QuVA 2021: Quality of Experience (QoE) Driven VR/AR Multimedia System Design

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***Abstract* – Virtual Reality (VR) and Augmented Reality (AR) technology has a potential to be the next major multimedia contents because VR/AR can provide immersive experience to the users. The VR/AR systems must be designed to provide high quality multimedia experience to the users depending on their applications. VR/AR systems consist of many design components, such as sensors, networks, audio, and display devices. The sensors are necessary for implementing VR/AR services. Sensors are not only used for generating VR/AR contents, but also for the acquisition of viewer's position. There are many kinds of sensors, such as infra-red, Radar, Lidar, image sensors, temperature sensors, and gyro sensors. Data captured from the sensors help recognizing environment or user behavior. Networking is necessary to deliver high quality VR/AR data. The network includes wireless or wired connectivity, and networking infrastructures. Vehicle-to-Vehicle (V2V) network and underwater communications are possible solutions for expanding connectivity between machines. Networking performance significantly affects VR/AR service quality. Audio and display devices directly affect the user experiences. To provide the best VR/AR services, these components must work together. Therefore, it is necessary to optimize the VR/AR system considering all these design components to provide high quality VR/AR services. This Special track focuses how to design these design components to improve VR/AR systems.**

Keywords – VR/AR, V2V, underwater communications, Radar

I. INTRODUCTION

An efficient utilization of wireless resources is getting more important with increasing data traffic being over wireless networks, especially multimedia traffic. Since the display panels in mobile devices are getting bigger and having a higher resolution, video streaming over a wireless network becomes a more challenging problem. Multimedia data traffic occupies more than 70% of the Internet traffic and is still growing [1]. On-demand video is already a major video content platform and private broadcast is getting more popular. In addition to this, virtual reality (VR) and augmented reality (AR) data traffic is increasing very fast. To provide the good quality of the multimedia service, huge amount of resource is needed because users' service experience is usually proportional to the video rates they can receive. Moreover, the variation of the bandwidth also affects to the users' experience, while more users want to use their mobile devices to see multimedia data by accessing the network through wireless links, such as Long-Term Evolution (LTE) and Wi-Fi. Therefore, better spectral efficiency during wireless transmission and video rate adaptation to provide better quality to users are in great demand.

The enhanced capabilities of mobile devices and the improved capacities of wireless networks have led to a massive growth in mobile video consumption. MPEG's Dynamic Adaptive Streaming over HTTP (MPEG-DASH) [2] is thus proposed as an effective video streaming platform, which enables the adaptive rate selection based on the channel conditions. DASH can provide superior video experience by giving clients a chance to receive the video quality based on their channel condition and buffer status, resulting in better quality of experience (QoE). Most of Internet video service providers, such as Netflix and Youtube, support DASH in their video streaming platforms. DASH is extended for VR video streaming (DASH-VR) and it supports tiled video rate adaptations and reconstruction of VR videos.

VR/AR is getting more popular these days, and more people can enjoy more realistic experiences with VR/AR systems [3]. Moreover, it allows people to look around the virtual world and feel like they are actually in the environment. VR gaming can provide a more exciting experience to gamers. However, it is a more challenging task to make users satisfied with the quality of VR videos, because VR videos need much higher resolution than conventional videos. Users cannot see the whole video at the same time, they can only focus on the area that they want to see and the area is usually only 20% of whole video [4]. Therefore, 4–6 times more resolution is required for VR videos to provide the same experience as conventional videos. On the other hand, this fact allows the saving of bandwidth, because 80% of the video is unseen by the user at a given time. In an ideal case, we could save 80% of the bandwidth; but in practice, we still need to transmit redundant areas of the video because it is difficult to predict how a user's viewport will change.

Various connectivity solutions are introduced such as Multiple Radio Access Technology (Multi-RAT), Vehicle-to-Vehicle (V2V) and underwater communications. Multi-RAT system can achieve higher data rate by using multiple data path

[5][6]. The system transmitting scalable video coded (SVC) video through Wi-Fi and LTE channel is introduced in [7]. V2V or V2X networking technologies are getting more important as electrical vehicles are equipped with autonomous driving capability. VR/AR technologies are critical to implement autonomous driving because vehicles should recognize surrounding environment in 3D. Radar and Lidar sensors generate 3D data and this data must be delivered over the internet.

II. CONTRIBUTIONS

This section summarizes four contributions of the special track. The first contribution is "Scalable Video Streaming over Multi-RAT Network" [8]. Multiple Radio Access Technology (Multi-RAT) system is one of the solutions for streaming high-quality video through wireless channel since most of the mobile devices are equipped with multiple radio technologies, such as Wi-Fi and LTE. Moreover, scalable video is suitable to adaptively change the quality of the video depends on the wireless channel condition. In this research, optimal rate distribution through the Wi-Fi and the LTE will be derived to efficiently utilize both wireless technologies to transmit video to provide the best video quality to the user equipped with Wi-Fi and LTE.

The second contribution is "On Security and Energy Efficiency in Underwater Wireless Sensor Networks for Maritime Border Surveillance" [9]. Underwater wireless sensor networks (UWSNs) based on acoustic communications attract interest as an enabling technology of maritime border surveillance. However, due to differences in environments, many of the techniques used in typical terrestrial wireless communications are not directly applicable to UWSNs. Of the challenges, designing a secured and energy-efficient UWSN takes the greatest significance for application to maritime surveillance applications. To provide an overview on the UWSN technology, this paper (i) characterizes key technical challenges that are drawn in UWSNs and (ii) discusses methodologies to improve security and energy efficiency of an UWSN.

The third contribution is "Simulations for Stochastic Geometry on the Performance of V2X Communications in Rural Macrocell Environment" [10]. Vehicle-to-everything (V2X) communications is a concept that has been around for the past decade. It involves communication between vehicles and other types of infrastructure. This application is exceptionally useful for emergency services such as ambulances, fire trucks etc. This is because an emergency vehicle can communicate with the traffic light infrastructure and make it give the green signal thereby allowing vehicle to pass quickly. This is useful because it alerts other cars and pedestrians on the road when an emergency vehicle is present. In this paper, a V2X communications system in an urban setting will be simulated using MATLAB and the Automated Driving Toolbox.

The fourth contribution is "High Resolution mmWave Radar by Radar Fusion and Sparse SAR" [11]. In automotive applications, mmWave radar has been limited to measuring the range of objects. Its limited role comes from two reasons: low resolution in 3D imaging and blind spot from specularity. A single automotive radar typically has less than 5GHz bandwidth, and therefore its distance resolution is insufficient. By fusing multiple radars operating different frequencies, the total bandwidth of the radar system can be increased. Strong specular effects of mmWave signals cause incomplete or shabby radar images due to few or none of the reflected signals back to the radar. The author of the paper addresses the blind spot problem with random spatial sampling, resulting in the ability to reconstruct the radar image with missing reflected signals. The numerical results are illustrated to prove the concept.

III. CONCLUSION

Various novel technologies related to VR/AR are introduced in the special track. Multi-RAT is a useful technology for streaming videos, since it can achieve better data rate than using only one channel at once. Moreover, if we distribute the data in an optimal way, the receiver will get better quality video. We can expand this work to VR/AR multimedia streaming systems to improve quality of VR/AR services. V2V and underwater communication technologies will help providing reliable connectivity solutions in various environments. mmWave Radar technology will allow vehicles to recognize obstacles more accurately.

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