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Network centric QoS performance evaluation of IPTV transmission quality over VANETs

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ABSTRACT

Internet Protocol Television (IPTV) traffic streaming over vehicular ad hoc networks (VANETs) challenge could be distinguished by the frequent VANETs topology change, paired with real-time streaming of IPTV traffic which requires high bandwidth and strict performance service quality. For VANETs to deliver better quality IPTV traffic, the network must satisfy the compelling Quality of Service (QoS) requirement of real-time traffic streaming, such as jitter, bandwidth, delay, and loss. There are numerous metrics defined in the literature for evaluating multimedia streaming traffic QoS such as: video quality metric, peak-signal-to-noise-ratio, moving picture quality metric and many more. However, these metrics relied upon the objective approach of quality evaluation that requires the original signal as reference, and cannot isolate the impact of network impairments on the video quality. Therefore, fail to provide any mapping between the network QoS parameters and the respective deteriorated quality of the multimedia traffic. Similarly, such procedures are not practically applicable to VANETs whose network characteristics make it practically impossible to access the reference video sequence. Hence, in this paper, we conduct an experiment to determine the feasibility of delivering a qualitative IPTV service over VANETs. We derived analytical model to quantify the IPTV QoS influencing parameters, where we establish relationships between the variables of each parameter and their impacts on the IPTV traffic QoS. Through extensive experiment, we evaluate the IPTV transmission QoS parameters, to assure a priority for handling bandwidth allocation, delay and loss control to a negligible level.

1. Introduction

The advances in mobile ad hoc and wireless communication have presented a new potential for Intelligent Transportation System (ITS). Increasing attention has been centered on developing these technologies on vehicles in order to utilize them for improving driving conditions. By introducing short range communication means to vehicles, an ad hoc network of vehicles known as vehicular ad hoc networks (VANETs) is formed, allowing vehicles to communicate with one another, thereby exchanging vital information's regarding road conditions. VANETs is a unique type of Mobile Ad-Hoc Networks (MANETs), it differs from infrastructure based networks such as cellular networks on its demanded equipment to form a transportable network [1]. VANETs makes use of the wireless technology such as 802.11p wireless standards, General Packet Radio Services (GPRS), as well as Dedicated Short-Range Communications (DSRC) to communicate with surrounding vehicles [2–4]. Based on VANETs technology, a large number of safety related applications and non-safety applications have been implemented. Safety applications offer relevance traffic safety information to drivers while on the road, some good examples are: Intelligent Road Traffic Signalling System (IRTSS), collision warning, incident management cooperative, speed violation detection, and many more [5–8]. While non-safety application offers information and entertainment for both drivers and passengers, e.g., Internet access, multiplayer games, multimedia applications, etc. A variety of relevant data such as weather information, tourist information, gas prices and parking space information can also be spread using this same procedure. These services, also known as infotainment, can offer unlimited opportunities for vehicle internet applications that can make the driver and passengers experience more pleasant. In this paper, we focused our attention on the infotainment aspect of VANETs application, where we proposed the deployment of Internet Protocol Television (IPTV) over VANETs. However, to successfully deploy IPTV over VANETs, it's imperative to first overcome the major challenge faced by VANETs, which are

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the issues of Quality of Service (QoS) and its operation. Unlike other mobile network, VANET has certain unique characteristic (i.e., high node mobility and frequent link break) [9], that poses several difficulties in supporting a quality IPTV service transmission. Consequently, streaming IPTV traffics which by nature are multimedia traffic that requires on time information delivery, huge bandwidth and strict performance service quality, possess a greater challenge. Multimedia communications generate traffic at an inconsistent rate and in general require that the network supports the rate at which the traffic is being generated. Unfortunately, VANETs resources are finite, as such; there are sections of the network in which resources may not be available to meet the multimedia application requirements. Therefore, requires QoS mechanisms to control the allocation of the network resources to the application traffic such that will meet their end-to-end quality service requirements.

