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The H.264/SVC Codec for K-Hop Cooperative Video Streaming Protocol over the Hybrid Vehicular Networks

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***Abstract*—Vehicular ad-hoc network (VANET) is a subclass of mobile ad-hoc networks which provides wireless communication among the vehicles. At the point when various persons, e.g., a family or a gathering of companions, drive their vehicles for a trip together, they can structure an armada of vehicles and impart their network resources during trip. Let one member want to watch a video from the Internet. He might not have high resolution or video quality because of his restricted 3G/3.5G bandwidth capacity to the Internet. The cooperative video streaming scenario permits the requested member to ask other members of the same fleet to download video cooperatively. As such, different individuals can help can help to download parts of the video from the Internet and then forward video data to the requested member hop by hop through the ad-hoc network. This work proposes the k-hop cooperative video streaming protocol using H.264/SVC over the hybrid vehicular networks which consist of 3G/3.5G cellular network and Dedicated Short-Range Communications (DSRC) ad-hoc network. In order to smooth video playback over the DSRC-based ad-hoc network, this work proposes: (1) one streaming task assignment scheme that schedules the streaming task to each member over the dynamic vehicular networks, and (2) packet forwarding strategies that decide the forwarding sequence of the buffered video data to the requested member hop by hop. Finally, we utilize the network simulator version 2 (NS2) to simulate the proposed protocol. Based on the simulation results, the proposed scheme can estimate the assignment interval adaptively and the playback priority first (PPF) strategy has the best performance for the k-hop video forwarding over the hybrid vehicular networks.**

***Index Terms*— Cooperative streaming, SVC (scalable video coding), Goodput, vehicular ad-hoc network (VANET), dedicated short-range communication (DSRC)**

I. INTRODUCTION

Due to the development of interactive media transforming and network technologies, i.e., H.264/SVC codec and 3.5G/3G/4G wireless network, there is a significant increase in demand for universal multimedia services. A practical example is that a family or a gathering of companions drive their cars or RVs to take a road trip together, e.g., from Bangalore to Hyderabad in India or on the other hand from London to Paris in Europe. They drive their cars to meet in an entrance point of highway and then structure an armada along the highway. In the other words, a fleet which is composed of several vehicles starts at the same point with same travelling route and the same destination. If one of the vehicles in an armada needs to demand a video stream from the internet, it can download video data and the related information utilizing 3G/3.5G cellular network. Since the bandwidth of the 3.5G/3G network over the moving vehicular networks is unstable and deficient, the quality of video for the requested video stream may not be adequate. Even utilizing 4G cellular network, the bandwidth of corresponding network still may not be adequate for the following issues. First, other applications may use 4G network simultaneously. Second, the moving conduct of one car, e.g., moving faster or around the coverage area of one base station, makes the deteriorating of 4G network bandwidth. To improve the quality of video during the travelling route, one car would ask other cars belonging to the same fleet to download video data using their redundant 3.5G/3G bandwidth. Once different cars download video data from the Internet, the downloaded video is forwarded by them to the requested car through the ad-hoc transmission among cars, in which Dedicated Short-Range Communications (DSRC) is intended for car to have one-way or two-way short to medium-range wireless communication particularly in the very dynamic versatile environment. In this work, the previously stated scenario is characterized as Cooperative Video Streaming (CVS) over the hybrid vehicular systems, which comprises of (1) 3G/3.5G system for vehicle-to-Infrastructure (V2I) communication and (2) DSRC ad-hoc network for vehicle-to-vehicle (V2V) communication.

