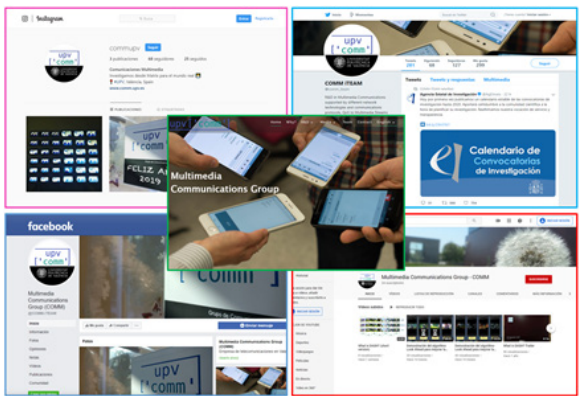
MULTIMEDIA COMMUNICATIONS GROUP (COMM) ANNUAL RESEARCH REPORT 2018/2019

HEAD OF THE GROUP RESEARCH REPORT

Multimedia Communications Group (COMM) started its activities in 2004, and nowadays is composed of a group of 6 researchers, focusing its research lines on multimedia systems and Quality of Experience (QoE). During the last year 2018/2019 the group has continued with its work lines focused on the distribution of multimedia content using protocols like Dynamic Adaptive Streaming over HTTP (DASH); carrying out more in-depth studies into the Internet of Things (IoT) trend; analysing and proposing new metrics for estimating the QoE; developing new functionalities for multimedia systems based on DRM and cross-layer techniques; and continuing studying new trendy lines such as the integration of protocols for broadcast distribution.

These lines of action have been articulated through the execution of different research and development projects, as well as scientific publications. In addition, in order to promote the main activities of the group, we have been continuously updating the webpage and we continue being very active in social networks (Facebook, Twitter, Youtube and Instagram).

Following, the main results of the group are summarized, which are accessible through the COMM webpage (www.comm.upv.es).



Website and social networks of the COMM

1.- PROJECT ACTIVITIES

The COMM has continued during the last year with its main research lines. Also, new emerging activities have appeared. A short summary of the main advances carried out is presented below:

Adaptive video through MPEG-DASH

As in the previous year, one of the main research lines of this year has been the development and analysis of a new algorithm called Look Ahead, which takes into account the information of the size of the forthcoming segments. With our proposal, there is no need to encode videos with constant bitrate because clients will have the tools to choose the best quality that fits in its available bandwidth. To test the algorithm, we have implemented Look Ahead for the ExoPlayer library, the video player behind the YouTube app in the Android platform. Also, the proposed algorithm is compared to relevant algorithms existing in the literature, specifically the Müller and Segment Aware Rate Adaptation (SARA) algorithms as well as to the adaptive algorithm integrated into ExoPlayer. The comparison is carried out by using the most relevant parameters that affect the Quality of Experience (QoE) in video playback services, that is, the number and duration of stalls, average quality of the video playback and number of representation switches. Also, during this year we carried out a subjective study with real users in order to prove the validity of the proposed algorithm.

Measure of the Quality of Experience

Another important research line this year has been the analysis of different metrics that help to calculate the quality perceived by users when consuming video contents. We have deeply analyzed the recommendation P.1203 proposed by the International Telecommunications Union (ITU). This recommendation describes a set of objective parametric quality assessment modules that help to predict the impact of media encoding and observed IP network impairments on quality experienced by the end-user in multimedia streaming applications.

Also, we have proposed different QoE metrics for the evaluation of adaptive bitrate (ABR) algorithms. Specifically we have proposed a bitrate-based QoE metric, a QoE metric based on the PSNR (Peak Signal-to-Noise Ratio) and a metric based on VMAF (Video Multimethod Assessment Fusion). The different evaluations carried out have proved that the proposed QoE metrics results more accurate than other similar metrics proposed in the literature, including the ITU-T P.1203 recommendation.

Optimization of the multimedia content transmission with cross-layer

In this year we have deepened in the use of cross-layer mechanisms in order to improve the performance of the network when several users are consuming multimedia contents concurrently. Specifically, we have developed a system based on a cross-layer server which, depending on the reports received by the clients (which include parameters like estimated bandwidth or video representation displayed), force the clients to change their displayed video quality in order to minimize the stalls of the overall clients. To that extent, the cross-layer server is based on MPEG SAND (Server and Network Assisted DASH). This technology offers standardization messages and protocols in order to improve the user experience in the streaming service and to better use the bandwidth.

