

Resilient Video Streaming Analytics for Traffic Surveillance

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Abstract: protocol helps to achieve the highest quality at the TMS server Traffic surveillance is an important issue for Intelligent Transportation systems (ITS) that helps to detect incidents automatically, such as wrong-way drivers, still-standing vehicles, and traffic jams. Traffic surveillance system requires a fast and short-term deployment of video cameras on the roads. In traffic surveillance, ad-hoc networks could be a low-cost and feasible option, but they have poor performance for video delivery. We propose a smart live video adaptive streaming technique to be employed in transportation for the video streams captured from the cameras to the external road Traffic Monitoring System (TMS) servers in a more efficient way. To achieve this goal, the proposed system analyzes video quality under their inherent constraints, given by the node's connectivity topologies, the inbuilt video streaming protocol, node's performance, and routing protocols. The methodology consists of two stages. In the initial stage, the identification of proper network is considered to transmit the road traffic video in an adaptive way using a reliable transport protocol which is Transmission Control Protocol (TCP). This. On further analysis, it has been found that among the available streaming alternatives, Dynamic Adaptive Streaming over HTTP (DASH) exhibits the best results over the other video streaming techniques. In the second stage, a complete analysis was carried out on multi-hop networks under the scenarios used for TMS based on the specific topologies required, with DSR routing protocol. The behavior of the received video is studied with relative merits in terms of throughput, delivery ratio, routing overhead, and delay. The experimentation motivates configuring more efficient routing protocols and streaming video techniques. It is also concluded that multi-hop networks and routing protocols will enhance QoS metrics and improve the overall network performance. The proposed video steaming analytics helps understand the behavior of on-road vehicles. It

explores the possibility of significant time and space to avoid accidents in micro variations of space and time.

Index Terms- TMS – Traffic Monitoring Systems, Traffic surveillance, ITS - Intelligent Transportation Systems, Adaptive live video streaming, multi-hop network, DASH-dynamic adaptive streaming over HTTP

I.INTRODUCTION

On heavy traffic roads, Traffic surveillance is a challenging and tedious task. Traffic surveillance is an important issue for Intelligent Transportation Systems (ITS), which helps to detect a stream of traffic incidents automatically, such as wrong-way drivers, still-standing vehicles, and traffic jams. The surveillance system requires a fast and short-term deployment of video cameras in completely synchronized mode. In these scenarios, ad-hoc networks could be low-cost and feasible, as they form their network within their frequency band but have poor video delivery performance. A smart live adaptive streaming technique has been proposed to transport video streams from the cameras to the externally affixed on-road TMS servers. To proceed with the implementation, the system analyzes video quality under its inherent constraints, with the node's specific topologies, video streaming protocols, the node's performance, and routing protocols. There are two steps exhibited in the technique; in the first step, the type of the network to transmit the on-road traffic video adaptively is verified, followed by using a reliable transport protocol such as Transmission Control Protocol (TCP) to achieve the highest quality of video at the TMS server. Our technique shows better results than existing video streaming techniques by analyzing the different streaming alternatives, such

as Dynamic Adaptive Streaming over HTTP (DASH). Finally, we analyzed the multi-hop networks under various traffic scenarios using the TMS server. The behavior of the received video is analyzed with relative merits in terms of throughput, delivery ratio, routing overhead, and delay. A proper understanding of the streaming traffic at different bandwidths has been received and adjusted for better performance using ffm

peg with traffic synchronization. The routing protocols functioning over the multi-hop networks can make a difference as they can enhance QoS metrics and improve the overall network performance with the proposed technique.

Wired association with wireless devices like IoT primarily relies on adopting dynamic adaptive Streaming techniques; as always, data is on the fly. It increases the potential of video transfer information measure rate. The valuable data transmission rate is usually calculated as the measured number of data units during a significant measurement time interval divided by the measurement time interval regardless of the data's modality, as the networks always carry the digital data. Traffic surveillance is vital for building Intelligent Transportation Systems (ITS) in any network. It helps to discover traffic incidents impulsively, like wrong-way drivers, still-standing vehicles, and roadblocks. Several cities have installed on-road cameras and utilized the effectiveness of traffic-monitoring systems (TMS), with the adoption of CCTV (closed circuit television system) to discover traffic congestion and spot accidents. Sometimes TMS, conjointly referred to as Incident Detection Systems (IDS), which are supported by video cameras (separated between twenty-five and seventy-five-meter distance), detect the road traffic jam and on-road incidents within a few seconds.