Three discriminating roles of the proposed CVS are (1) requester, (2) forwarder, and (3) helper. Fig. 1 portrays the proposed CVS situation in this paper. A requester is the part having the demand for streaming service. Forwarders are individuals that are in charge of sending bits of video information bounce by jump through DSRC-based ad-hoc network. Helpers are individuals that not just forward video information through DSRC-based ad-hoc network, additionally utilizes their 3G/3.5G interfaces to download video information from the Internet. In our supposition, these individuals know one another ahead of time, e.g., they may be companions or families. Then again, alluding to Fig. 1, the vehicular networks' condition is progressive and unusual. A few vehicles that don't fit in with the armada would stick the parkway and afterward let the separation among individuals be more than one jump. In this manner, the downloaded video information ought to be sent hop by hop and is transmitted -

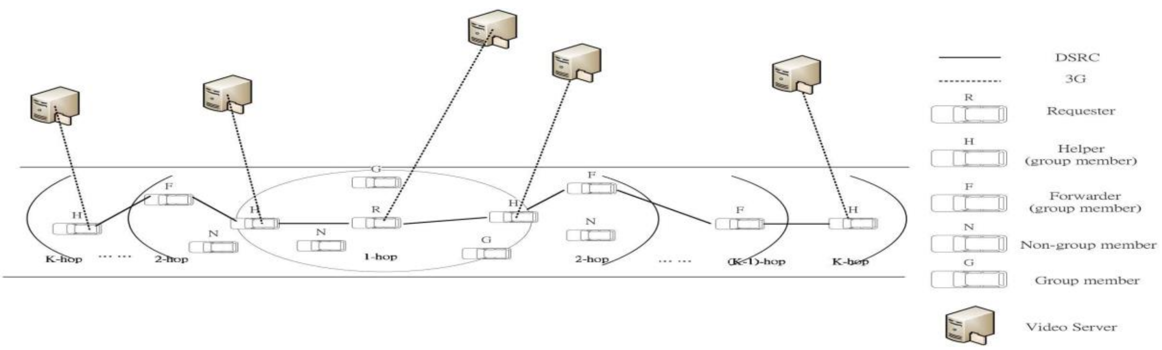

Fig. 1. The proposed k-hop CVS protocol scenario.

from numerous ways back to the requester. This work proposes the k-hop CVS protocol which is versatile to the hybrid vehicular systems environment. This work studies and determines the CVS situation in the application layer. Issues and problems of lower layers, i.e., transport layer, network layer and link layer, are past the extent of this work.

In the proposed CVS protocol, four issues that need to be determined for having helpful streaming are (1) selection of helper, (2) packetizing video, (3) streaming task assignment and (4) packet forwarding method. The initial two issues, i.e., (1) selection of helper determines how to choose helpers from neighboring individuals and (2) packetizing video determines how to packetize layered video information for conveyance, have basically been examined in our preliminary examination [16],[17]. The other two issues, i.e., (3) streaming task assignment determines how to allot streaming tasks to helpers and forwarders and (4) packet forwarding method how to choose the sending succession of the buffered video information in a helper or forwarder to the requester, are determined in this work. First and foremost, this work embraces the scalable video coding strategy, i.e., H.264/SVC, to encode video feature into one base layer and different upgrade layers. The base layer is downloaded by the requester itself. On the other hand, enhancement layers are transmitted through DSRC-based ad-hoc network that is made out of helpers and forwarders. Because of conceivable activity conditions in all actuality, each partner's 3G/3.5G bandwidth capacity and the hop count distance between every helper and the requester may change with time. Consequently, the proposed k-hop CVS protocol incorporates a streaming undertaking task plan which adjusts the task interim as indicated by partners' 3G/3.5G bandwidth and chooses the task scheduling scheme taking into account the playback time of video information and the hop number distance in the middle of helpers and the requester. Second, since upgrade layers are downloaded by helpers, these layers need to be gone through the DSRC-based ad-hoc network. For a forwarder, it may get video information from diverse helpers or forwarders all the while. Since the DSRC system bandwidth is still constrained, which buffered video information in a forwarder ought to be transmitted first would influence the video quality of the requester. Thus, the proposed k-hop CVS protocol considers (1) time of arrival, (2) playback strategy and (3) accessible bandwidth independently. A few transmission procedures inside a forwarder for sending video information over the DSRC-ad-hoc network are analyze and discussed in this work.

The rest of this paper is presented as follows. Section II presents related works about the CVS. Segment III surveys our preliminary study, including helper selection and packetizing video plans. Section IV portrays the proposed streaming task plan and Section V depicts the proposed packet forwarding procedures in subtle elements. Segment VI demonstrates the simulation results. At long last, we condense and finish up our work in Section VII.

