Towards a QoE-driven Mechanism for Improved H.265 Video Delivery

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***Abstract*—The employment of video-equipped vehicles is growing apace. Following the same trend is the number of available applications and services place at disposal in Vehicular Ad-hoc Networks (VANETs). Conversely, video services are commonly referred as one of the most stringent applications, on the grounds that it requires a quality-aware steady and uninterrupted flow of information. Because of that, a number of challenges arose, including how to deal with the scarce network resources, the high-error rates and the time-varying channel conditions. This unveils the need for an adaptive video-aware and Quality of Experience (QoE)-driven mechanism to take care of these challenges and deliver video sequences with good quality. To this end, Forward Error Correction (FEC) techniques can be customized to support video transmissions with QoE assurance over high-mobility and error-prone networks. The adaptive QoE-driven mechanism proposed in this paper improves the resilience of real-time video transmissions against packet losses. It relies on the combination of VANETs characteristics and High Efficiency Video Coding (HEVC) details to provide a tailored amount of redundancy, which improves both the usage of resources and the user experience. The advantages and footprint of the mechanism are evidenced through extensive experiments and QoE assessments, proving that the proposed mechanism outperforms non-adaptive and also adaptive competitors.**

***Index Terms*—VANETs; Forward Error Correction (FEC); Unequal Error Protection (UEP); Fuzzy Logic; Quality of Experience (QoE)**

I. Introduction

The rapid growth of real-time video services is evident in recent years [1]. This leap is related to the impressive technological advances in broad connectivity and the widespread adoption of smart devices. One example of broad connectivity advances is the Vehicular Ad-hoc Network (VANET). This type of network is contemplated as the core component of Intelligent Transportation Systems (ITS), which provides support for a wide variety of applications, including video services. These services flood the wireless systems with video content on a daily basis. As a result of this sharp increase in video traffic, the prospect of errors due to network interference and congestion rises. Additionally, these services have to deal with a highly dynamic network and unreliable connections, being subject to high packet losses [2]. As a consequence, this will lead to a diminished video quality, resulting in an inferior Quality of Experience (QoE) for the end user.

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There are a number of aspects that can impact on video quality. They range from video characteristics, such as bitrate, video content, and the codec type, to the network conditions, such as throughput, packet loss, and delay. On top of that, not all packets yield the same impact on the perceptual quality. This happens because there is a correlation among the information that each packet is carrying and the impact it has on the QoE. This reveals a need for an Unequal Error Protection (UEP) scheme to better protect the information which will cause the highest degree of impairments if lost.

Several attempts to improve the video quality over VANETs have been proposed in the last few years. A common technique is to use adaptive routing protocols [3]–[6]. A reliable routing protocol is a major part in the process of improving the video quality. This technique, however, is tethered up to a particular level of improvement because it does not provide any type of error correction. The addition of redundant data is needed if the network constraints, such as the packet loss, cannot be surpassed only by changing the route. Through the use of redundancy, the original data set can be reconstructed in case of packet losses. Forward Error Correction (FEC) techniques are known to be a good way to provide the redundancy needed. This technique has proven to offer good results in video quality enhancement of real-time transmissions [7], [8]. However, an adaptive FEC-based and QoE-driven mechanism is required to cope with the video strict requirements of timely delivery [9] and the network wireless channel resources.

Despite the latest developments in VANETs there is still a shortage of adaptive FEC-based and QoE-driven mechanisms to improve real-time video transmissions [10], [11] These mechanisms need to be able to perform on unforeseen situations to protect the most QoE-sensitive data, while not adding unnecessary network overhead. In order to do that, several aspects of the video details, along with the network characteristics and condition need to be considered.

In the light of the above-mentioned issues, this paper proposes a self-adaptive FEC-based and QoE-driven mechanism to enhance the transmission of videos encoded with High Efficiency Video Coding (HEVC) named ShieldHEVC. This mechanism is an improvement over our previous proposal [12]. The main advance is the full customization to take advantage of the new HEVC encoder characteristics. This codec follows the ITU-T H.265 standard. The H.265 standard is envisioned as a promising successor to the broadly used H.264 (ITU-T) or MPEG-4 Part 10 (ISO/IEC). The new standard advances in several areas, especially in coding efficiency, intra prediction, motion compensation, and motion vector prediction. It also offers support for videos with higher resolution (up to 8192x4320 pixels) and has better methods for parallel processing [13].

