Sender Based Forwarding (SBF) and Receiver Based Forwarding (RBF). Instead of measuring the packet delay and delivery ratio, this work has evaluated the Peak Signal to Noise Ratio (PSNR) in order to analyze the quality of decoded video at receiver nodes. The results of this performance study provided a clear insight on how to choose more reliable network layer-centric solutions for video broadcasting. Yao H. Ho et al. in [5] have also studied a number of routing protocols in high mobility and large obstacles environments to compare their scalability and reliability in terms of packet delivery, delay and duplication. This study categorized the best routing solution for different scenarios based on nodes' mobility, density, pause time, communication load and application type.

The work done in [4] is a comparative study that focuses on data muling combined with three error resilience techniques in scalable video coding . Erasure coding, network coding and repetition coding are three reliable and timely solutions that have been evaluated in this study for broadcasting video content on top of the application layer. Results in this work show that using network coding yields the best performance in term of data delivery delay compared to the other mentioned error resilience techniques.

In another performance evaluation study [10] by Rahim et al., the impact of malicious nodes in different VANETs scenarios have been considered to provide secure multimedia communication between vehicles and other entities on the road. In this study, PSNR, sending rate, receiving rate and end-to-end delay have been measured for vehicles that are moving in the same or opposite directions. The results proved that the mobility of vehicular nodes, their moving direction, and the presence of malicious nodes can have a direct effect on the network throughput.

Furthermore, video broadcasting solutions over the link layer have been proposed in a number of studies [2], [11], [12]. However, there is no comparative study for video broadcasting which specifically focuses on link layer solutions that are mostly enhancements of IEEE 802.11. These types of solutions propose modifications in the Media Access Control (MAC) sub-layer to overcome network challenges such as fair sharing of bandwidth, end-to-end delay and packet loss in high congested networks.

Different MAC layer solutions have been suggested in [13], [14] to select nodes in the furthest position in the source's transmission range as relay nodes for data. The Urban Multi-hop Broadcast (UMB) protocol in [13] uses a channel signal (black-burst) that is proportional to the nodes' distance from the source, which can be used by the source to determine which node is the furthest. Once a source node sends out a Request to Broadcast (RTB) message, all nodes that have received this RTB will send out a black-burst signal. At the end of the black-burst, the furthest node will sense the channel for idleness and can therefore announce itself as a relay node by sending a Clear to Broadcast (CTB) message to the source.

Stanica et al. in [15] have suggested a link layer-centric protocol by modifying the back-off time for controlling congestion in networks. Most of these approaches rely on dynamic adjustments of the minimum threshold of the contention window size (CW_{min}) to determine an optimal back-off time. In some proposed schemes, obtaining an optimal back-off time depends solely on the duration of the collision in the channel. This is not suitable in many cases where packet drops can occur for reasons other than collisions, and therefore should not be the only factor used to achieve an ideal CW_{min}.

III. Description of Protocols

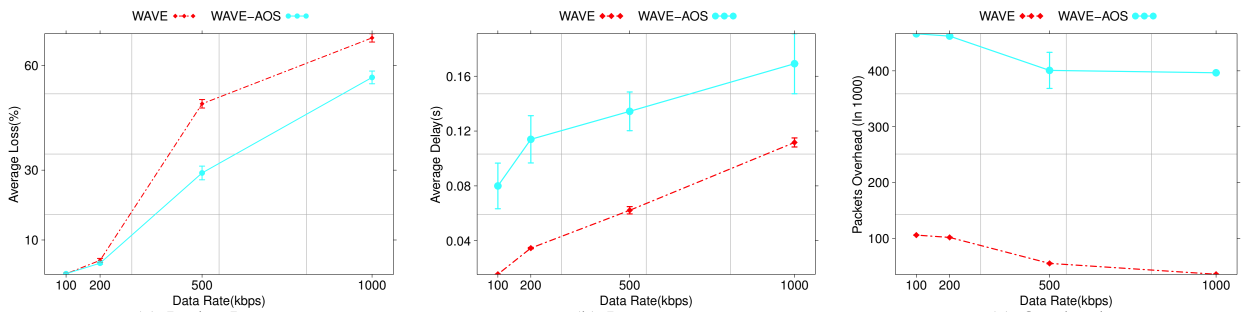
Following section provides a detailed description of the main solutions that are evaluated in this paper. Moreover, this study distinguishes how the network coding technique at the source or intermediate nodes affect video quality as the impact on delivery ratio and delay. The achieving result in this section gives clear insight in how employ network coding for video streaming over VANETs.