II. RELATED WORKS

In this section, we study existing exploration issues in the CVS, including neighbor discovery over vehicular networks, cooperative WWAN and WLAN integration, bandwidth aggregation and multipath routing, and scalable video coding. Step by step instructions to find neighboring vehicles rapidly and efficiently is one of the basic issues in vehicular ad-hoc networks (VANET). Concerning group formation in VANET, Luo and Guo used a CDMA-like on-off signaling for group testing and afterward they got hub can induce which hubs are neighboring in light of the by and large on-off pattern [2]. Tsai et al. proposed an auto armada support plan in view of a swarming model and the little world phenomenon [3]. In [3], an element grouping convention arranges vehicles into pseudo-pioneers and devotees. Khalili et al. presented (i) a vitality identification component that empowers hubs to gauge their gathering status and (ii) a feedback mechanism that gives crash information to the transmitters [4]. As indicated by the recreation and simulation results, gathering status input can decrease the time of the discovering neighbor. When neighboring vehicles can structure a gathering, they can enhance system execution by imparting system assets. Taleb et-al. overviewed a routing protocol to guarantee the communication strength of VANET [5]. Okamura et al. proposed wireless direct distribution protocol (WDDP) to give a gathering correspondence mechanism among vehicles [6]. The previously stated grouping mechanisms considered how to form a group to disperse information. In this paper, our proposed plan concentrates on the most proficient method which forms a group to aggregate bandwidth from individuals, which go on the same route to the same destination, not just for forwarding data in the paths of ad-hoc, but also for downloading information from 3G/3.5G systems to have video streaming.

There were a few explores focusing on the thought of cooperative downloading. In [7], the authors proposed a cooperative method for content delivery and partaking in vehicular systems, in which the proposed methodology did not concentrate on streaming and is intended to assemble a piece of the information from first-hop helpers only. In [8], authors proposed a system for cell phones that get the same video stream and in this way can impart got video information over WLAN. Concerning helpful streaming situation, a collective downloading framework called COMBINE was composed by Ananth etal. [9]. COMBINE integrates neighboring hubs' Wireless Wide Area Network (WWAN) interfaces to download assets for a dynamic hub. In [17], Guan et al. proposed a cross layer plan utilizing rate control, transfer determination and force control for video streaming. . In [18], Xing et al. proposed a helpful vehicle hand-off plan utilizing vehicles and street side unit to improve feature quality in light of the variety of system condition. The principle contrasts between the work portrayed in [18] and our work are as per the following: (1) utilize 3G/3.5G networks instead of road side units to augment wireless signal scope for downloading video; (2) the selected helpers are decided to aggregate different hubs' wireless bandwidth to increment downloaded throughput taking into account their 3G/3.5G and DSRC organizes in our work, in comparison, they are just for wireless network relay in the work of [18].

A related issue of the CVS framework is the multipath routing. Except those single-hop cooperative helpers, a helper may utilize multiple routing ways to send the information to the requester. In [10], the authors introduced a structural engineering supporting transmission of different video streams in specially appointed systems by securing numerous steering ways to provide additional video coding and transport plans. In [11], the proposed multipath transmission control conspire not just totals the accessible data transfer capacity of different ways, additionally lessens the superfluous time of parcel reordering at the collector. In [12], authors proposed a convention that chooses numerous maximally incoherent ways without bringing on stream blockage. Bandwidth aggregation is the essential and central issue of the CVS framework. A few papers have tended to this issue. In [13], authors focused on bandwidth aggregation of a host by all the while utilizing various interfaces and displayed a system layer building design that empowers assorted multi-access administrations. In [14], the authors proposed a k-path intermediary revelation calculation to aggregate unmoving cellular links' data bandwidth of others, which is like our work. In [15], authors focused on the bandwidth aggregation service for an Internet "conglomeration intermediary". In the proposed system design, the scalability issue may be the most obstacles on the grounds that all extra functionalities are developed proxies.