These systems don't have to be compelled to monitor all the video frames, whereas a minimum of four or five frames per second must be supervised. The TMS governs gathering parameters like vehicle volume, average speed, queue length, expected delay, and waiting time. However, these mechanisms have to be inbuilt based on the requirements and made proprietary, using a closed-circuit Television (CCTV) to access the video cameras.

The multi-hop wireless networks will be low-priced and must have a possible required resolution to collect the video streams from the deployed cameras,

wherever the packets are sent from one supply which is the node camera, towards the destination, which is the TMS server, which also collects data from the relaying nodes in a hop by hop fashion to transmit the road traffic video in an adaptive approach, to achieve the very best quality at the TMS server.

The methodology is stranded on two steps. Initially, various adaptive choices are available to transmit the video surveillance data adaptively by overcoming the impact of network dynamics to achieve the best video quality at the server. An adaptive live streaming technique is the need of the hour due to the turbulences callused not only by the network dynamics but also due to the changing nature of the traffic. Based on its bar, reliability, and compatibility in video streaming, we used DASH. The routing protocols and their behavior have an impact in terms of the video quality metrics on the received video. The relative features and how they affect the quality of Services (QoS) in output, delivery magnitude relation, routing overhead, and delay is being analyzed. The motivation is to build a more robust understanding of the problem domain and build a strong video streaming technique by comparing and analyzing the pros and cons of the existing video streaming techniques.

In several circumstances, IDS (Incident Detection Systems) need a quick and straightforward readying of video cameras for periodic inspections and a short-time observation of special events, during the starting of holidays, mass-attendance sports events, etc. Wireless networks support TCP/IP protocols along with UDP protocols. Multi-hop wireless networks are the possible resolution to collect videos from the deployed cameras in an Adhoc manner.

1.1.1 Features of DASH

- Live streaming using Dynamic Adaptive Streaming over HTTP with minimized delay in performance.
- The specification of DASH is designed to address current industry standards and practices.
- It supports interoperable DRM, allowing different vendor devices to communicate and stream.
- It allows the independence of using the bit rate control algorithm in the client, video, audio coding, and metadata.
- They are designed to reuse most of the existing infrastructure and tools.

2. LITERATURE SURVEY

Regarding adaptive video streaming, there are several protocols for the dissemination of multimedia content, such as HTTP Live Streaming (HLS), Adobe HTTP Dynamic Streaming (HDS), Microsoft Smooth Streaming (MSS), and Dynamic Adaptive Streaming over HTTP (DASH) [1]. Concretely among them, DASH is an ISO standard [2] launched to unify the adaptive transmission methodology. DASH works by breaking the video sequence into small HTTP-based file segments [3].

Each segment contains the actual multimedia bit streams in chunks, in single or multiple files, usually multiples of several Group of Pictures (GOPs), with a duration in the order of seconds. These segments are encoded with a specific resolution and bit rate to allow a proper streaming adaptation according to network congestion. The DASH clients do the adaptation process. With DASH, the audio and video files are called Media Presentation (MP), and the description files are called Media Presentation (MPD), encoded in XML. This MPD file indexes the segment content. Initially, the DASH client requests the MPD file to obtain the necessary information. Later through HTTP requests, the client captures the segments of videos. Simultaneously, the client monitors the network to get the most appropriate streams based on the network status.

DASH clients use a bit rate adaptation algorithm to automatically select the segment with the highest possible bit rate that can be downloaded in time with the best quality. For DASH, the resolution of the images and frame rates are critical values. It is needed to fulfill the requirements given by the IDS systems while receiving regular resolutions, which will be between 1080p to 360p, with 4 or 5 frames per second [4]. Together with the resolutions, it is also necessary to specify the video codecs and containers.