The ShieldHEVC mechanism was assessed using an objective QoE metric and actual maps' clippings. The remainder of this paper is organised as outlined next. The related work is described in Section II. Section III features the ShieldHEVC mechanism and its assessment is given in Section IV. Section V presents the conclusions and future work.

II. Related Work

A range of different solutions has been proposed to address video transmissions challenges over VANETs. As mentioned before, there are proposals based on adapting the routing protocol to better suit the video strict requirements, such as the QoE-based routing protocol for video streaming over VANETs (QOV) [5]. Another proposal provides a strategy for the Road Side Units (RSUs) retransmission limit using an adaptive multi-objective Medium Access Control (MAC) [14]. Both solutions are able to improve the performance of the video transmissions, however, there is a lack of any type of error correction (EC) on them. As previously mentioned, without using an EC technique the video quality can only be sustained up to some degree. After that, an impact on the visual video quality will be noticed if the amount of errors overcomes the natural video resilience to packet loss.

Additionally, there are several proposals using EC methods to improve the video transmission quality in VANETs. A mechanism that offers a benchmark comparison between Random Linear Coding (RLC) and XOR-based coding [15] shows that both techniques are capable of enhancing the video quality. This happens because they are able to raise the amount of video packets recovered in case of loss. The proposed mechanism also finds the optimal packet block size, which enables it to add a specific amount of redundancy. While this is true, important network and video characteristics are not taking into consideration. Some of these features, such as packet loss, video content, and codec, are important in the optimization process to provide a way to compute a precise amount of redundancy leading to both high video quality and low network overhead.

Another mechanism to improve the video quality is The Hybrid Video Dissemination Protocol (HIVE) [16]. The HIVE uses a multi-layer strategy, which combines an application layer EC technique with a node selection method and a traffic congestion control scheme. The result is an increase on the packet delivery ratio along with low latency and collisions. The assessment was performed using the Peak signal-to-noise ratio (PSNR). This is a well-used metric, however, it is known that the PSNR results do not hold a close relationship with the human vision system [17]. Another drawback is the absence of video details in the mechanism, especially the codec type. This information plays a critical role on ascertaining how resilient is a video sequence when experiencing packet loss.

The SHIELD mechanism is a self-adaptive FEC-based scheme to improve the video transmission [12]. This mechanism uses a set of parameters in the process of defining the most suitable amount of redundancy to each video sequence. Some of the parameters are the network density, the vehicle's position, the packet loss rate (PLR) and the Signal-to-noise Ratio (SNR). The results show that the SHIELD mechanism is able to protect the most QoE-sensitive data generating a more resilient video transmission. The main disadvantage of this mechanism is that it is not optimized for video encoded with the H.265 standard, which is expected to be the new industry format.

III. Towards the design of ShieldHEVC

Taking into consideration the above-mentioned issues, this paper shows and evaluates the self-adaptive FEC-based and QoE-driven ShieldHEVC mechanism. This mechanism represents an important step towards a QoE-driven method to improve the reliability of HEVC video transmissions over VANETs. Our mechanism is able to combine specific VANETs features with video characteristics in order to provide better QoE for end uses, while reducing the network overhead footprint. This proposal builds upon and improves our previous work [12]. Key enhancements are described and discussed next.

The main target of this work is to improve the transmission of video encoded following the H.265 standard using vehicle-to-vehicle (V2V) communication. Although VANETs allows for other types of communication with the aid of roadside infrastructure, V2V technology was chosen because it's easier deployment and mobility features. This means that the ShieldHEVC mechanism will only perform optimizations on connections between vehicles. Nevertheless, if there is an infrastructure available it can be used without the optimizations procedures, though.

One of the main differences from previous work is the improvement of the ShieldHEVC to provide better support for HEVC (H.265) video. As previously mentioned, this standard is a candidate to replace the widely used H.264. The H.265 standard is designed to satisfy a variety of goals, including the better usage of parallel processing architectures, the ability to handle very high video resolutions, to facilitate the integration with the transport system, and specially to offer better coding efficiency. This last goal is very important to reduce the network load, as the video consumption increases on a daily basis. The aim is to provide twice the coding efficiency of the H.264 standard. Although the outcome of this process may differ depending on the encoder settings and type of content, it has proven to give results between 30% and 50% of better compression efficiency [13].