III. PRELIMINARY STUDY REVIEW

As depicted in Section I, we have determined the initial two issues in our preliminary studies [16], [17]. The brief survey of our past studies in [16] and [17] is given in this area. Keeping in mind the end goal to give higher quality of video to the requester, how to choose suitable individuals as helpers to download video from the Internet is the principle challenge handled in [16]. The Greedy Approach (GAP) is intended to accomplish the maximal throughput in the CVS situation. In the proposed plan, individuals would answer their (1) hop -count distance, (2) accessible bandwidth of 3G/3.5G and DSRC, and (3) encompassing individuals to the requester. The requester executes the Greedy methodology (GAP) to choose suitable individuals as helpers. The fundamental thought of every system is firstly to rank individuals as per their abilities in both 3G/3.5G and DSRC interfaces and the hop-count distance from their answered messages. At that point, every technique will confirm applicant helpers from the most noteworthy positioning one and check whether including the new movement stream produced by selecting the part in the i-th hop as an helper would surpass left DSRC benefit available bandwidth capacity of any selected partner in the (i-1)-th jump or not.

Then again, how to packetize a layered video stream into numerous units utilizing H.264/SVC was determined in [17]. As per the H.264/SVC standard, the encoded video bit stream is made out of various network abstract layer (NAL) units. In the header of every NAL unit, three labels with respect to scalability facilities and decoding dependency are (1) Dependency ID (DID), which demonstrates spatial adaptability, (2) Quality ID (QID), which shows quality/SNR scalability, and (3) Temporal ID (TID), which shows fleeting scalability. We just consider QID and TID in [17]. General talking, NAL units with QID=N rely on upon those ones with QID=N-1. Along these lines, NAL units with QID=0 is characterized as base layer (BL). Then again, NAL units with QID > 0 is characterized as enhancement layer (EL). Since BL is more critical than EL, all NAL units having a place with BL (QID=0) are downloaded straightforwardly by the requester. Remaining NAL units fitting in with EL (QID>0) are downloaded by helpers and then sent to the requester.

We use a two-tuple NAL(x,y) to speak to the corresponding QID and TID of a NAL unit from this point forward, in which x indicates the TID and y means the QID. Just NAL units with the same TID have decoding dependency. It is not suitable to assign NAL units with the same TID to different helpers. For instance, NAL (1, 1) is doled out to a fourth hop helper and NAL(1,2) is allocated to an alternate first hop helper. If NAL (1,2) is received by the requester effectively, it gets to be pointless and is not able to be decoded. Along these lines, NAL units with the same TID ought to be packetized into one task unit (AU) that is characterized as the fundamental trans-mission unit in this paper. Taking into account the previously stated portrayal, AU0 is made out of NAL(0,1) and NAL(0,2). AU1 is made out of NAL(1,1) and NAL(1,2). Henceforth, NAL units having a place with EL can be packetized into one AU array sequence.

IV. TASK ASSIGNMENT SCHEME

In the CVS situation, helpers are chosen utilizing the greedy methodology proposed as a part of [16]. After the helper selection phase, the requester has picked a few individuals to be helpers and requested that they give their excess 3G/3.5G bandwidth for downloading obliged video information. In any case, before asking the helpers to download video information, the requester needs to choose (1) how to segment the video into numerous streaming tasks for helpers to download and forward video information hop-by-hop to the requester and (2) how to choose proper workload for every helper in light of the fact that distinctive helpers are described with diverse abilities, e.g., distinctive 3G/3.5G transfer speed and hop count. Task assignment scheme can be implemented using assignment interval and streaming task scheduling strategies.

A. Assignment Interval

The task assignment interval is utilized to assign streaming tasks to helpers periodically. Before really appointing streaming assignments to helpers, the requester needs to focus about assignment interval to over and again trigger the strategy of allocating streaming task to helpers. However, the span of this interval ought to be deliberately planned on the grounds that a too long task interval would result in helpers unmoving for long time in the interval; then again, a too short interval would result in helpers that cannot complete its assigned task during the task interval. Subsequently, to get a suitable task interval, we attempt to calculate an assignment interval for this scheme.