Proxy-based near real-time TV content transmission in mobility

In this line, the group has developed a multimedia system that provides users in mobility with TV and radio services in near real-time. To that end, the system uses advanced selective pre-storage strategies of content sent to the vehicles from transcoding servers located on the cloud. One of the key elements of the system is an on-board proxy in charge of creating and managing the buffers associated to each video flow offered in the platform. Thus, the proxy is designed to adjust the amount of segments in buffer with the aim of providing continuous playback in on-board clients.

During this year we have carried out several tests to ensure the reliability of the service when numerous users access simultaneously. To perform the tests we have used a panel of tablets, as shown in the figure.

Testbed of the TV transmission system in mobility

The developed system has been assessed and results have demonstrated that using the proposed advanced on-board proxy in mobility help reduce video interruptions and, therefore, the quality of experience perceived by final users is improved. The recommendation ITU-T P.1203 is also applied in order to estimate this QoE more precisely.

Adaptive streaming for 3D video

Considering the importance of replicating and assessing the results obtained in a research environment, during this year we have focused on developing an easily exportable, reproducible and scalable system that allows automation and systematization of the quality of experience assessment in adaptive video streaming scenarios. The proposed system is oriented to the automated execution of a DASH player, using the Google Chrome browser and, specifically, using Puppeteer, the new library developed by Google that allows the automation of functional tests in web environments. Puppeteer enables access to the Chrome Developer Tools, thus allowing the capture of metrics and records related to network statistics, state of the buffer, number of stops, duration of stops, playback time and transmitted representations of the video, among others.

This data can be obtained either parsing the output log or analyzing a generated JSON file that records the interaction between the client and the server. These files are then processed to extract the data required for the reconstruction of the video and their subsequent subjective assessment through the ITU-T P.1203 recommendation. The different components of the system (client-server), including the emulation of bandwidth conditions, can be executed on the same machine. Thus, the aim is to use a virtualization system or a container-based system, such as Docker, to be able to deploy each module of the system independently, even deploying the client and server in the same computer, which would allow the system to be easily exportable and replicable by the scientific community.

Internet of Things

The application of the potential of Internet of Things (IoT) to improve the life of citizens leads to what nowadays the Smart Cities represent. A Smart City can be seen as an instrumented, interconnected and intelligent urban ecosystem. Hence, IoT technologies are fundamental for Smart Cities, since sensors are responsible for collecting data on the state of the city and then disseminate them among citizens, often making use of an urban platform and its capabilities.

During this year, the group has been working on tasks related to Valencia urban platform (VLCi). Within the context of MAtchUP project, we aim at improving the performance of the city, decision making or citizen participation, among others, guaranteeing interaction between the city of Valencia and its citizens. In addition, all these developments follow the same principles, ensuring that data is open and guaranteeing interoperability through open APIs. For this, the UPV collaborates closely with the City Council and the other partners of the Valencia demonstrator,

in order to design the new models and data sets that will be used for the new services and devices integrated into the urban platform, as well as the indicators and significant metrics to monitor the progress and improvements developed in the project, following the most relevant standards in IoT.

Reliable multicast transmission over communication networks

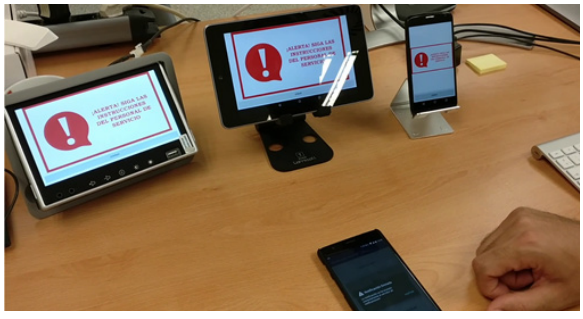
During this year we have carried out different comparative study between unicast, multicast and hybrid networks for live videos. In this sense, we have continued analysing a protocol named ROUTE (Real-Time Object Delivery over Unidirectional Transport), which is considered the evolution of FLUTE (File Delivery over Unidirectional Transport), a highly studied protocol by part of the research group. The ATSC (Advanced Television Systems Committee) published in 2016 a new candidate standard which proposes the jointly use of ROUTE and DASH. ROUTE, apart from the functionalities of the FLUTE protocol (such as multicast transmission of files), allows to provide video streaming services in multicast.