The most commonly used video codecs for resolutions below HD (720p) or FHD (1080p) are VP8 and H.264 from the MPEG family linked to the codecs, which are MP4 containers. The choice of H.264 codec is mainly justified for two reasons. On the one hand, H.264 performs better than VP8 in terms of perceptual video quality, encoding speed, and bit rate handling [5]. On the other hand, H.264/AVC was developed in 2003 and is still widely used because of its almost universal compatibility with different devices and platforms [6].

Road traffic monitoring based on image and video processing has attracted interest recently [7].

But none consider the constraints imposed by unreliable transport data networks, such as wireless multi-hop networks. However, several works related to performance evaluation for video streaming in ad-hoc networks are worth mentioning. An adaptive video transport over low bit-rate multi-hop WSNs, using a cross-layer priority algorithm that combines information from the network and the video quality, proves the experimentation behind it. This design tries to optimize the required QoS for the video streams.[8]. The delay-constrained video surveillance speaks about the low delay and high-quality video transmissions. By modeling the system, a method experimented with optimization features based on two concepts, intercommunication and intra-processing. The results show intra-processing techniques based on packet retransmission are preferred over forward error correction techniques [9].

An improved MAC- Medium Access Control algorithm, allowing per-node reservation of a block of contiguous transmission opportunities, improving end-to-end delay performance of real-time traffic, delivery ratio, jitter, and throughput [10]. An opportunistic routing technique to enhance the performance of wireless multi-hop networks with lossy links for video transmission, providing a bandwidth guaranteed for bandwidth-sensitive traffic, while the admission control is also applied [11]. All these previous works are based on simulation and different theoretical proposals, far from being implemented due to the complexity introduced by the models. [12] None of them provided an acceptable-grained solution as in adaptive streaming techniques due to the requirements imposed by the TMSs. The adaptive mechanisms must be simulated using the design principles to get good video quality on data networks.

A model to estimate the delivered video quality in live video streaming based on QoS parameters measured within 4G networks is also proposed. In their research, the authors proposed using different techniques such as factor analysis, multinomial linear regression, and artificial neural networks, where in these scenarios factor analysis technique showed better results [13]. A different model was proposed to estimate video quality in live video streaming but applied to cloud mobile media networks [14].

It also surveyed the video quality on live transmissions using IEEE 802.11ac wireless networks, comparing different channels and RF bands with different commercial off-the-shelf adapters. This work concluded that these Wi-Fi adapters follow and fulfill the standards. Still, many issues in their implementations must be simplified to make them cheaper, which is a drawback when transmitting high-resolution videos [15]. The methodology of flexible live video streaming on the multi-hop network for road traffic monitoring without losing the performance of the video [16].

3. AVAILABLE MODELS

The Present Transportation system uses Closed-circuit television (CCTV) video surveillance, where CCTV is employed to gather parameters like vehicle volume, average speed, queue length, etc. All of them will be proprietary and expensive, requiring a separate Closed-Circuit Television to access the video cameras, which is relatively rigid and not versatile. All the connections are structured in a wired network with the poor video quality.

Many steps are configured to produce quality services that support the surrounding, which needs high coverage and reliability. Existing systems cannot research high-throughput traffic tracking and find numerous violations in a period. Thus, a real-time vehicular traffic violation detection system is in demand. The existing system is difficult to stream video in real-time by storing video. The introduction of the DASH protocol addresses these problems.

4. PROPOSED SYSTEM

The Proposed smart live video adaptive streaming technique is to transport video streams from the cameras to the external road traffic monitoring servers. These networks need a thorough study to analyze the video quality under their inherent constraints, given by their specific topologies, the video streaming protocol, nodes' performance, and routing protocols. We validated several performance metrics in terms of quality and video quality. They are using H.264 codec with four resolutions (1080p, 720p, 480p, and 360p) at five frames per second, fulfilling all the requirements for the TMSs. The advantage of the proposed system

is it provides the efficiency of the video transfer bandwidth rate. It Increases the camera video bandwidth rate transmission by compressing the video stream by dynamically adjusting the stream's compression level and video quality to match bandwidth availability and End-to-end QoS. The illustration is in Figure 1.1

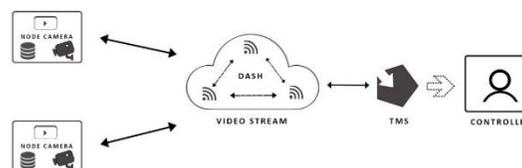


Fig.2 Working of Video Streaming over HTTP

4.3 Traffic Monitoring Systems Server

TMS servers provide the most relevant information with the stream information obtained from the video camera nodes. Usually, TMS, called Incident Detection Systems (IDS), is based on video cameras, detecting traffic congestion, jams, and incidents in less than 5 seconds. These systems need not process all the frames.