For the purpose of in depth analysing of each selected protocol, this section has included some simulation results. Therefore, it is important to define simulation set-up before description of protocols.

- **Simulation Set-up**
  For the evaluation of all these approaches, the Network Simulator (NS2) [16] has been used to support protocols' implementation. In addition, the Freeway+ [17] has been chosen to model a highway of 12km with an average density of 50 vehicles per kilometre moving at two different directions with three lanes each. The speed of vehicles depend on which lane they are and in general it ranges from 5 to 40 meters per second. The sent video is from a well-known benchmark and widely available online (akiyo-cif) [18]. The video consists of 300 frames divided into the payload of 1,000 bytes of 353 different packets. It is assumed that video content be distributed by only one camera source and the case of multi sources have not been considered. However, the scalability of each solution was measured by the number of packets transmitted by them and this allows us to estimate the impact of multi sources. This study has compared the solutions based on frame loss, delay and overhead. The first two metrics are obtained with the assist of the Evalvid framework [19] and the overhead is calculated as the number of transmissions by the network. The transmission range used is of 300 meters and the used broadcast bandwidth is of 1 MBps (mega bytes per second).
  In order to statistical analysis and plot of the observed results R [20] has been used. Each plotted point is an average of 10 runs and confidence intervals are calculated using Student's t-distribution at a confidence level of 95%. Videos are excessively demanding in terms of data rate, therefore, this study attempts to measure how each solution performs through different data rates. The data rate used here is the network data rate so it is the frequency by which packets are sent by nodes in the network.

A. MAC Channel Congestion Control Mechanism in IEEE 802.11p/WAVE Vehicle Networks

This study have picked a link layer-centric solution to evaluate the effect of Media Access Control (MAC) sub-layer which is responsible for managing the interaction of devices with the shared wireless medium. Proposed protocols for video broadcasting in VANETs at the link layer are extensions of IEEE 802.11 that have been introduced to provide wireless access in a vehicular environment. According to the previous research works [11], [21], [22] pioneer MAC layer approaches are not suitable to provide reliable and robust video broadcasting techniques. The major challenge is the acknowledgment (ACK) explosion that would happen due to the transmission of numerous ACK control frames via all receivers of a broadcasted message. In addition, another challenge surfaces from the hidden terminal problem, which is a severe issue in broadcasting scenarios since the RTS/CTS (Request To Send/Clear To Send) handshaking process cannot be treated in the same manner as in unicasting scenarios. However, deploying the proposed techniques for ad-hoc networks is not suitable in VANETs due to their specific characteristics. Therefore, IEEE 1609 group, in collaboration with the 11p group, developed a standard for vehicular communication, known as IEEE802.11p, which improves the proposed approaches over VANETs in terms of packet loss, average end-to-end delay, and throughput [23]. Chih-Wei Hsu, et al. in [2] have proposed a MAC channel congestion control mechanism in IEEE 802.11p/WAVE vehicle networks. The 802.11p/WAVE is an amendment to the IEEE 802.11 standard to enable wireless access for Vehicle to Infrastructure (V2I) and vehicle to vehicle (V2V) communication. The 802.11p standard has the same core mechanism as 802.11e which integrates the Quality of Service (QoS) into its MAC layer. IEEE 802.11e defines a new medium access procedure based on the Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) scheme called the Hybrid Coordination Function (HCF). The 802.11p follows an Enhanced Distributed Channel Access (EDCA) scheme as one of the provided medium access methods by HCF. The EDCA takes advantage of the Listen Before Talk (LBT) and back-off time that are defined based on a random waiting time and a channel access parameter known as the Arbitration Inter-frame Space (AIFS). The channel access parameter, AIFS, in addition to the contention window size (CW_{min}, CW_{max}), are assigned to traffic of the access categories to provide distributed channel access. With all the 802.11p standard improvements for data transmission over vehicular networks, there are still some issues such as large end-to-end delays due to switching between different channels and lack of guaranteed bandwidth in high congestion networks, which makes it unsuitable to be used as-is for video broadcasting applications. MAC channel congestion control mechanism in [2] introduces a new parameter called AOS to control the back-off time based on the modified minimal value of CW. In this approach, the CW_{min} value is altered depending on the potential number of vehicles neighbours that have been defined in the congestion estimation function. The number of neighbours is calculated by considering the broadcasted hello messages by those neighbours as it listens to the control channel during the listening interval. The numbers of neighbouring vehicles update in predefined amount of time to pick maximum numbers among vehicles in the last interval or average of neighbouring vehicles in the all previous intervals according to the following formula:



