

COMM Annual Research Report 2016/2017

Head of the Group research report

Multimedia Communications Group (COMM) started its activities in 2004, and nowadays is composed of a group of 7 researchers, focusing its research lines on multimedia systems and QoE. During the last year 2016/2017 the group has continued with its work lines focused on the distribution of multimedia content through the DASH protocol; developing new functionalities for multimedia systems based on DRM and cross-layer techniques; providing new contributions focused on energy consumption for the video transport in adhoc networks and its integration in IoT (Internet of Things) and starting new lines such as the integration of protocols for broadcast distribution.

These lines of action have been articulated through the execution of research projects, the presentation of a thesis and scientific publications in conferences and journals.

In addition, in order to promote the main activities of the group, the webpage has been updated, with a new look and field and new sections. For instance, a dedicated page for each research and development line, or a new open source section that contains libraries developed by the group. Also, promotion tasks through social networks (Facebook, Twitter and Youtube) have been carried out.

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

1.- Project activities

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

Energy consumption in ad hoc networks

Research carried out about energy consumption has meant great improvements on the experience the group has in ad hoc networks. A new algorithm to reduce energy consumption in ad hoc networks has been developed and tested, resulting in several international publications. Not only have studies led to significant scientific results but also to an implementation of a real testbed using actual devices.

These developments have been directly applied within the framework of Riegonets project, which is a thematic network for the adoption of ICT in agricultural environments. Moreover, the knowhow acquired has been reflected in an agreement established with a company interested in ad hoc network technologies for video and voice communications.

The results obtained during this year have culminated with the reading of the doctoral thesis:

- S. González, "Diseño de un esquema cross-layer para el balance entre eficiencia energética y calidad de servicio en la transmisión de tráfico multimedia en redes ad hoc," Doctoral thesis supervised by P. Arce and J. C. Guerri, Universitat Politècnica de València, May 2017.

A summary of the thesis presentation (in Spanish) can be found in:
<https://www.youtube.com/watch?v=3o2NR2DfAFw>.



Home page of the COMM website



Thesis defence of Santiago González

Adaptive video through MPEG-DASH

This year we have gone over a big milestone in DASH adaptation algorithms. We have proposed a new algorithm called Look Ahead, that takes into account the information of the size of the forthcoming segments. This information has been scorned for a long time based on the encoding habits of the media distributors. Nevertheless, all videos have variable bitrate. The difference is that videos that have been encoded with a target bitrate will necessary have quality changes while the videos that have been encoded with constant quality will have variable bitrate. 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 it for the ExoPlayer library. The video player behind the YouTube App in the Android platform. The work is under review process. Once this work will be published we will offer it to be included in the ExoPlayer Open Source Project so everyone can enjoy better quality playback with avoiding stuttering.

Adaptive streaming for 3D video

During this year, different tests were performed to evaluate the behavior of an adaptive streaming system over HTTP and how it affects the quality of 3D video. For this purpose, different channels of transmission with variable bandwidth have been emulated using the NetEm tool, which allows to modify and restrict the server output bandwidth (also the delay or packet loss). Also, as a previous step, a comparative study of the main standards in the field of coding of stereoscopic video sequences (3D) were carried out using, in addition to the free software ffmpeg-libx264 and ffmpeg-libx265, the reference encoders HEVC test Model (HM 16.7) for HEVC encodings of the separate and multi-view

HEVC views, and JM19.0 and JMVC 8.5 for the AVC encodings seen separately and multi-variant MVC-AVC, respectively. The comparison of the encoders has been made taking into account aspects such as coding time, and the efficiency in the reduction of bitrate in relation to different objective quality parameters such as PSNR (Peak Signal-to-Noise Ratio) and SSIM (Structural Similarity).

These results help to keep on developing this research line, and will be presented in the III Workshop QoS and QoE in Multimedia Communications (III QQCM 2017) programmed in the XIII Jornadas de Ingeniería Telemática (JITEL) in September 2017.



QoE assessment system for 3D video.

Video streaming over mobile wireless ad hoc networks

Taking advantage of the elongated experience of the group in ad hoc networks, new routing algorithms have been proposed and tested, resulting in multiple publications on international

journals. These algorithms have been presented as enhancements to the routing protocols used in ad hoc networks with the aim of improving the quality of video streaming services.

These routing algorithms work in a cross-layer manner, meaning that they can obtain relevant parameters from network and transport layers and take advantage of them in order to improve the quality of video flows. This is achieved by means of the adaptation of the video bitrate, either using scalable video coding or simply pre-encoded variants of the same video.