One of the main new features to provide this major advance in the compression efficiency is the use of coding tree unit (CTU). Instead of using the small and fixed size macroblocks for motion compensated prediction and transform coding, as it happens in the H.264, the H.265 employs a larger and flexible CTU structure. Each section of this structure can be divided several times, if needed, to better accommodate the information that is representing. This enables the H.265 standard to encode motion vectors with greater precision, leading to a more accurate predicted block resulting in less residual error. This will be translated as better video quality even in lower bitrates. Unfortunately, these advantageous properties come at a cost, it needs higher processing power to both encode and decode video sequences. In the future, this can be easily compensated by using codecs implemented in hardware.

Considering the above-mentioned details, the proposed mechanism needs to fully understand the CTU structure to enable real-time and high-quality video transmissions without any unnecessary network overhead, while performing as few operations as possible to do so. There is a multitude of benefits in operating with fewer operations. Providing that video data is highly time-sensitive is imperative to send it to the client node as soon as possible. Because of that, performing a small amount of operation means that the video can be quickly dispatched. Additionally, the execution of fewer operations also lesser the energy consumption, and at the same time, releases the processor to perform other tasks. Lastly, due to the fast time-varying network conditions, all the gathered information has to be pondered as soon as possible to remain accurate.

A. Outlining the ShieldHEVC design

The design of the ShieldHEVC mechanism encompasses basically three steps, namely (1) the creation of a knowledge database, (2) the definition of the fuzzy components (fuzzy sets, rules, membership functions, and hierarchical levels). Both aforementioned steps are performed offline, leading to the last step (3) which is to load all the generated information on the fuzzy interface engine. After this, it can be used in the real-time process to improve the quality of the video transmissions. The first step, the knowledge database, is conceived using a hierarchical clustering technique [18]. After a detailed exploratory analysis, several video characteristics and their impact on the QoE are stored into this database. A thorough description of the intrinsic process can be found in [19].

The second step is the definition of the fuzzy components. The use of Fuzzy Logic (FL) enables the possibility to create a dynamic and comprehensive mechanism. Because of that, it can assess a large amount of information about network conditions as well as video characteristics and still operates in real-time. Additionally, the ShieldHEVC was designed using Hierarchical Fuzzy System (HFS). This further improves the on-the-fly capabilities of the mechanism by arranging the rules in low-dimensional fuzzy systems, which are latte concatenated in a hierarchical form. This also reduces the global number of rules, providing both faster run-time operation and easy maintenance.

In order to build an HFS it is necessary to define the same components as in a standard fuzzy logic system, namely rules, sets, membership functions and the inference engine. A fuzzy set is an assortment of elements connected by some degree of membership. The membership functions specify the degrees of truth of each and every element in the set. Another component is the fuzzy rules. They are an association of linguistic control commands, which actively express the system functions. The last component is the inference engine, being accountable for the decision-making process in real-time. It takes the fuzzy sets, rules and the needed input linguistic parameters, resulting in a specific output.

The ShieldHEVC real-time effectiveness depends on the joint use of the offline knowledge database and the correct definition of all the fuzzy components. This process, however, needs to be performed only one time. Once the analysis is finished, the produced data are loaded in the fuzzy inference engine, making it possible to be performed in real-time. This is a very important step in the mechanism because it reduces the number of rules that will be processed in real-time, leading to a more precise and faster mechanism. A comprehensive portrayal of this process is disclosed below.

Figure 1 depicts the hierarchical levels used by ShieldHEVC and also helps to differentiate it from our previews mechanism. The layers are still the same, however, all modules but two were upgraded to better characterize and protect HEVC video sequences. The same way as before, there are three levels, i.e. (A) Objective function, (B) General criteria, and (C) Specific criteria. The information produced in each low-level layer is passed up to the next layer. The lowest layer (C) handles all the input parameters that are part of the inference system. This layer has two subdivisions. The first one (C-1) encompasses all the input parameters and it is only performed at the server node. The subdivision (C-2) is responsible for the network parameters and it is performed at each hop. The middle layer (B) holds the most important decision-making rules, being responsible for the classification of the network conditions and the video characteristics. The top layer (A) carries the responsibility to assign a specific amount of redundancy to each video sequence, given the network and video constraints.