QoS in any network, be it local area network, wireless network, mobile ad hoc network or vehicular network cannot be overemphasised. In computers and all packets switched networks, the term QoS does not refer to the achieved service quality. Rather, it refers to the resource reservation control mechanisms, which is the capability of a network to provide dissimilar priority to diverse applications, users, or to ensure a certain level of performance to informations flows [10]. Quality of service therefore, is the measure of service availability of a network and its transmission quality. The availability of service in a network environment is a crucial fundamental element of QoS. Network Qos metrics are used to collect information regarding network status. And using the collected information from these metrics, actions or decisions can be taken to alter or adjust network parameters or configurations in a way that can guarantee better quality delivery. To provide a minimal level of IPTV quality in VANETs, VANETs must satisfy the compelling QoS requirement of real-time traffic streaming. It was deduced from literatures [11], that the transmission quality of IPTV network is determined by four major factors namely: minimum bandwidth, packet loss, delay and delay variation. For VANET to deliver better quality IPTV services, the network has to meet certain requirements for bandwidth, jitter, delay, and loss. There are many metrics defined in the literature for the evaluation of multimedia streaming traffic QoS such as: video quality metric (VQM), Peak-Signal-to-Noise-Ratio (PSNR) [12], Reduce-Reference Image Quality Assessment (RR-IQA) [13], Structural Similarity Index (SSIM) [14], V-factor [15], to name only a few. Nevertheless, all these methods depended upon the immanent and the intrusive approach of video quality evaluation that involves a reference picture or video, and as such, not suitable for use in monitoring real-time traffic in a complex environment such as VANETs. Whose network characteristics make it practically impossible to access the reference image or video sequence, and so requires a measurement approach that evaluates the multimedia traffic quality blindly.

The primary objective of this paper is to experiment via simulation to determine the feasibility of delivering a qualitative IPTV service over VANETs, by evaluating the IPTV transmission QoS determinant parameters (loss, throughput, and delay). To achieve this objective, we developed analytical models to quantify the VANETs QoS influencing parameters; where we established a relationship between the variable of each parameter and their impacts on the IPTV traffic QoS. In addition, through extensive simulation, using network simulator NS-2, we evaluate the IPTV transmission QoS determining parameters (loss, throughput and delay), to assure a priority for handling bandwidth allocation, delay and loss control to a negligible level. Furthermore, we adopted an objective QoS evaluation metric known as the Media Delivery Index (MDI) scheme [16], to identify, locate and address the loss or out-of-order packet. MDI is a set of measure that can be used to monitor IPTV streaming quality and to show the margin for IPTV services with no requirement for reference video or images. MDI has the potential to provide a holistic IPTV approach that gives detailed information about jitter, packet loss and delays at any instance in the network and could detect instantly when there is a problem with the packet delivery. MDI provides accurate measurement for identifying delay and packet loss at a network level, identifying and quantizing these parameters is the key to sustaining high quality IPTV delivery over VANETs.

2. Related works

The rise of IPTV has brought about potential to transform digital TV entertainment. Streaming multimedia traffic across a high extensive wireless networks bring about easy access to personalized digital entertainment. IPTV being one of the existing home wireless network application which is aimed at streaming digital television over wireless internet and its ability to do so has made digital television content easily available for a wide range of users. It allows for portability and flexibility in terms of space control for personal amusement. The importance of acquiring an understanding of IPTV QoS over wireless network has been highlighted in several recent works. Previous work in [17] proposed an effective model to study statistical QoS guarantees, based on efficient bandwidth and delay-bound violation probability for multi-layer video conveyance across a fading wireless channels. However, only the separate queues manage the multi-layer video arrival process in their evaluation and so does not take into account the statistical characteristics of the video traffic. Study in [18] proposed an extended two-dimensional Markov-chain model for IEEE 802 multi-hop wireless network, throughput analyzing and taking into consideration the error-prone channels, non-persistent traffic, post-back off stage and finite retry limit. The analysis of the throughput provides the upper-bound throughput performance of the streaming video. Nevertheless, traffic being considered lacks a description of the characteristics of video because it is generally non-persistent traffic. A seamless cross-layer interworking between broadcasting network and 802.11 WLAN network for delivery adaptive and interactive mobile TV was proposed in [19]. They evaluate the packet losses and the TV quality perceived services using an experimental test-bed. Though, the test-bed results validated their proposed algorithm. But then, the test-bed base performance realization, consumed allot of time and the setup is too complex. Study in [20] investigates the performance of IPTV loss packet that can be caused by overflow buffer, in various scenarios of home networks, which include constant rate data wired link, multi-hop wireless path and variable data rate for single-hop wireless link. An on–off traffic sources was used for the arrival process to characterize the video source, for the service process, an exponential distribution was presumed for the service time distribution of the data linked examined. However, using on–off arrival model for exponential service time and video source distribution for the protocol behavior of complex network like IEE 802.11 MAC protocols considerably limits the feasibility of the analytical results. Although, there are many metrics defined for providing QoS for audio and video traffic streaming over VANET such as the one proposed in [21,22], where they concentrate on monitoring video quality based on human perception (human judgment) subjective, however the scheme, lack monitoring as well as solution to fixed jitter, delay nor loss problem, in a network and these are the major parameter that call the shots as to whether a network can convey good quality IPTV services or not. Subsequently, the most recent works in [23], suggested a novel architecture for ensuring QoS for seamless mobile IPTV services in heterogeneous access networks. The architecture was designed to account for three technical issues, which are: the network to client conditions, the