Towards QoE-driven service configuration strategies for multi-party mobile video conferencing

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***Abstract*—Video conferencing is becoming increasingly popular in both leisure and business contexts, offering opportunities to increase productivity, reduce costs, and share information in real time. High resolution displays, front and rear cameras, along with high speed Wi-Fi and 3G/4G/LTE networks enable such services for an increasing population of smartphone users. On the other hand, new technologies, such as WebRTC, make video conferencing free and available anywhere at any time. Dynamic wireless networks and limited mobile end user devices require dynamic service adaptation strategies to achieve acceptable perceived quality. The main objective of this research is to identify and quantify the impact of various encoding, system, and network influence factors on QoE during multi-party mobile video conferencing, with the aim to work towards QoE-driven service adaptation strategies.**

I. Introduction

The landscape of classic communications has notably changed over the past years with the proliferation of high-end video-enabled mobile devices. In October 2016, mobile and tablet Internet usage was reported to exceed desktop usage for the first time worldwide [1]. While video conferencing was previously both expensive and often quality impaired, nowadays video conferencing services are expected to be secure and easy to manage, reliable, available for every user, network connectivity, end user device, and context.

In a mobile environment, with limited and variable resource availability, video conferencing applications should be capable of adapting the real-time audiovisual content streaming to current network and device conditions so as to secure a high level of Quality of Experience (QoE). Video conferencing assessment requires evaluation by all participants in a conference. Standardized subjective quality assessment methods for several elements used in two-way communication, such as speech, codecs, characterized by bit rate (fixed or variable), frame rate, resolution, noise cancellation, background noise, synchronization and transmission impairments are well establish in [2-4]. However, methods for multi-party conversational and interactive video service quality assessment in mobile environments are not completely standardized up to day [4]. Regardless of system complexity, the service has to be simple and participants should be able to use it without intense training. Features and functions must be useful and access seamless, especially for a business context. To reach acceptable QoE, service providers have to be able to manage and control resources efficiently.

Therefore, we conducted five studies with experiments involving subjective end user assessments and address the following research questions [5], [6]:

- What is the degree of impact of different smartphone configurations on QoE (with devices differing in CPU, display size, and resolution)?
- How significant are additional functionalities available on the conferencing web page to end users?
- When considering a three-way video call where each participant sees three video streams (the other two participants and their own video stream), what video resolutions are needed to achieve satisfactory QoE under different bandwidth constraints and taking into account device screen size?
- What is the impact of bandwidth restrictions on conversational interaction in a three-way video call established using smartphone devices?
- How does the Google Congestion Control algorithm handle packet loss in WebRTC (Web Real-time Communications) and what effects does this have on QoE?
- What is the influence of packet loss on audio and visual quality in a three-way mobile video call?

The main objective of the studies is to define a relevant QoE model for mobile multi-party videoconferencing and to provide the basis for improving service quality with service adaptation strategies.

II. Methodology and Current Results

Experiments, summarized in Table 1, included subjective end user assessments with the goal being to investigate the impact of different smartphone configurations, topology and video parameters setup on QoE under symmetric (to eliminate the impact of certain parameters) and asymmetric (trying to create more realistic scenario) conditions. Results of the first two studies are published in [1] and [2], while the results from case studies 3-5 are still being analyzed.

TABLE I Overview of conducted subjective studies for three-party mobile video conferencing

Case study	**Participants**	**Number of tests**	**Topology**	**Media Server**	**End user devices**	**Operating system**	**Browser**	**Parameters variation**	**Goal**
1. March 2015 [1]	18 male 12 female	120	P2P	Kurento Appear.in Talky vLine	Samsung S5, S3, LG G3 3 x laptop	Android 4.1.2 Android 4.4.2 Windows 7, 8.1	Chrome 40.0.2214.109	None	Explore possibility of three-party video on smartphone
2. April 2016 [2]	14 male 13 female	108	MCU	Licode	3 x Samsung S6	Android 6.0.1	Samsung internet browser 4.0.10-53	Video resolution, bitrate	Influence of different video parameters on MOS and traffic load
3. October 2016	13 male 11 female	96 for S5 96 for S3	MCU	Licode	3 x Samsung S5 3 x Samsung S3	Android 6.0.1 Android 4.3	Samsung internet browser 4.0.30-24	Video resolution bitrate	Impact of smartphone configuration on MOS
4. March 2017	16 male 14 female with 1 fixed user per each group	120	MCU	Licode	3 x Samsung S6	Android 6.0.1	Chrome 55.0.2883.91	Video resolution, bitrate, frame rate, packet loss	Analyze GCC behavior in case of a packet loss
5. May 2017	21 male 6 female	72	MCU	Licode	3 x Samsung S6	Android 7.0	Chrome 57.0.2987.132	Video resolution, bitrate, frame rate	Determine lowest QoE acceptable configuration

In each experiment participants used the same multi-party video conferencing service in a realistic home environment setting, leisure context under controlled network conditions, (Figure 1). The selected participants had no special AV knowledge. Participants were acquaintances, therefore a natural conversation was chosen for a task. The test schedule consisted of groups with 3 participants under different conditions, each lasting 3 minutes. With respect to limited smartphone processing power, results in Study 1 showed that P2P topology in multi-party scenarios impose too much burden on the end user device. To obtain acceptable QoE, a Multi-control Point Unit (MCU) was subsequently used. Furthermore, higher video resolutions and bitrates might bring better video quality but also require, in this case unavailable, processing capabilities. On the other hand, higher resolutions and bitrates generate significantly more traffic, flooding the network with unnecessary load. Scenarios with highest resolution in case Study 2 scored the lowest QoE in all cases. Since it is possible to achieve high QoE with a setup lower than 600kbps bitrate, resolution 640x480, and frame rate 15, we recommend such a setup as an upper threshold for three-way video calls on smartphone devices. As a next step, we aim to determine threshold service configurations (in terms of video encoding parameters: resolution, bitrate, and frame rate) for achieving acceptable QoE.

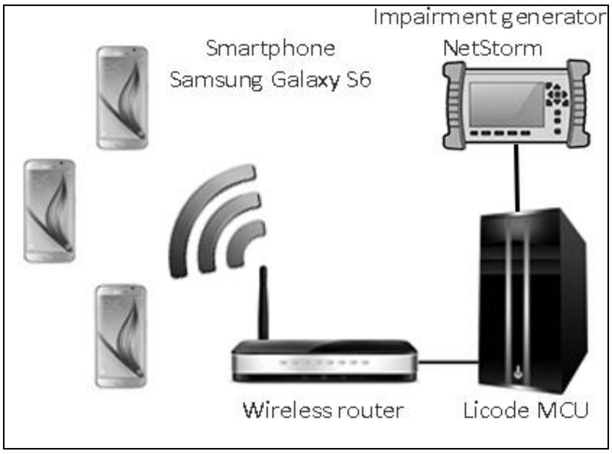

Fig. 1. System set-up over LAN in Case Study 4.

III. CONCLUSION

Providing high QoE for multi-party video conferencing remains challenging, with a need for service adaptation strategies considering mobile device resources and current network conditions. Our methodology is based on conducting empirical user studies to correlate objective network and device QoS factors with subjective QoE scores, thus aiming for deriving QoE-aware service adaptation strategies.

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