(a) Packet Loss (b) Latency (c) Overhead

Fig. 1. Experimental Results of WAVE-AOS vs. WAVE approach

$$EST[N] = \max(Pre[N_{K-1}], [\frac{\sum_{i=1}^{k} N_i}{k}]), \quad (1)$$

In the next step, an expected offset calculation function picks offset slot values depending on the number of neighbouring vehicles which is mean of the possibilities.

$$EO[N] = [\frac{1}{N+1} \sum_{i=0}^{n} i], \quad (2)$$

The calculated number of offset slots will be added to the minimum value of the old contention window size to get a new CW_{min} depending on the vehicular traffic volume. Figure 1 illustrates an evaluation of 802.11p/WAVE performance compares to MAC channel congestion control mechanism using AOS (WAVE-AOS). As a result, the number of packet collision is reduced and higher packet delivery ratio is achieved. In order to increasing back-off time in high congested network, WAVE-AOS approach causes more delay which is not more than 1 second and still complies with the video-streaming requirements. The number of transmission in WAVE-AOS solution is much higher than original WAVE due to propagation of hello messages. However, that is not consider as a problem while hello message are much smaller than video packets and gathering this information can be used by other layers and approaches. As it is showed in 1(c), overheads of both applications increase in the same trend which clearly has impacted by distributing control messages.

B. Reactive, Density-aware and Timely Dissemination Protocol

Selecting a subset of intermediate nodes as relay in optimal manner can be used as an appropriate solution in data broadcasting to minimize packet redundancy as well as collision and packet latency. Since, in this method, only a subset of receiver nodes will participate in the rebroadcasting, it is important to choose nodes as relays appropriately in such a way that will optimize the network throughput. Based on the participant nodes' nature, relay node selection technique can be sender-based or receiving-based.

According to the study in [9], the receiving-based forwarding scheme outperforms the sender-based forwarding scheme in the terms of packet delay, collisions, and overhead, and is therefore more suitable to provide video dissemination services over vehicular networks.

The receiving-based techniques are dependent on decision of each receiver nodes to either broadcast a received message further or to drop it. In contrast to the source-based methods, receiving-based techniques are mostly reactive and do not rely on topology information.

Algorithm 1 REACT-DIS - Receiving packet p

```
if p has not been received before then
    if node is a relay node then
        forward packet p with probability depending on the
        number c of duplicates
        reset counter c
    else
        if node is scheduled to try to broadcast then
            insert p into buffer of packets to send
        else {Node is idle}
            Schedule to try to become a relay node; store p
        end if
    end if
else {p has been received before}
    increment counter c
end if
```

The REACT-DIS is a receiving-based solution that overcomes the high delay of this class of solutions and also avoid excessive overhead in denser regions while maintaining connectivity through sparser regions. In REACT-DIS, the choice of relaying nodes is performed at receivers instead of the last broadcasting nodes (senders). Hence, once nodes receive a packet they schedule themselves to forward it further in a time inversely proportional to their distance to the last hop node. REACT-DIS keeps track of overheard duplicate messages to estimate local density and tune their decision of retransmission. This density-aware property works as when the waiting time t expires, a node chooses to be a relay node depending on the number of overheard transmissions of the same packet. The chance of a node to become a relay node