The thought behind a suitable task assignment interval is that this interval ought to be sufficiently long for all allotted streaming video information of helpers to be transmitted to the requester in time. As such, before another task assignment begins, all the requested video information in the past round ought to be transmitted by helpers. We have the requester to gauge the assignment interval as follows. During initial assignment, we assume that the requester will begin video playback when the buffered video information can playback 10 seconds, and those 10 seconds' cradled feature information are relegated to 1-hop partners only. Let the assessed spending time of 1-hop helpers transmitting these 10 seconds' video information is represented as $T_{initial}$. Estimate $T_{initial}$ in Equation (3) approximately, where BW^i_{DSRC}, $BW^i_{3G/3.5G}$, and $size_i$ stand for the DSRC bandwidth of helper i, 3.5G/3G bandwidth of helper i and initially downloaded streaming task size of helper i, respectively.

$$T_i = \max\left(\frac{size_i}{BW^i_{DSRC}}, \frac{size_i}{BW^i_{3G/3.5G}}\right) \forall i \in 1-hop\ helpers \quad (1)$$

$$T_{initial} = max(T_1, T_2, \dots T_i) \forall i \in 1-hop\ helpers \quad (2)$$

Since the courses of action of transmitting video information from the server utilizing 3G/3.5G and forwarding by helpers using DSRC systems are simultaneous, we calculate the maximum transmitted time between each helper for downloading and forwarding the data. Then the maximum time of all the helpers forwarding video information from the server to the requester is set as $T_{initial}$. In any case, during 1-hop helpers are transmitting these beginning 10 seconds video information, k-hop's helpers (k>1) can utilize their 3.5G/3G network to download video information. Hence the total throughput of k-hop's helpers (k>1), Th_H after getting $T_{initial}$ is calculated as Equation (3).

$$TH_H = \sum_i BW^i_{\frac{3G}{3.5G}} * T_{initial} \ \forall i \notin 1-hop\ helpers \quad (3)$$

When the 1-hop helpers are forwarding initial 10 seconds video information, k-hop helpers (K>1) are also sending their downloaded video to 1-hop helpers and this video is buffered at 1-hop helpers until the video is transmitted for initial 10 seconds. Therefore the approximate duration of forwarding downloaded video by k-hop helpers (k>1) is as shown in Equation (4).

$$T_{extra} = \frac{TH_H}{\sum_{\forall i \in 1-hop\ helpers} BW^i_{DSRC}} \quad (4)$$

Therefore, the assignment interval TAI can be calculated approximately as shown in the Equation (5).

$$T_{AI} = T_{initial} + T_{extra} \quad (5)$$

B. Streaming Task Scheduling

In this sub-segment, we depict the system of assigning streaming task to every helper in point of interest. As mentioned earlier, at first, the requester will begin to playback until the initial buffered data is received. Here, the initial buffered information is set to be 10 seconds. To start the streaming task, the requester will firstly have the initial stage of scheduling and choose the task assignment interval. At the initial stage of scheduling, the requester will allow 1-hop helpers be responsible for beginning 10 seconds video information and appoint AUs utilizing the round-robin strategy to every 1-hop helper. For streaming tasks to k-hop helpers (K>1) during the initial scheduling state, the requester will initially calculate the amount of AU's approximately, denoted by Num_{Au} , to every k-hop helper utilizing Equation (6), where $size_{avg\text{-}Au}$ stands for the average size of AU.

$$Num_{Au} = \frac{BW^i_{\frac{3G}{3.5G}} * T_{initial}}{size_{avg\_Au}} \quad (6)$$

V. PACKET FORWARDING STRATEGY

After the requester determining and assigning tasks to helpers, every helper would attempt its best to transmit the allotted video information to the requester. At the point when video information is sending from a K-th hop helper to the requester, this video information would be received and transmitted hop-by-hop by forwarders. Since this video information is handled by various forwarders, the end-to-end transmission quality is extraordinarily influenced by every forwarder. As it were, the manner by which a forwarder uses its DSRC wireless channel to transmit its buffered information to the requester has affected the streaming video quality. In this segment we discuss about transmission scenario. The three transmission scenarios to manage the utility of DSRC asset for a forwarder are First in First out (FIFO) strategy, PPF (Playback Priority First) and TD metric scenario.