The "General Network" module at the layer (B) is responsible to define the network quality indicator. It receives the output of two layer-(C) modules, namely "Network status" and "Communication surroundings". It is not an easy task to characterize what is a good or bad channel, particularly in wireless networks [20]. Because of that, it is not advisable to rely on a single metric. The ShieldHEVC uses four key inputs to produce a reliable network quality indicator, i.e. Signal-to-

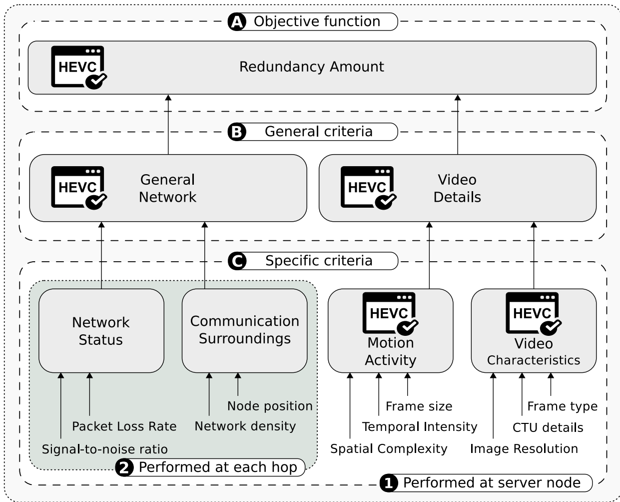


Fig. 1. ShieldHEVC Hierarchical Fuzzy Logic structure

noise Ratio (SNR), packet loss rate (PLR), network density, and the position of the vehicles.

The first two inputs, SNR and PLR, are attached to the "Network status" module. The SNR measures the level of the desired signal in comparison to the level of background noise. This is a proper parameter to assess the physical medium, however, it is not suitable to define the general network quality by itself [20]. The second input is the PLR, which determine the amount of losses from the application layer point of view. These inputs have a negative correlation, which means that when one decreases, the other increases and vice versa. They fit well together because, on the one hand, we have an assessment of the physical spectrum of the transmission and, on the other hand, an application layer measurement closer to the end user.

The last two inputs, named network density and the position of the vehicles, are linked to the "Communication surroundings" module. The network density is computed dividing the number of vehicles by the area taken by them. Conversely, VANETs are very dynamic networks in nature, making a complex process to estimate the surface area. To address this challenge, the ShieldHEVC mechanism resort to the Bentley-Faust-Preparata (BFP) approximate convex hull algorithm [21]. Another parameter is the position of the vehicles. This is a straightforward, but meaningful information. Considering the radio-frequency interference and signal attenuation, vehicles far apart from one another will demand a higher amount of redundancy in order to keep an acceptable video quality.

Despite the fact that the network inputs are the same from our previous work, the output of the "General network" layer had to be enlarged to provide better options for the upper-layers. The previous four-value set (Excellent, Good, Average, and Bad) was sufficient to provide a general depiction of the network state to adjust the redundancy amount in videos using the H.264 standard. However, as the H.265 standard is equipped with higher video compression methods needing a more precise value to classify the network conditions. To improve on this, the output was upgraded to a seven-value set (Excellent, Very Good, Good, Average, Below Average, Bad, and very Bad). All others fuzzy rules and sets that were related to the network conditions had also to be redesigned for this specific situation. This allows the ShieldHEVC mechanism to provide a "General network" layer output with a strong correlation to the conditions of the VANETs in which the video sequences are being transmitted. The final result is a higher QoE for the end-users, while not introducing unnecessary network overhead.

Additionally to the network conditions, the video details are also critical to find a proper amount of redundancy. In the proposed hierarchical fuzzy system, the "Video details" module is divided into two specialized components, namely "Motion activity" and "Video characteristics". All these modules have undergone a major overhaul to better reflect the intrinsic video characteristics of the H.265 standard.

The motion activity module uses three parameters, namely temporal intensity, spatial complexity, and frame size, to specify the pace of action in each scene. These parameters are normalized before use, this allows ShieldHEVC to protect video sequences of arbitrary resolutions. The temporal intensity describes the amount of motion in each scene. It is computed using the motion vector (MV) information. Another detail used by this module is the spatial complexity. It portrays the static information disparity from one frame to another. In this operation, the frame size also helps to better correctly identify the amount of static information in each frame.