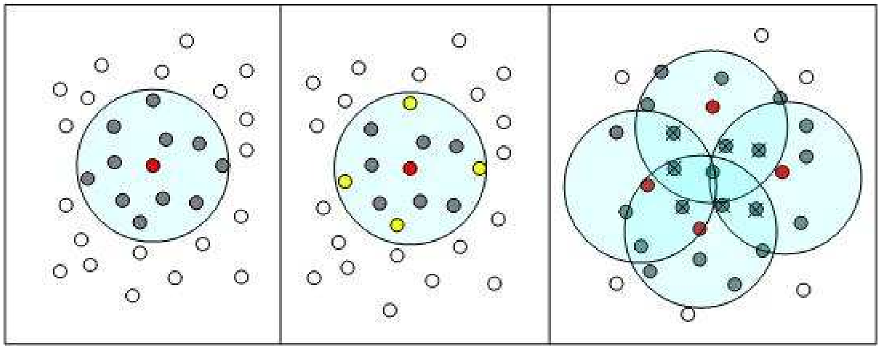


Fig. 2. Dissemination of video content in REACT-DIS approach

starts at 100% if no retransmission of the packet is observed and it decreases exponentially with the number of overheard retransmissions. In addition, to be aware of vehicle density, the relay node forward received packet with the probability p which is exponentially inversely proportional to the number of overheard copies. This manner reduces the cost of transaction by limiting duplicated packets.

As receivers elect themselves as relay nodes, this solution is extremely reactive to changes in topology. The disadvantage of receiving-based solutions is that the schedule waiting time accumulates through hops leading to prohibitive end-to-end delays (specially for a delay sensitive application as video-streaming). REACT-DIS deals with this by extending the decision of a node to become a relay node from a single transmission to a time window in which every further received packet is immediately forwarded. Figure 2 illustrates dissemination of video content in REACT-DIS and algorithm 1 explains the steps taken by this approach when a node receives a packet.

C. Network Coding based Data Dissemination

The idea of Network Coding (NC) proposed by Ahlswede et al. [24] showed that the combination of data packets using a linear function is a robust solution for saving in bandwidth and improving network throughput. Traditionally source nodes send simple packets and interior nodes only replicate and relay the received original packets. In network coding technique, if a node receives more than one packet (e.g. packet A, B), it can encode them using a linear function f and forward a packet $f(A, B)$ with the equal size of original packets [25]. To achieve better results, the linear function can be designed randomly to generate new packets by different combination of buffered packets [26].

The NCDD uses the Network Coding technique to try to take advantage of shared medium to achieve high delivery ratios. The idea is to use network coding by dividing the original data into blocks of η segments. Each block is distinguished by a unique ID that is equal to the first segment number belonging to the same block. A coded packet $C_{(B_{id},\eta)}$ is a linear combination of the segments in $(blockid, blocksize)$.

$$C_{(B_{id},\eta)} = \sum_{k=1}^{\eta} e_k P_{(k-1+B_{id})} \tag{3}$$

When nodes receive their first packet of a new block, they schedule themselves to handle received packets at a time proportional to η divided by the data rate in other words, the expected time to receive η packets from a block. When this time expires, receivers check if they have received enough packets to decode the whole block using a coefficient e_k, which is randomly chosen from a finite field F. The coefficient is embedded in each received block in order to generate a matrix used to recover the original block by multiplying the inverted coefficient matrix with the coded block.

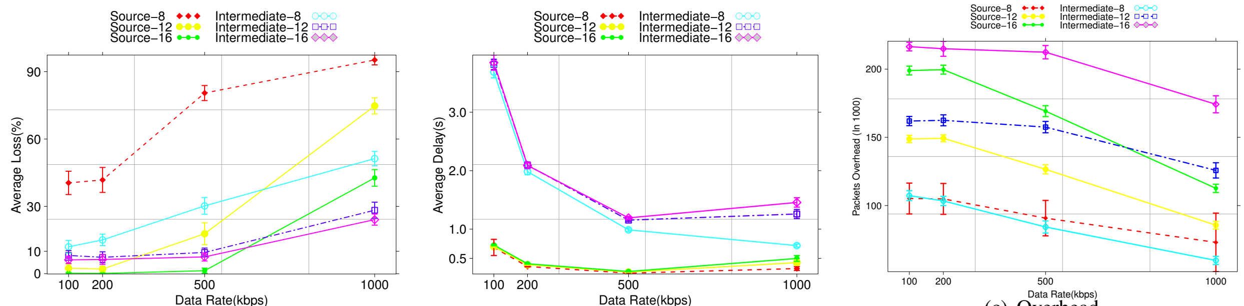
$$P = E^{-1}C \tag{4}$$

In case they did, they broadcast η newly encoded packets, otherwise, they broadcast a help message requesting neighboring nodes that have decoded block to forward further packets. NCDD aims at taking advantage of the network coding capability of permitting intermediary nodes to generate new encoded packets by re-encoding received packets, thus, they can efficiently use the shared wireless medium. Algorithm 2 shows how nodes handle a incoming packet.