A. First in First out (FIFO) strategy

The FIFO is a natural transmission procedure which doesn't embrace any thought to upgrade the efficiency of the use of a forwarder's DSRC asset. In the FIFO transmission method, when a forwarder receives a packet, it just inputs this video information into the tail of its buffer. At the point when the forwarder needs to send video information, it generally gets the first of the support to send. However, when a forwarder has received video information of another round assignment from the video server or different forwarders, it would drop all left information fitting in with the past round in its buffer in light of the fact that now is the ideal time for sending recently assigned video information. The transforming method of the FIFO technique is portrayed in Fig. 2.

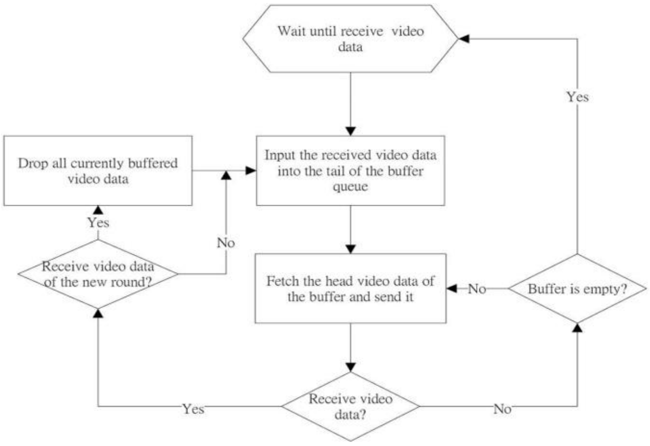

Fig. 2. FIFO strategy Processing procedure

B. PPF- Playback Priority strategy

The essential thought of the PPF transmission technique is that at whatever point a forwarder has buffered information that need to be sent, it generally lets video information having the most elevated playback need to utilize its DSRC asset first. The playback priority stands for the playback sequence of the video information and is chosen when the requester appoints tasks to every helper. As mentioned earlier, the requester utilizes the round-robin system to appoint AUs one-by-one to helpers with the similar hop-count distance and allocates assignments from 1-hop helpers to K-hop (K > 1) partners. Since AUs are brought one-by-one from the AU cluster and are assigned to helpers hop-by-hop, we let streaming tasks of helpers with the same hop distance have the same playback priority and NAL units are determined with the same playback priority of the streaming. The playback priority is expanded by one as the allotting technique changes to allocate tasks to the following hop partners. As such, streaming task downloaded by partners with the same hop-count has the same playback priority and their playback earlier is higher than assignments of helpers with the bigger hop count distance.

In the PPF transmission method, a forwarder will set up a line for every task that it has received. At whatever point a forwarder gets video information, it will categorize it as indicated by which helper is capable to download this video information through its 3G network and after that inputs this video information into the comparing line. In the event that a forwarder has buffered information of various streaming assignments and along these lines has numerous lines, this forwarder will take after a determination principle to allow video information inside particular queues have the privilege to get to its DSRC asset. For the determination lead in PPF, forwarders attempt to let video information with prior playback time utilize the DSRC asset first. The PPF processing procedure is portrayed in the following Fig. 3.

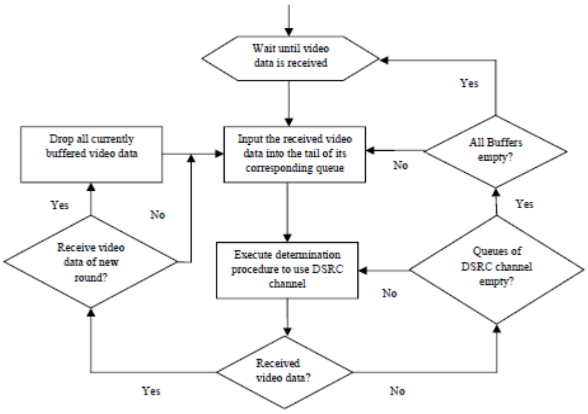

Fig. 3. PPF strategy Processing procedure

C. TDR-Time Distance Ratio Metric

Time Distance Ratio refers to the ratio of end-to-end delay and distance of packet to be delivered. In the co-operative video streaming scenario the good-put can be improved using time distance ratio metric. The TDR *M* of packet *p* can be expressed as in Equation (7).

$$M = (T' + T_d) / L \qquad (7)$$

Where T' is time, T_d is delay is delay time and L is the transmission distance of the packet p.