The last module in this layer is the video characteristics. The purpose of this component is mainly gathering information to be used by the upper-layers. There are three inputs, i.e. image resolution, CTU details, and frame type. The image resolution is important to get a sense of the scale of the video that is being transmitted. This is imperative because the amount of redundancy will be defined according to each image resolution. Another parameter is the CTU details. As aforementioned the H.265 standard has modernized the old macroblocks structure and now uses the more flexible CTU arrangement. The type, number, and size of the subdivisions in this structure are indicators on how this scene was encoded. These details enable the proposed mechanism to define a tailored amount of redundancy. Another noteworthy input is the frame type. It plays an important role in defining the amount of redundancy needed because not all frames are equals, some are more important than others [22].

At the end, after the definition of all fuzzy components, they are ready to be loaded up into the Fuzzy Logic Controller (FLC). This is an off-line process and has to be carried out just once at the system bootstrap period. As soon as everything is in position, all the mechanism functions are ready to be performed in real-time. This gives the ShieldHEVC mechanism the ability to establish the most suited amount of redundancy to each video sequence in accordance with its characteristics and the network conditions.

IV. Performance Evaluation and Results

The ShieldHEVC primary goal is to ensure a good QoE, while avoiding unnecessary network overhead. This leads to an improved end-users satisfaction and, at the same time, saves the already scarce wireless resources. All the experiments were performed in the Network Simulator 3 (NS-3) using an urban environment. This environment was chosen because there are several structures that impact on the signal propagation. Additionally, it has a lot of driving options and the vehicle's motion changes frequently due to lights, crosswalks, speed bumps, and traffic conditions. In order to improve the accuracy of the experiments, a set of mobility traces was generated in the Simulation of Urban MObility (SUMO) [23]. A real map clipping of 2 by 2 km of the Manhattan borough (New York City) was used as input for SUMO. Furthermore, two propagation models were simultaneously used, namely logDistance and Nakagami-m, to simulate the fast fading characteristics of this environment [24].

All vehicles are equipped with IEEE 802.11p Wireless Access for Vehicular Environments (WAVE) [25], using V2V communication. The scenario is comprised of up to 360 network nodes (vehicles) and their velocity ranges from 20 to 60 km/h (12-37 mph). Only private passenger cars are considered, this means that there is no taxies, buses, trucks or any other type of vehicles in the simulation. The Cross-Layer Weighted Position-based Routing (CLWPR) [26] protocol was used to provide position-based details of the vehicles to the mechanisms. In addition, the Evalvid tool [27] was used to transmit the traces of real video sequences, which were encoded using the H.264 and the H.265 standards. Three different video resolutions were adopted, i.e. 1080p, 720p, and SVGA. In each one, 10 distinct videos were transmitted. These videos encompass several contents and represent commonly material found on the Internet. The transmission process is as follows. At a random time, the source and destination nodes are arbitrarily chosen. After that, one video clip of approximately 20 seconds is sent using unicast transmissions. At the end of the transmission, the process restarts. Table I shows the simulation parameters.