Algorithm 2 NCDD - Receiving packet p

```
if p has not been received before then
   if p first packet from p's block then
      Schedule to try to broadcast newly encoded packets in
      η/(data rate) seconds.
   else
      store p
   end if
end if
```

As mentioned before this paper also evaluates the impact of network coding by itself. For this purpose, we have expanded flooding to use Network Coding and there are two ways of using NC in this circumstance. The first is using it through intermediary nodes with a similar perspective to NCDD. For clarity reasons, the remainder of this paper refers to this approach as Network Coding at Intermediary nodes (NC-Int).



(a) Packet Loss (b) Latency (c) Overhead

Fig. 3. Experimental Results of NC-Int and NC-Source with additional redundancy

Differently from NCDD, NC-Int does not use help messages so it does not require a timer and the broadcast of newly encoded packets is performed once a block can be decoded upon the reception of a new packet. The η newly encoded packets are all broadcast following the same dissemination strategy of flooding based on a probabilistic approach. Algorithm 3 describes the behaviour of a node using NC-Int when it receives a packet. The second method is through adding redundancy from the source node itself and we call this solution as Network Coding at Source nodes (NC-Source). NC-Source follows the exact same dissemination approach as flooding with predefined probability for forwarding packets in intermediate nodes. The difference is that instead of non-encoded packets, the source node broadcasts encoded packets at a ratio of κ packets per block of η segments (with $\kappa > \eta$). This solution does not require intermediary nodes to wait for the reception of η packets to continue the dissemination process, however, they do not fully take advantage of an efficient use of the available bandwidth.

Algorithm 3 NC-Int - Receiving packet p

```
if p has not been received before then
  if p's block can now be decoded then
    forward η newly encoded packets with probability γ
  end if
end if
```

In all the solutions, the $\eta = 8$ and $\kappa = 12, 16$ which means for the cases that used forced additional redundancy, there was an increase of 50% and 100% in the number of packets sent.

As figure 3 shows, the effect of application layer solutions can be extended by employing hybrid approaches that consider additional redundancy in network coding where source or intermediate nodes forward κ newly encoded packets. The use of Network Coding is definitely an effective measure to reduce frame loss as it is shown by the observed results of NC-Int, NC-Source. This happens because these approaches exploit Network Coding as both an error correction technique in forcing additional redundancy and in using efficiently the available bandwidth. In addition, by comparing the overhead of NC-Int and NC-Source, it becomes clear how requesting intermediary nodes to stall the dissemination process until they are able to encoded new packets with new sets of coefficients is an efficient way of using transmissions to achieve higher delivery ratios. However, as results demonstrate in general, forcing additional encoded packets at the source have better impact on network throughput in terms of delay, delivery ratio and cost of the network specially in lower data rates scenarios.

IV. Discussion and Results

In order to achieve a well performed analysis of the proposed protocols for video dissemination over ad hoc networks a decent literature review have been performed to form strong basis for framing and refining the paper objectives.

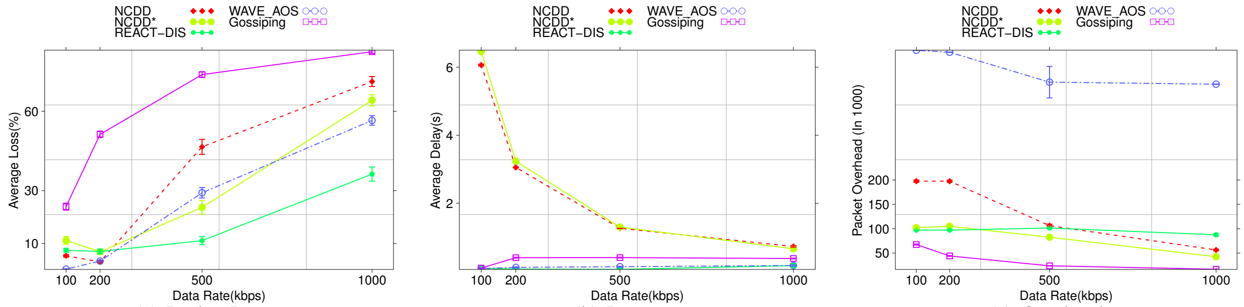
This study has selected numbers of reliable and suitable solutions based on how they cover mentioned techniques and how widely accepted in terms of QoS. The solutions that are described in section III have been compared with Gossiping which is a well-known basis approach for data dissemination.