VI. EXPERIMENTAL RESULTS

Keeping in mind the end goal to confirm our works, the NS2 simulation tool is used to evaluate the execution and performance of the proposed protocol. In the simulation, every mobile hub is outfitted with two wireless interfaces, in which one is 3.5G/3G cellular interface and the other one is DSRC interface. The 3.5G/3G interface is utilized to communicate with a base station that gives the availability to the Internet. The IEEE 802.11p interface of every portable hub is utilized for communication between hubs through the ad-hoc networks and the settings of comparing parameters are summarized in Table 1. We set related parameters of IEEE 802.11p into the 802.11Ext module and the WirelessPhyExt module supported in the ns2 and the radio propagation model for the interface is situated to be the two-ray ground reflection model. To simulate the proposed CVS protocol, a YUV video file is encoded into three enhancement layers and one base layer using H.264/SVC.

Packet Payload	8000 bits	Mac+Phy headers	384 bits
ACK	112 bits	RTS	160 bits
CTS	112 bits	SIFS	32 us
DIFS	58 us	Slot Time	13 us
Propagation Delay	1 us	Channel Bit Rate	6 Mbps (BPSK)

TABLE 1. Simulation parameters of IEEE 802.11p interface

The goodputs of different intervals among helpers and hops are depicted as shown in the following Fig. 3.

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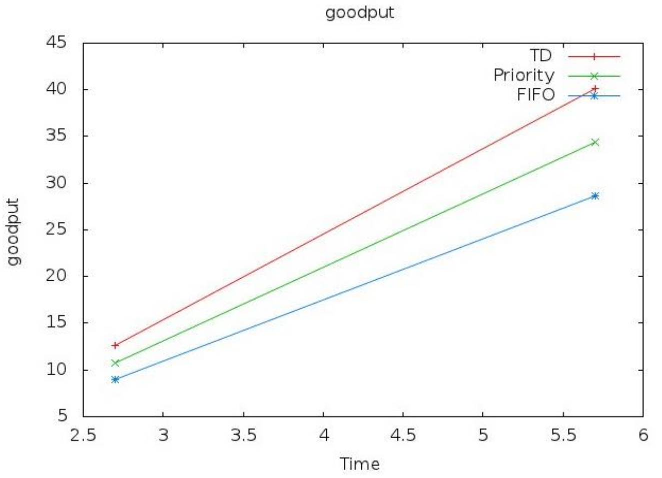

Fig. 3. Goodput of different intervals.

VII. CONCLUSION

This paper proposed a k-hop armada based co-operative video streaming (CVS) protocol over the hybrid vehicular networks, which is made out of 3G/3.5G cellular network and DSRC based ad-hoc system. The proposed k-hop CVS protocol has concentrated on the issues having a place with the application layer. Initially, keeping in mind the end goal to adjust to the time-differing characteristic of the hybrid vehicular systems, the steaming task plan considers (1) each helper's 3G/3.5G bandwidth capacity and (2) the hop count distance between every helper and the requester in this work. Second, with a specific end goal to transmit video information hop by hop easily through the DSRC based ad-hoc network system, three diverse transmission procedures, i.e., first in first out (FIFO), playback priority first (PPF) and time distance metric, have been proposed and examined in this work. At last, we have evaluated the proposed k-hop CVS protocol utilizing NS2 and used two parameters, i.e., (1) goodput that speaks to the effectively received rate and (2) the quantity of NAL units that arrived before the due date, for execution and performance comparison.

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