1.1.- ONGOING PROJECTS

Name of the project: *Desarrollo de nueva plataforma de entretenimiento multimedia para entornos náuticos (CDTI TIC-20170102)*

Summary of the project: *The overall objective of the project is the definition and implementation of a new platform capable of supporting and providing real-time content distribution services and Internet access in an environment of high user density and high mobility, taking into account the complexity of the reception and signal transmission in maritime environments, in which there are usually connectivity problems so Internet access is only possible by satellite. The project started in July 2017 and it has finished in 2019. During this last year, the COMM has developed different mechanisms for the improvement of the Quality of Experience of users, specifically a new adaptation algorithm for video adaptation as well as the use of cross-layer mechanisms to deal with several users connected at the same time. Also, it has been developed a notification service to inform clients about alerts and general information.*

Funding entity: *Ministerio de Economía, Industria y Competitividad. CDTI (Centro para el Desarrollo Tecnológico Industrial)*



Notification service within the CDTI TIC-20170102 project

Name of the project: *MAtchUP: MAximizing the UPscaling and replication potential of high level urban transformation strategies (774477, Call H2020-SCC-2017)*

Webpage of the project: http://www.matchup-project.eu

Summary of the project: *The project aims at strengthening the planning processes for urban transformation, consolidating the benefits of deploying large scale demonstration projects of innovative technologies in the energy, mobility and ICT sectors, by means of substantially improved models for replication and upscaling, based on impacts evaluation, and ensuring the bankability of the solutions by means of innovative business models, which lead to achieve real deployment further than the pilots carried out in the lighthouse cities. With this, it is sought a high penetration of the validated technologies in those cities less prepared to adopt very innovative solutions and formalize it in a standard commitment, accompanied by capacity building strategies, to guarantee at least medium term implementation. The project started in October 2017, with an expected duration of five years. COMM focuses on actions related to ICT. During this year, first IoT sensors have been integrated into the Valencia urban platform (VLCi). Among the sensors, there are smart meters that measure energy and power consumption, and comfort parameters, such as temperature, humidity and luminosity. On the one hand, significant information is analysed and recommendations are provided to users regarding energy efficiency and ways to save expenses. On the other hand, anonymized data is published as open data sets on the city Open Data Portal so that citizens, entrepreneurs and third parties could build applications based on this data. New dashboards have been built to manage and control relevant KPI (Key Performance Indicators).*

Funding entity: *European Union's Horizon 2020 Research and Innovation Programme*

Meeting of the MAtchUP project in Valencia (Spain)

Name of the project: SSPressing - Smart Sound Processing for the digital living (TEC2015-67387-C4-4-R)

Webpage of the project: http://sspressing.upv.es

Summary of the project: The project performs systems for analysis and synthesis of environments and sound scenes in an "intelligent" and computationally efficient way

through network acoustic nodes. Specifically, the following objectives/developments are addressed: conformation of interactive virtual sound environments with distributed multinode control systems, creation of interactive virtual sound scenes and analysis of sound scenes for detection, location and classification of events and scenes, and development of systems to aid hearing and improve intelligibility. The tasks of the third and last year of the project have been focused on improving the acoustic classifier of the ad-hoc network. Specifically, different classes from an urban sound 8K dataset with different outdoor noises have been selected: siren, car horn and gun shot. The feature extraction is processed by each acoustic sensor where the classification process is carried out by the server using a multi-layer neural network.

Funding entity: Ministerio de Economía, Industria y Competitividad (Programa Estatal de I+D+i orientada a los Retos de la Sociedad)

2.- RESEARCH RESULTS

2.1.- FEATURED PUBLICATIONS

- ***Proxy-based near real-time TV content transmission in mobility over 4G with MPEG-DASH transcoding on the cloud***. *P. Arce, I. de Fez, R. Belda, J. C. Guerri, and S. Ferrairó, Multimedia Tools and Applications, vol. 78, no. 18, pp. 26399-26425, 2019.*

