Towards Cooperative QoE Management Schemes for Multimedia Applications

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***Abstract*— The end-to-end Internet service delivery chain includes many different actors trying to provide the optimal Quality of Experience (QoE) to their users. However, lack of cooperation between multiple actors makes identifying the root cause of QoE impairments, and thus finding a solution, a challenging task. A key goal in the scope of this research is to specify cooperative QoE management schemes between service/cloud and network providers, while taking into account incentives, business models, and potential regulatory issues.**

Keywords—cooperative QoE management; cross-layer; multimedia

I. Motivation and Current Results

In today's Internet, many players are involved in end-to-end service delivery: content providers, cloud providers, network operators, etc. All of them aim to meet users' needs and expectations in terms of both Quality of Service (QoS) and Quality of Experience (QoE) [1]. To achieve that goal, they employ various QoE management strategies. Today, most solutions focus on either application management or network management [2]. Application management solutions implement strategies on the server and client terminal, at an application level, making it possible to adapt the application to network conditions measured by client devices. QoE-driven network management solutions mostly focus on resource allocation decisions that maximize user-perceived quality [3][4]. All of these solutions rely on underlying specific QoE models to calculate QoE based on QoE-relevant factors measured in the network or on client devices.

Due to the widespread encryption of OTT traffic (e.g., YouTube, Netflix, Skype, etc.), it is challenging for network providers to obtain insight into application performance as perceived by end users. Network operators are thus aiming for application-layer monitoring solutions that will enable QoE-driven network management schemes. In our previous studies, we have proposed a solution for YouTube QoE estimation based on the analysis of encrypted network traffic [5]. We have developed a system called YouQ which includes tools for monitoring and analysis of application-layer KPIs and corresponding traffic traces, and the subsequent use of this data for the development of machine learning models for QoE estimation based on traffic features. The system was tested in a laboratory environment (Fig. 1) and the results show that up to 84% QoE classification accuracy could be achieved using only features extracted from encrypted traffic. While these are promising results, the question still remains what potential gains may be achieved if cooperative efforts are established between OTT providers and network operators.

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II. Research Challenges and Methodology

Due to a lack of cooperation and information exchange between actors involved in service delivery, it is still challenging to achieve cross-layer QoE management solutions. Future research will focus on resource allocation and service adaptation algorithms targeting different optimization strategies and taking into account multiple stakeholder perspectives. The following challenges will be addressed (Fig. 2):

Incentives for cooperation. QoE-relevant information can be collected all along the service delivery path (Fig. 3). Combining this information has the potential of enhancing and optimizing the service delivery and resource utilization efficiency. From a business oriented point of view, there is a need for business models to define relationships between actors in the service-delivery chain.

Technical solutions. Studies are needed to define functions, information exchange interfaces, and protocols for cooperative QoE management. The Software Defined Networking (SDN) paradigm is a promising solution in this direction.

Regulatory issues. The implications of network neutrality regulation on potential QoE management and control solutions need to be considered.

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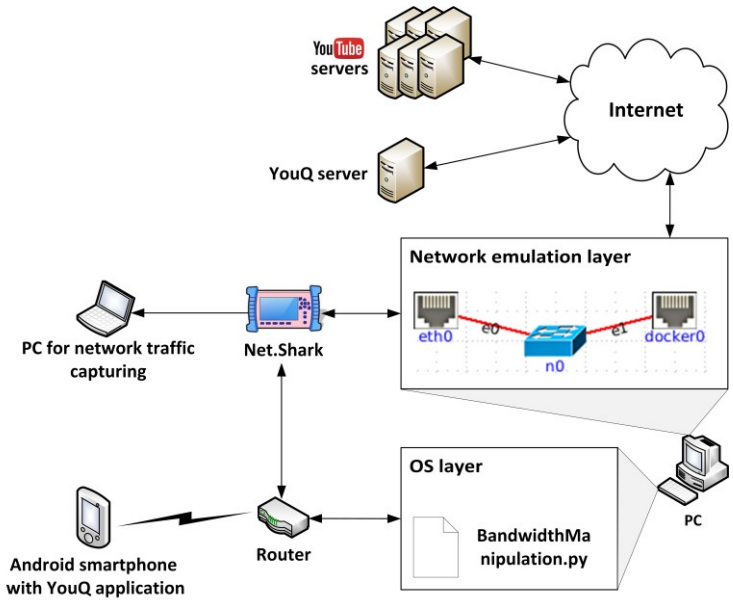

Fig. 1. Testbed for measuring and evaluating YouTube application-layer KPIs

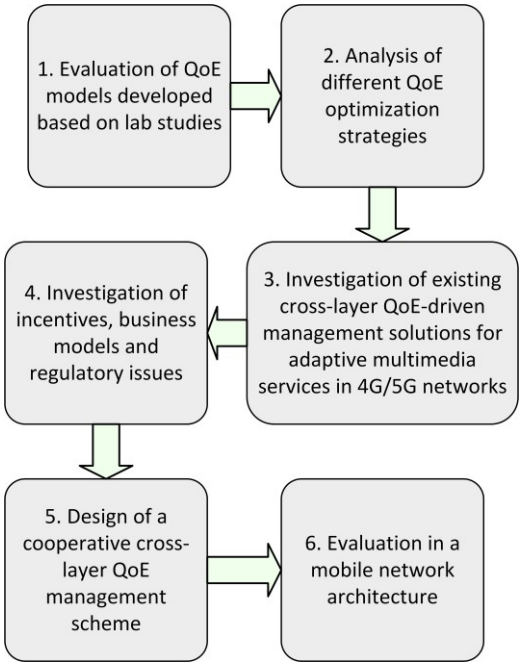

Fig. 2. Research methodology

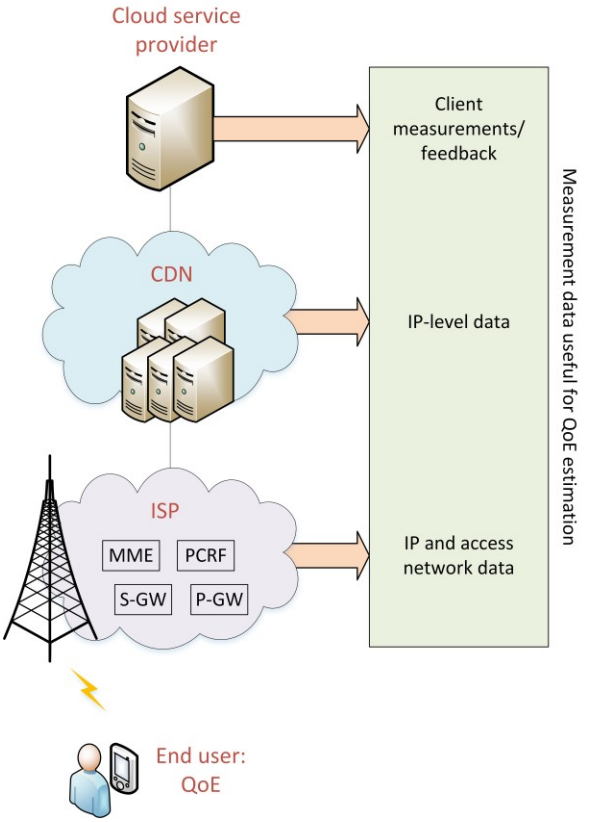

Fig. 3. QoE-relevant information available along the end-to-end service delivery path (adapted from [1])