TABLE I
Simulation parameters

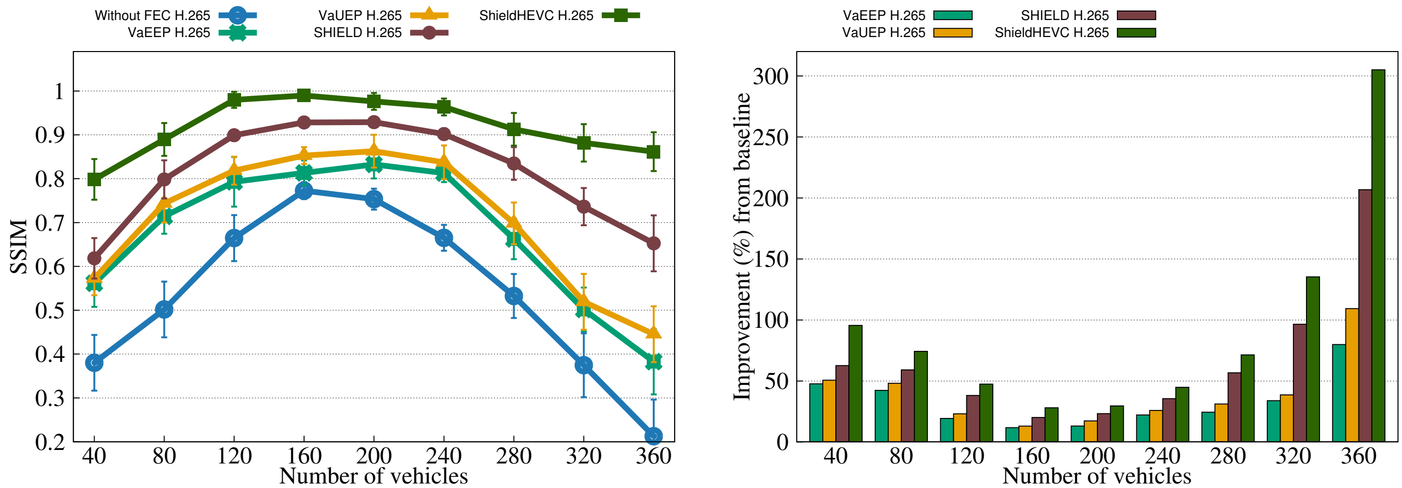
Parameters	Value
Display sizes	1920x1080, 1280x720, and 800x600
Frame rate mode	Constant
Frame rate	29.970 fps
GoP	19:2
Coding standard	H.264 and H.265
Container	MP4
Wireless technology	IEEE 802.11p (WAVE)
Communication	Vehicle To Vehicle (V2V)
Routing protocol	CLWPR
Mobility	SUMO mobility traces
Radio range	250m
Internet layer	IPv6
Transport layer	UDP
Propagation model	logDistance + Nakagami-m
Location	Manhattan borough (New York City)
Map size	2.000 m x 2.000 m
Vehicles speed	20-60 km/h (12-37 mph)

In order to compare the results, five different arrangements were evaluated. Initially, the experiments were performed without any type of FEC. These results will be employed as a baseline. Two baselines were produced, one for each standard (H.264 and H.265). The second arrangement is a video-aware equal error protection (VaEEP) mechanism. It uses a fixed amount of redundancy in the FEC scheme to equally protect I- and P-frames. In another scenario, the third one, a video-aware unequal error protection FEC (VaUEP) mechanism is adopted. This mechanism adds a tailored amount of redundancy according to the importance of each I- and P-frames. To provide a fair comparison with our previous proposal, the SHIELD mechanism [12] is the fourth scenario. It takes into consideration several video characteristics and also the network conditions. The fifth and final scenario, is the proposed ShieldHEVC mechanism.

An objective QoE metric was used to assess the experiments, namely Structural Similarity Metric (SSIM) [28]. Objective metrics are desirable because they are unbiased and measurable as well as verifiable. The SSIM mimic the human visual system to quantify how impairments are perceived by end-users. It grades from one to zero, being that the higher the grade, the better the video quality.

Fig. 2 shows the outcome of the experiments with videos encoded following the H.265 standard. (a) depict the SSIM average and (b) shows the percentage of QoE improvement of each mechanism against the baseline. The simulations start with a small number of nodes, i.e., 40 vehicles. The network, in this circumstance, is sparse and experiencing connectivity issues. In Fig. 2(a), it is possible to notice that the baseline, and also all the mechanisms, is achieving a QoE score considered low. As aforementioned, the transmissions in this setting are relying on few and scattered vehicles, proving difficult to maintain a dependable connection. Even in this harsh scene, the ShieldHEVC mechanism outperforms all its competitors and turns over higher video quality. This means that our mechanism is capable to safeguard the most QoE-sensitive data. Fig. 2(b) shows that ShieldHEVC provided over 95% of QoE improvement against the baseline, the second best result was SHIELD with only 62% of improvement.

Another noteworthy information depict in Fig. 2(a) is that the best QoE scores, for all mechanisms, showed up between 120 and 240 vehicles. This is expected, since with these numbers of nodes the network is getting the best coverage.