Reliable multicast transmission over communication networks

In this line, we have started to study 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: CONECTMOV - Plataforma avanzada de conectividad en movilidad (CDTI IDI-20150126)

Webpage of the project:
<http://www.azimutbussolutions.com/>



Cloud server providing TV/radio services

Summary of the project: The objective of the project is the creation of an enabling system for high quality connectivity in public transport (bus, train and ferry) to allow access to live TV and Internet content, improving the quality and comfort of the traveller, and using advanced coding, streaming, caching and monitoring technologies.

The project develops a platform to provide high-quality Internet access and television and on-demand entertainment services, as well as travel information, security notices, etc. to bus, train and ferry users. The solution encompasses the development of an embedded routing system that has several wireless multi-operator interfaces. Through a quality analysis of the links based on the monitoring of their performance in real time, it is possible to dynamically establish the interfaces with the highest quality link at any time and redirect and balance the traffic through them. Users can access the Internet and other multimedia services (videos, TV) from their mobile devices. To manage and guarantee higher quality, the platform can pre-store and distribute content in the wireless network of the vehicle, after being recorded and adapted for transmission, through processes in the cloud. The project, which started in March 2015, finished last year. During the last year, the integration of all the modules that composed the architecture was carried out as well as the evaluation.

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

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. During 2017, the COMM has helped to prepare the proposal and the project has finally started in July 2017 and it will finish in December 2018.

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

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 (in particular musicals: distributed technological concerts, virtual accompaniment, etc.) and analysis of sound scenes for detection, location and classification of events and scenes, and development of systems to aid hearing and improve intelligibility.

On the other hand, the generic concept of “smart sound processing” defines the intelligent generation and/or acquisition of sound signals by means of potentially heterogeneous, distributed and mass-used signal processing/computation devices, together with network intelligence, to manage data, make decisions, and configure capture/playback/computing devices. In summary, the present project addresses the design and implementation of “smart sound processing” of: products, systems, programs and signal processing and communications algorithms, using state-of-the-art architectures, advanced computing and efficient communications. During the first year of the project it has been possible to create a network of distributed nodes with the platform Raspberry Pi 3 as the main element in the node. It has been developed ad hoc network of sensors that captures audio and processes it on the node itself. The result of the audio processing is the calculation of the sound pressure level. This value is transmitted by the network until reaching the gateway node. This node is responsible of uploading the data to the server, which shows the power levels sent by the network in the webpage:
<https://sspressing.iteam.upv.es/>

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

Name of the project: *Ambiental Sensor: Plataforma para monitorización ambiental basada en IoT.*

Summary of the project: The main objective of the project is the development of a web platform for environmental monitoring based on IoT. The platform is designed to collect and store geo-referenced data in real time from different distributed sensors and display them in user-friendly interfaces. The platform allows real-time monitoring of environmental systems or agricultural environments and promptly detect faults so that immediate corrective measures can be taken, minimizing the detrimental effects or losses caused by any incidence. The demonstrator focuses on the monitoring of environmental sensors, but in future developments the nodes could be equipped with other sensors for applications in different scenarios (video, acoustic sensors, etc). In fact, although the main application is environmental monitoring, the platform architecture is generic enough to allow the future development of a broader range of environmental monitoring applications in different sectors, such as the industrial sector and the Smart Cities.

Funding entity: Cátedra Telefónica Universitat Politècnica de València.

Name of the project: *Riegonets – Aplicaciones para comunicación y control de redes de riego sobre redes y sistemas de comunicación inalámbricos. Red temática riegonets para la apropiación y uso de TIC en el sector agrícola.*

Webpage of the project:
<http://www.riegonets.org>

Summary of the project: The objective is to facilitate the interaction, cooperation and transfer



3rd meeting of the SSPressing Project in Gijón

of knowledge between research groups, companies and users on the applications and telematic services supported by wireless communication networks and information systems that support the monitoring and control of irrigation networks in order to propose and implement joint R&D projects that contribute to the application of ICTs in the agricultural sector in the Ibero-American region.

In Latin America there is a high potential and experience in research and development in the Information Technology and Communications sector. Many of the research groups are transferring their knowledge to the productive sector of each region. In Latin America, the agricultural sector needs to incorporate technology to accelerate its productive processes to compete with major powers in the scenario of free trade agreements. The incorporation of applications and telematic services in the agricultural sector can satisfy part of the needs of the sector.