The Traffic Monitoring System Server stores and streams live traffic incidents. But all of them are proprietary and expensive, requiring a dedicated Closed-Circuit Television to access the video cameras, being relatively rigid and not very flexible.

4.4 Traffic Monitoring Systems Controller

TMS Controller gathers information from road Traffic Monitoring Systems servers and sensors for pollution and weather monitoring. Besides, the controller could propose several actions according to predefined strategies.

The DASH Streamer comprises four modules. These modules are responsible for efficient streaming over the network.

- Creation of the wireless multi-hop network
- Routing technique implementation
- Setup to live video
- Open QoS for the delay and buffering reduction

5. EXPERIMENTAL WORK

The work is experimented with DASH protocol and with ffmpeg.

5.1 Process flow of Video Streaming

In TMS, the video starts the capture process and then tries to communicate with the camera nodes. If the TMS can't communicate with camera nodes, it goes to waiting mode and restarts the communication again. After the successful communication, the camera nodes start to capture the live video. By using DASH video streaming, the camera nodes reply with Media Presentation Description manifest to TMS. Then the live video information is stored in the database storage. By sending the information to the controller, the controller recollects the data from several input nodes, and the process will be ended. The Process flow of video streaming for road traffic video surveillance is depicted in figure 3.

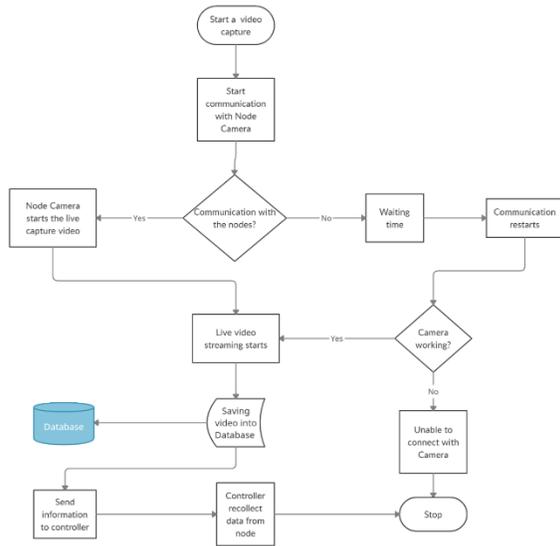


Fig.3 Diagram for Process flow of video streaming for road traffic video surveillance

The overview working of the intelligent traffic surveillance system is explained in the following modules of section 5.

5.1.1 TRAFFIC MONITORING SYSTEM

The precise traffic data can be provided by traffic monitoring systems that are usually integrated with road infrastructure. Such systems allow the detection and classification of vehicles in selected areas using data from sensors such as inductive loops, video

detectors, magnetometers, etc. This is typically used for monitoring the traffic on roads.

5.1.2 ADAPTIVE VIDEO STREAMING

Dynamic Adaptive Streaming over HTTP (DASH), also called MPEG-DASH, is an accommodative bit-rate streaming technique that permits high-quality streaming of media content over the web delivered from typical HTTP web servers. MPEG-DASH breaks the content into a sequence of little segments served over HTTP. Each segment contains a brief playback time of content that is potentially many hours, such as traffic surveillance.

The manifest file format of DASH is Media Presentation Description, an XML document containing information about media segments, their relationships and information necessary to choose between them, and other metadata that the client may need.

Shell ffmpeg commands to encode live DASH streaming at the camera node, with dynamic bit rates, are as follows.

```

ffmpeg -input_format h264 -s 1920*1080 -i live.mp4 -map 0 -map 0 -c:a aac -c:v libx264 -b:v:0 800k -b:v:1 300k -var_stream_map "v:0,name:800k v:1,name:300k" -f dash -dash_segment_type mp4 -single_file 1 test_manifest.mpd
    
```

To show the demonstration practically is done by using FFmpeg- Fast Forward MPEG software. The above command represents that the system has already installed FFmpeg software. The FFmpeg program itself is designed for command-line processing of video and audio files. FFmpeg has an extensive suite of libraries and programs for handling video, audio, and other multimedia files and streams. An adaptive bit-rate streaming protocol is a mechanism where the video quality is selected based on the bandwidth or internet speed of the client or media player used in the device.