(a) Average SSIM (b) Percentage of SSIM improvement

Fig. 2. Experiments with H.265 standard

Even the baseline, which does not have any type of protection, is giving better results. This consequently decreases the improvement percentage of other mechanisms. This situation is clearly evidenced in Fig. 2(b), in the same range of vehicles (between 120 and 240). The ShieldHEVC mechanism has demonstrated again that it can handle this situation better than the competitors, providing higher video quality once more. Conversely, as the network becomes progressively denser, especially above 320 vehicles, the mechanisms are compelled to deal with higher interference and degraded network connections. Here again, the proposed mechanism exceeds the competitors, granting up to 300% higher SSIM scores when compared to the baseline. All things considered, the ShieldHEVC mechanism surpasses all its competitors and provides a major increment in the video quality when the network conditions are not favourable.

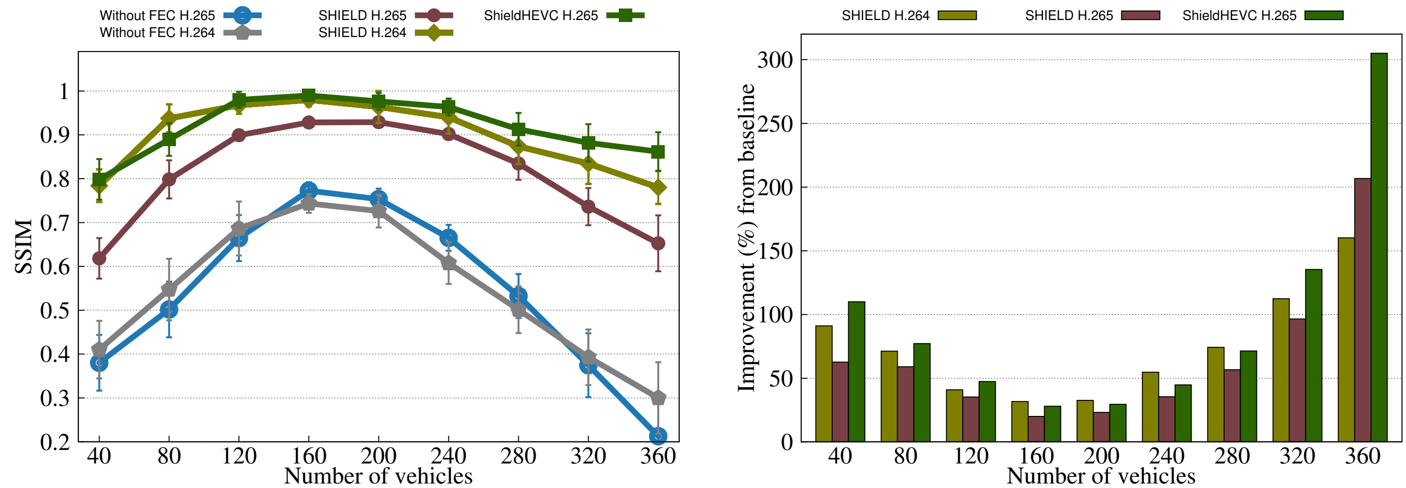
To further understand the ShieldHEVC achievements, a comparison analysis is showed in Fig. 3. These results were reached using videos encoded following both H.264 and H.265 standards. (a) shows the SSIM average and (b) depict the improvement percentage of each mechanism against its baseline. This means that videos encoded with H.264 are compared to the H.264 baseline and vice versa.

At the beginning, the network is still sparse and all the QoE scores are fairly low, specially the baselines as depict Fig. 3(a). At this point, videos encoded with H.265 are receiving worst scores than the ones using H.264. This is expected because the H.265 standard provides much higher coding compression, thus the loss of a smaller number of packets will have a greater impact on the QoE. On the other hand, as the network grows and becomes more populated (i.e., between 160 and 280 vehicles), the H.265 standard provides better QoE results, which are evidenced even in the H.265 baseline. This means that, when the network conditions are favourable the new standard grants higher video quality. It is also important to point out that the videos encoded with H.265 are, on average, between 30% and 50% smaller than those using H.264. If the parameters used to encode the videos were set to generate outputs with the same file size, the H.265 would have much better results. However, as mentioned before, one of the main goals of the new standard is to provide a higher coding efficiency. Because of that, it would make no sense to force the encoder to generate such larger file.