In order to incorporate ICT into the agricultural sector, there is a need for interaction, cooperation and knowledge transfer among researchers in the ICT sector, researchers, companies and users in the agricultural sector to find mechanisms for technological incorporation in an accessible and low cost manner that meet specific needs.

Funding entity: CYTED, Programa Iberoamericano de Ciencia y Tecnología para el Desarrollo.

2.- Research results

2.1.- Featured publications

- **SVCEval-RA: an evaluation framework for adaptive scalable video streaming.** W. Castellanos, J. C. Guerri, P. Arce, *Multimedia Tools and Applications*, vol. 76, no. 1, pp. 437-461, 2017.

Multimedia content adaption strategies are becoming increasingly important for effective video streaming over the actual heterogeneous networks. Thus, evaluation frameworks for adaptive video play an important role in the designing and deploying process of adaptive multimedia streaming systems. This paper describes a novel simulation framework for rate-adaptive video transmission using the Scalable Video Coding standard (H.264/SVC). Our approach uses feedback information about the available bandwidth to allow the video source to select the most suitable combination of SVC layers for the transmission of a video sequence. The proposed solution has been integrated into the network simulator NS-2 in order to support realistic network simulations. To demonstrate the usefulness of the proposed

solution we perform a simulation study where a video sequence was transmitted over a three network scenarios. The experimental results show that the Adaptive SVC scheme implemented in our framework provides an efficient alternative that helps to avoid an increase in the network congestion in resource-constrained networks. Improvements in video quality, in terms of PSNR (Peak Signal to Noise Ratio) and SSIM (Structural Similarity Index) are also obtained.

DOI: 10.1007/s11042-015-3046-y

- **Simulation and Experimental Testbed for adaptive video streaming in ad hoc networks.** S. González, W. Castellanos, P. Guzmán, P. Arce, J. C. Guerri, *Ad Hoc Networks*, vol. 52, pp. 89-105, 2016.

This paper presents a performance evaluation of the scalable video streaming over mobile ad hoc networks. In particular, we focus on the rate-adaptive method for streaming scalable video (H.264/SVC). For effective adaptation a new cross-layer routing protocol is introduced. This protocol provides an efficient algorithm for available bandwidth estimation. With this information, the video source adjusts its bit rate during the video transmission according to the network state. We also propose a free simulation framework that supports evaluation studies for scalable video streaming. The simulation experiments performed in this study involve the transmission of SVC streams with Medium Grain Scalability (MGS) as well as temporal scalability over different network scenarios. The results reveal that the rate-adaptive strategy helps avoid or reduce the congestion in MANETs obtaining a better quality in the received videos. Additionally, an actual ad hoc network was implemented using embedded



Meeting of the Riegonets network in Valencia

devices (Raspberry Pi) in order to assess the performance of the proposed adaptive transmission mechanism in a real environment. Additional experiments were carried out prior to the implementation with the aim of characterizing the wireless medium and packet loss profile. Finally, the proposed approach shows an important reduction in energy consumption, as the study revealed.

DOI: 10.1016/j.adhoc.2016.07.007

- **Performance evaluation of scalable video streaming in mobile ad hoc networks.** W. Castellanos, J. C. Guerri, P. Arce, *IEEE Latin American Transactions*, vol. 14, no. 1, pp. 122-129, 2016.

The development of video streaming services on wireless ad hoc networks is a challenge task as a consequence of different limitations such as bandwidth-constrained, variable capacity links and energy-constrained operation. Moreover, the dynamic topology of nodes causes frequent link failures and high error rates. We propose in this paper a performance evaluation of the scalable video streaming over mobile ad hoc networks. In particular, we focus on the rate-adaptive strategy for streaming scalable video (H.264/SVC). In order to provide QoS mechanisms in the routing process, a new routing protocol is introduced. This protocol estimates the available bandwidth value, which is sent to video source in order to adapt the bit rate during the video transmission. We also propose a simulation framework that supports evaluation studies for scalable video streaming. In the simulation experiments, SVC streams with combined scalability (quality and temporal scalability) were used. As quality scalability method, we used Medium Grain Scalability (MGS). The results reveal that the rate-adaptive method helps avoid or reduce the congestion in MANETs obtaining a better quality in the received videos.

DOI: 10.1109/TLA.2016.7430071

- **A QoS-aware routing protocol with adaptive feedback scheme for video streaming for mobile networks.** W. Castellanos, J. C. Guerri, P. Arce, *Computer Communications*, vol. 77, pp. 10-25, 2016.