Gossiping is a generalization of the common Flooding solution where the source nodes starts the dissemination by broadcasting packets and every node that receives a packet retransmits it. The difference with Gossiping is that the retransmission of a packet by a intermediary node is subjected to a random test of probability p (Flooding happens when $p = 100\%$). These are the most simple dissemination protocols but they serve as baselines for delivery ratio, latency and overhead. The protocol followed by Gossiping when packets are received is shown in Algorithm 4.

Algorithm 4 Gossiping/Flooding - Receiving packet p

```
if p has not been received before then
  forward packet p with probability γ
  {Flooding at γ = 100%}
end if
```

The first observation is that higher data rates are exceedingly more challenging than scenarios with lower rates, for all solutions there are steep hikes on frame loss as data rates increase. Therefore, it is crucial that solutions aimed at the dissemination of content that requires the delivery of large amount data over short periods of time to be evaluated under scenarios with demanding data rates. The high ratios of frame loss by Gossiping is expected as they do not have any



(a) Packet Loss (b) Latency (c) Overhead

Fig. 4. Performance comparison of video dissemination protocols

mechanism to prevent or handle packet loss due to congestion. Although NCDD could achieve low frame loss at low data rates, this was not sustained at higher data rates. A minor modification has been applied on NCDD to form NCDD* where only half of receiving video packets broadcast by intermediate nodes and each node send help message to 80% of its neighbouring nodes. This solution improved the ratio of frame loss in NCDD for scenarios with high data rate. REACT-DIS had a similar performance to NCDD but it handles much better in the high data rates networks. As illustrated in the IV, the WAVE approach with use of AOS performs better than NCDD and REACT-DIS in term of frame loss in lower data rate but it is not as efficient as REACT-DIS in high data rate scenarios.

In Figure 4(b), in term of the end-to-end delay, solutions that make use of Network Coding with re-encoding at intermediary nodes (both NCDD and NCDD*) is highly influenced by the data rate used. This is the outcome of the necessary wait at each hop for nodes to receive at least η unique packets from each block before they can decode and encode new packets to be further forwarded. Although this delay is prohibitively at low data ratios, it decreases significantly at higher data rates as the time for the reception of a whole block is inversely proportional to the data rate. All the other solutions had an average end-to-end delay inferior to 1 second which complies with the video-streaming requirements.

These solutions have been also compared in terms of the overhead they incur into by measuring the total number of transmissions through the simulations. Gossiping low number of transmissions is due to the high frame loss that these approaches are subjected to. NCDD flooding characteristics associated with the use of help messages causes it to be the solution that requires the high amount of transmissions. In compare to NCDD, NCDD* saves cost of the network in terms of overhead by reducing numbers of redundant packets in the network. As it is demonstrated in 4(c) REACT-DIS could sustain reasonable levels of frame loss while not incurring into an excessive number of transmissions .In contrast, WAVE-AOS has the most amount of transmission due to broadcasting of control messages for neighbouring vehicles recovery. These control messages only carry the source identifications then they are much smaller than video packets or help messages in the NCDD.

V. Final Remarks

Video dissemination over VANETs is necessary for the deployment of useful and crucial services over vehicular networks. However, there are many challenges that need to be overcome in order to fulfill all video-streaming requirements. This study has discussed and compared a number of selected approaches for video broadcasting. From these selected approaches, the most reliable and suitable technique has been highlighted for each specific protocol stack layer. These solutions have been compared through simulation and their performances have been analyzed in terms of frame loss, delay and communication overhead. These techniques could be combined to form a reliable cross-layer approach as they tackled video-streaming challenges in different protocol layers. The results showed that all of these highlighted approaches have improved the performance of the gossiping as a basis for data dissemination and are equipped with enough capabilities to enhance existing video broadcasting solutions by touching on the different aspects that have not been considered before.

Furthermore, the observations that have been gathered in this study can be a guide to the design of a new complete hybrid solution by deploying the best techniques on each layer in an optimal manner. In terms of future work, there is a need to design different solution for video dissemination for each protocol stack layers in order to develop a full system which can offer high delivery ratios, low end-to-end delays while keeping transmission costs limited.

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