In the direct comparison amongst the two adaptive mechanisms (Fig. 3(a)), it is possible to notice that the previous one (SHIELD) perform much better with H.264 than with H.265. However, the new proposed ShieldHEVC mechanism surpasses both. This result highlights even more the importance of mechanisms specifically tailored to deal with the intrinsic video details.

It is important to notice that, in Fig. 3(b) with vehicles ranging from 160 to 280, the SHIELD mechanism using H.264 shows a higher percentage of improvement over ShieldHEVC. This steams from the fact that H.265 baseline has better scores on this situation, thus reducing the improvement percentage. In terms of absolute SSIM scores, as showed in (a), the ShieldHEVC gives better results throughout all the experiments.

Besides the higher video quality, it is also desirable to lessen the network overhead. This is especially true for wireless networks, where the nodes have to share the same channels and resources tend to be unevenly distributed. Fig. 4 shows the network overhead of all mechanisms using the H.265 standard. The VaEEP and VaUEP are non-adaptive mechanisms thus generating a constant network overhead. These mechanisms protect video sequences with a wastefully amount of redundancy. For example, the VaEEP protects all videos with the same amount of redundancy, disregarding the video characteristics. In order to tackle this issue, the VaUEP scheme



(a) Average SSIM (b) Percentage of SSIM improvement

Fig. 3. Comparison between H.264 and H.265 standards

assesses the video details and adds a specific amount of redundancy to the most important frames. The result is less network overhead and improved video quality.

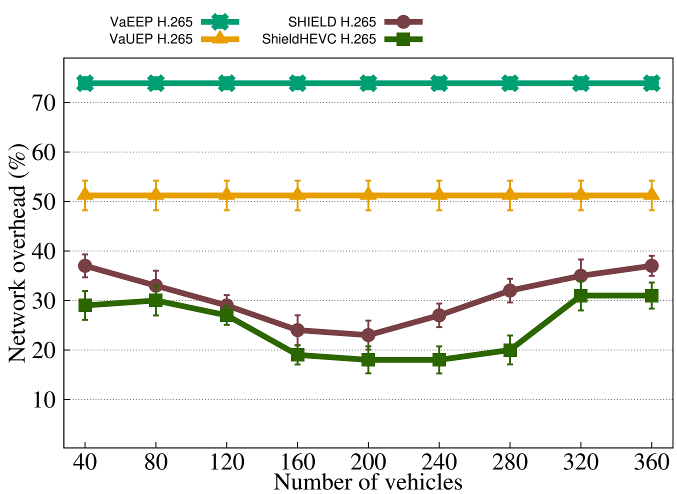


Fig. 4. ShieldHEVC network overhead

Although the visible improvement, there is a need for adaptive mechanisms to further advance the better usage of the scarce network channel resources. The SHIELD mechanism already produces a smaller network footprint, however, it is not tailored to work with the H.265 standard. Consequently, it does not yield as good results as the new proposed mechanism. ShieldHEVC is able to do both, lessen the network overhead while increasing the video quality. On average, it adds almost 20% less overhead than our previous mechanism (SHIELD). Additionally, in comparison to the VaEEP and VaUEP schemes, the ShieldHEVC mechanism generated 66% and 51% less footprint, respectively.

V. Conclusion and Future Works

The recent widespread embrace of smart devices and vehicles along with the continuous developments in wireless broad connectivity are making video services universally available. This trend deepens the stress of the resources usage and the high-error rates in wireless networks. The ShieldHEVC mechanism enforces a dynamic protection to safeguard the most QoE-sensitive data. On this account, the video quality is improved and a thorough use of the wireless resources is achieved. The experiments show that the proposed mechanism was able to accurately identify the video characteristics and the network conditions to better protect the most important data, which leads to a higher QoE for end-users.

The experimental results demonstrated that the ShieldHEVC mechanism outperforms the adaptive and non-adaptive competitors. Considering the video quality, it managed to produce gains between 13% (against SHIELD) and 69% (against the baseline) of SSIM improvement. In addition, the network footprint downsize was more than 19% in comparison to the SHIELD, as well as 66% and 51% lower than VaEEP and VaUEP, respectively. These results endorse the ShieldHEVC mechanism as qualified to improve the video transmission without wasting wireless resources. The future work includes the assessment of additional mobility scenarios and supplementary video parameters.

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