One of the major challenges for the transmission of time-sensitive data like video over mobile ad-hoc networks (MANETs) is the deployment of an end-to-end QoS support mechanism. Therefore, several approaches and enhancements have been proposed concerning the routing protocols. In this paper we propose a new QoS routing protocol based on AODV (named AQA-AODV), which creates routes according to application QoS requirements.

We have introduced link and path available bandwidth estimation mechanisms and an adaptive scheme that can provide feedback to the source node about the current network state, to allow the application to appropriately adjust the transmission rate. In the same way, we propose a route recovery approach into the AQA-AODV protocol, which provides a mechanism to detect the link failures in a route and re-establish the connections taking into account the conditions of QoS that have been established during the previous route discovery phase. The simulation results reveal performance improvements in terms of packet delay, number of link failures and connection setup latency while we make more efficient use of the available bandwidth than other protocols like AODV and QAODV. In terms of video transmission, the obtained results prove that the combined use of AQA-AODV and the scalable video coding provides an efficient platform for supporting rate-adaptive video streaming.

DOI: 10.1016/j.comcom.2015.08.012

- **Implementación de un banco de pruebas para redes inalámbricas ad hoc empleando plataformas Raspberry Pi y Node.js.** W. S. González, P. Arce, J. C. Guerri, in *Proc. of the Simposium Nacional de la Unión Científica Internacional de Radio (URSI)*, Madrid (Spain), Sep. 2016, article S3.2.2.

This paper presents the design and implementation of an experimental testbed for the evaluation of ad hoc wireless networks, using the IEEE 802.11 standard. Specifically, we implemented a set of 10 ad hoc nodes using low cost hardware platforms (Raspberry Pi) with embedded Linux. Also, an application based on Node.js was developed for the control of the experiments. In particular, we defined a set of messages using the socket.io library for the remote activation of process on the platforms as well as in order to generate requests about the traffic metrics and the status of a test. Additionally, the current sensor INA219 was installed in each node for the analysis of the energy consumption demanded by the wireless cards. Finally, we present some results of experiments performed to describe the effect of the data rate configured on the wireless card in relation with the energy expenditure and the effective throughput in a multi-hop scenario.

- **Energy optimization for video monitoring system in agricultural areas using single board computer nodes and wireless ad hoc networks.** S. González, T. R. Vargas, P. Arce, J. C. Guerri, in *Proc. of the Symposium on Signal Processing, Images and Artificial Vision (STSIVA)*, Bucaramanga (Colombia), Aug. 2016.

This paper presents the design and implementation of a set of prototype nodes that have the ability to establish communication links in ad hoc mode. The prototypes were implemented using low cost, single board computers with embedded Linux (Raspberry Pi devices). The implemented stations aim to set a wireless sensor network for the capture of variables applied to agricultural environments. In particular, a camera module has been included on a node for remote video monitoring of farming zones, and also a GPS module for the capture of geolocation information. Nodes can be accessed remotely by means of the developed web interface. The routing process between nodes is carried out using the S-OLSR mechanism (OLSR modification) in order to set up routes taking into account the energy limitations as well as the location of each device in the topology. Results describe the contribution of this work to the design of monitoring applications on agricultural zones by means of the deployment of autonomous ad hoc nodes and energy routing optimization.

DOI: 10.1109/STSSIVA.2016.7743350

- **Simulation and testbed evaluation for optimizing energy consumption in ad hoc networks based on OLSR protocol.**

S. González, P. Arce, J. C. Guerri, in Proc. of the International Joint Conference on e-Business and Telecommunications (ICETE), Conference on Wireless Networks and Mobile Systems (WINSYS), Lisbon (Portugal), vol. 6, Jul. 2016, pp. 129-136.

This paper presents a proposal to optimize energy consumption in ad hoc networks based on the OLSR protocol. This approach focuses on the set up of routes with less congestion level and higher energy capacity. Therefore, in addition to the remaining energy of nodes, a new metric is introduced, the strategic value, which reports the importance of a specific node in the network based on the numbers of neighbors it has. In order to obtain valuable results, the evaluation was performed in a simulation environment (NS3) and on a real testbed. In that sense, an actual ad hoc network was implemented using embedded devices (Raspberry Pi). Results show a decrease in energy consumption, especially in zones with the highest device density, as well as an increase of the time of operation for nodes with higher amount of neighbors. Additionally, the performed evaluation shows a positive effect in the quality of traffic flows, avoiding route breakages and packet losses.

DOI: 10.5220/0005955301290136