This paper presents and evaluates a system that provides TV and radio services in mobility using 4G communications. The system has mainly two blocks, one on the cloud and another on the mobile vehicle. On the cloud, a DVB (Digital Video Broadcasting) receiver obtains the TV/radio signal and prepares the contents to be sent through 4G. Specifically, contents are transcoded and packetized using the DASH (Dynamic Adaptive Streaming over HTTP) standard. Vehicles in mobility use their 4G connectivity to receive the flows transmitted by the cloud. The key element of the system is an on-board proxy that manages the received flows and offers them to the final users in the vehicle. The proxy contains a buffer that helps reduce the number of interruptions caused by hand over effects and lack of coverage. The paper presents a comparison between a live transmission using 4G connecting the clients directly with the cloud server and a near real-time transmission based on an on-board proxy. Results prove that the use of the proxy reduces the number of interruptions considerably and, thus, improves the Quality of Experience of users at the expense of slightly increasing the delay.

- ***Interoperability network for traffic forecast and full electric vehicles power supply management within the smart city.*** *V. Fernández, J. C. Guerri, and A. Roca, Ad Hoc Networks, vol. 93, article 101929, 2019.*

Information technologies and applied mathematics provide us with a comprehensive framework to search for solutions to problems derived from traffic management. It is relevant for the mobility in our future cities to integrate the Full Electric Vehicle (FEV) in an interoperability network which allows us to track the FEV autonomy and to forecast the traffic and the power supply demand in the city. The target is to optimize the energy consumption and to improve the mobility in the city. To achieve these goals we propose an infrastructure to efficiently manage the power supply availability in the network of charge stations in the city and an adaptive model to predict the traffic based on historic data and on time series obtained mathematically.

- ***Available bandwidth estimation for adaptive video streaming in mobile ad hoc.*** *W. Castellanos, J. C. Guerri, and P. Arce, International Journal of Wireless Information Networks, vol. 26, no. 3, pp. 218-229, 2019.*

We propose in this paper an algorithm for available bandwidth estimation in mobile ad hoc networks and its integration into a conventional routing protocol like AODV for improving the rate-adaptive video streaming. We have introduced in our approach a local estimation of the available bandwidth as well as a prediction of the consumed bandwidth. This information allows video application to adjust its transmission rate avoiding network congestion. We conducted a performance evaluation of our solution through simulation experiments using two network scenarios. In the simulation study, transmission of video streams encoded with the H.264/MPEG-4 advanced video coding standard was evaluated. The results reveal performance improvements in terms of packet loss, delay and PSNR.

- ***Algoritmo de adaptación DASH sensible al tamaño del segmento.*** *R. Belda, I. de Fez, P. Arce, and J. C. Guerri, in Proc. of the Simposium Nacional de la Unión Científica Internacional de Radio (URSI), Granada, Spain, Sep. 2018, article S7.1.3.*

Adaptation algorithms are one of the key elements regarding the performance of the Dynamic Adaptive Streaming over HTTP (DASH) video standard. Usually, adaptation algorithms use the average video bitrate to be compared with the estimated bandwidth as well as the playback buffer. This approach can cause stalls when there are peaks in the video segment sizes, since encoded videos have inherently variable bitrate, despite being encoded with a target bitrate. In this sense, this paper proposes an adaptation algorithm called Look Ahead which takes into account the bitrate variability of the videos in order to calculate in advance the appropriate representation that minimizes the number of stalls during the playback. The evaluation carried out proves that the

proposed algorithm outperforms other relevant adaptation algorithms both in number and duration of video playback stalls, but with hardly decreasing the average quality during playback.

· ***Mobility Network Model for Full Electric Vehicles to Interoperate with the Smart Grid and Efficiently Manage the Power Supply in the Smart City**. V. Fernández, J. C. Guerri, and A. Roca, in Proc. of the 5th ACM International Symposium on Performance Evaluation of Wireless Ad Hoc, Sensor, and Ubiquitous Networks (PE-WASUN 2018), pp. 26-32, Montreal, QC, Canada, Nov. 2018.*

Never before have we seen such a wide range of opportunities for Full Electric Vehicle (FEV) to develop. The different choices to use computing to integrate FEV in our future European Smart City ecosystem are within our reach, here and now. This paper presents how to model the mobility in our future cities in order to make FEV interoperate with the smart grid and what an efficient way to control and manage the energy availability from a centralized information system would be.