5.1.3 DSR - Dynamic source routing protocol

Dynamic source routing protocol –DSR, is an on-demand protocol designed to restrict the bandwidth consumed by control packets in ad hoc wireless networks by eliminating the periodic table-update messages required in the table-driven approach. The basic strategy of this protocol during the route

construction phase is to establish a route by flooding Route Request packets in the network.

6. RESULTS AND DISCUSSION

Traffic Monitoring System provides information from the traffic on roads and helps to detect incidents. The essential issues of Intelligent Transport Systems had been deployed only in popular cities. Fig.4 shows a Video of a Highway road captured by the camera nodes. Wireless multi-hop networks are a low-cost and feasible form of streaming video from the camera to the TMS web servers. TMS uses the DASH technique for video streaming. The software FFmpeg encodes the video streamed by the TMS web server. The behavior in terms of Quality of Service under realistic scenarios, with an adaptive streaming technique proposed, is based on DASH. Each encoded video is measured, and the quality is delivered on the Traffic Monitoring System.



Fig.4 Video of Highway road captured by camera nodes.

"FFmpeg" generate a manifest playlist file with a sample video named live in mp4 format. It is the FHD 1080p traffic surveillance video sample frame. The sample video file is placed inside the Apache tomcat server web apps folder to generate the manifest file. Opening the shell is done using the sample video file's directory location. Creating two different variations, such as 800 kbps bit-rate and another 300 kbps bit-rate, as when the bandwidth is low, it will show in 300 kbps, and 800 kbps is shown when the bandwidth is high. After the processing, the manifest file and two video variations are created successfully. The two variations are 300 kbps and 800 kbps bit-rate videos.

Figures 5, 6 and 7 show that the proposed system is cost-efficient, feasible, and reliable. DASH power consumption is high when the CPU usage is high. When the TMS web server is starting, and the CPU starts processing the video over the HTTP client.

They are opening the test_manifest.MPD file using the tomcat server in the firefox browser is exhibited in figure 8. The manifest file format of DASH is Media Presentation Description, an XML document containing information about media segments, their relationships and information necessary to choose between them, and other metadata that clients may need. The sample video is streamed successfully over the server. One disadvantage of using DASH as a streaming standard is the cost of data hosting due to different representations of the same video stream. We suggest taking advantage of some platforms' three-tier caching strategy for the data hosting problem.

7. CONCLUSION

TMS provides the foremost relevant data. TMS systems have shown that one square measure is needed to be deployed during a short time and as in wireless multi-hop networks, which measure a low cost and possible choice to transport video from the camera nodes to the TMS servers. TMS System analyzed the networks and their behavior in terms of quality of service in throughput, delay, DR, ROH, and packet losses shown in the simulation. As a radical analysis, it's complete that for TMSs used for video transmission on static wireless multi-hop networks, routing protocols in specific BATMAN are preferred with most well-liked with packet sizes larger than 800 bytes, thanks to its reduced ROH, higher stability, and better DR however it the lower performance of these networks. To analyze and identify the best approach for video transmission on static wireless multi-hop networks using SDN with BATMAN protocol and DASH video streaming techniques. The system is planned and executed by an adaptive streaming technique supported by DASH. TMS requests the video streams to at least one camera at any time and can adapt to the supported network congestion. The system evaluated the adaptive application by measuring the DASH streams used with every topology to measure the video quality. If the network's performance changes, the TMS can mechanically request a distinct chunk in line with the congestion as a DASH client. Using H.264 codec with four resolutions, such as 1080p, 720p, 480p, and 360p at five frames per second, fulfilling the necessities for TMSs could be executed. The planned system is currently possible in terms of

low cost and economics. In future work, we will try to conceive the complete mixing of the planned network with TMS servers. Also, we will extend this work to implement to detect traffic violations to act as an effective traffic violation detection system.

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