Future Network & MobileSummit 2012 Conference Proceedings
Paul Cunningham and Miriam Cunningham (Eds)
IIMC International Information Management Corporation, 2012
ISBN: 978-1-905824-30-4

A global customer experience management architecture

Antonio CUADRA-SÁNCHEZ[1], Mar CUTANDA-RODRÍGUEZ[2], Ismael PÉREZ-MATEOS[3], Andreas AURELIUS[4], Kjell BRUNNSTRÖM[4], Jukka-Pekka LAULAJAINEN[5], Martín VARELA[5], Jorge E. LÓPEZ DE VERGARA[6]

[1]Indra Sistemas S.A., Parque Tecnológico de Boecillo, Valladolid, 47151, Spain
Tel: +34 983 100 818, Email: acuadra@indra.es
[2]Indra Sistemas, S.A., Anabel Segura 7, Madrid, 28108, Spain
Tel: +34 91 480 7614, Email: mdcutanda@indra.es
[3]DYCEC, S.A. Torres Quevedo 1, Tres Cantos, 28760, Spain
Tel: +34 91 803 74 44, Email: iperez@dycec.com
[4]Acreo NETLAB, Electrum 236, 16440 Kista, Sweden
Tel: +46 8 632 77 00, Email: firstname.lastname@acreo.se
[5]VTT Technical Research Centre of Finland, Oulu, Finland
Tel: +358 20 722 111, Email: firstname.lastname@vtt.fi
[6]Naudit HPCN, Calle Faraday, 7, Madrid 28049, Spain
Tel +34 630 569 106, Email: jorge@naudit.es

Abstract: The quality of experience (QoE) is one of the main research lines in ITC industry, which seeks to manage quality as perceived by users. This document analyzes and describes requirements of a QoE driven management system architecture, which has been designed in the Celtic IPNQSIS project. The architecture is grouped into different levels: Data acquisition level, Monitoring level and Control Level. Each level comprises a specific set of capacities, such as Data collector, or Traffic Monitor amongst others. The architecture described in this paper constitutes the guidelines of the IPNQSIS project in terms of a QoE ecosystem that will settle the basis of global customer experience management architecture.

Keywords: QoE, QoS, Monitoring, OSS, network management, probes.

1. Introduction

Quality of experience (QoE) is a new paradigm of service excellence beyond Quality of Service (QoS), which is based on indicators that are more related to network infrastructure rather than customer experience. On the one hand QoS indicators, such as packet delay and loss, are critical considering the increased interest in the use of conferencing applications: videoconferencing, internal/external webinars/webcasts, etc. On the other hand, the QoS metrics correlate poorly with the user experience. Therefore, there has been an increasing interest in models and measures that could predict the user experience of a service. This is usually referred to as Quality of Experience, which quantifies the user experience, that is, how satisfied he or she is with a service. Although the experience of a single user is very subjective in nature, the mean experience of a panel of users has turned out to be very stable, which means there is good hope to be able to derive objective measure to predict it. The ability to measure QoE will give the operator valuable information about the network's performance and, more importantly, the overall level of customer satisfaction.

This paper summarises the current work carried out in Celtic IPNQSIS project, which is related to the specification of the architecture that will be implemented in next stages of the project. The components of the Customer Experience Management architecture that will be described in next subsections are QoE Data sources, Monitoring and Management system.

1.1 IPNQSIS overview

The focus of IPNQSIS (IP Network Monitoring for Quality of Service Intelligent Support) project is to develop continuous monitoring systems to study the behaviour of QoE through the analysis of network and service performance and their impact on end customers' experience. The outcomes of this project will provide crucial knowledge for designing future multimedia networks and systems for intelligent network control to cope with QoE and SLA (Service Level Agreement) in a network-centric approach, with a lower cost compared to traditional solutions operating in border devices. This approach for network operation will be scalable and robust. IPNQSIS will extend IP traffic modelling, issued from previous Celtic projects, such as TRAMMS (Traffic Measurements and Models in Multi-Service Networks) [1], and a smart combination of traffic measurement to implement real-time troubleshooting and quality degradation measurements in multi-domain scenarios.

An important novelty of IPNQSIS is that QoE will be taken up as the main driver for building a complete Customer Experience Management System (CEMS). The QoE input will come from multi-technology network devices (i.e. mainly probes) that will be developed and evaluated in the project. Deep packet and deep flow inspection techniques will be applied to monitor and analyze IP traffic in access networks in order to propose new techniques for distribution of multimedia content while maintaining acceptable levels of QoE. In summary, algorithms and measurements devices will be developed and tested to provide feedback to the control system. Furthermore, cognitive software will be developed to combine QoE-QoS correlation analysis with network operation and traffic modelling studies. All these elements constitute the Customer Experience Management (CEM) that is the main outcome of the project. Future activities inside this project will implement the different architectural modules described in this paper.

The impact of IPNQSIS spans network operators and service providers who will be able to develop SLA more efficiently. Also higher level European agents will have access to tested traffic modelling and other key elements for better understanding of QoS issues in a multi-operator scenario. In summary, the dissemination and exploitation of IPNQSIS results is expected to influence and promote the European Future Internet platform and enhance intelligent network development for its wide-spread adoption in a disaggregated market.

2. Customer Experience Management

As stated bellow, Quality of Experience (QoE) is an emerging term that arises as an evolution of the Quality of Service (QoS) as a measure of the excellence of a service Interest in QoE has risen significantly over the past years, as a natural extension of QoS. This is useful, as the end users' opinions on the quality of a given service is what will determine whether they use it or not, and hence whether in the end are willing to pay for it or not.

In contrast to traditional network QoS, where performance indicators can be objectively specified and measured, QoE is based on subjective evaluations, and are more dependent on the application considered. This adds a significant complexity in that it has to understand and predicatively model the human experience of quality. Furthermore, this process is not yet fully understood. It was suggested in [2] for image quality applications that it is very difficult or may be not possible to predict the image quality directly from technology variables e.g. resolution, colour depth. Instead, he proposed that step wise go from measurements of physical variables, through perceptual models predicting "nesses" e.g. brightness, colourfulness, naturalness, etc., and based on these variables predict image quality. Similarly, considering the subjective and application-dependent factors involved in understanding QoE, it is not likely to have an immediate correspondence between network QoS performance and the users' perception of a service's quality, and hence its value. It is clear, however, that a good understanding of the QoE is essential for better optimization of targets, both at the network and application levels, since any quality gain obtained will be related to the user's experience rather than network QoS that may not lead in the right direction.

It is because of the above, that within IPNQSIS we aim at optimizing the network performance guided by QoE measurements and estimations. This way, the effects of the control operations realized on the network will have a maximal impact on the actual service quality experienced by the users.

2.1 CEMS (Customer Experience Management System) architecture

This section describes the design of the overall architecture to manage the customer experience. There are three separate levels (see Figure 1) that are described in the following subsections: Data Acquisition Level, Monitoring Level and Control Level, each one composed of different components. This reference architecture has been devised to define next generation CEMS, although not all components will be covered inside IPNQSIS scope.

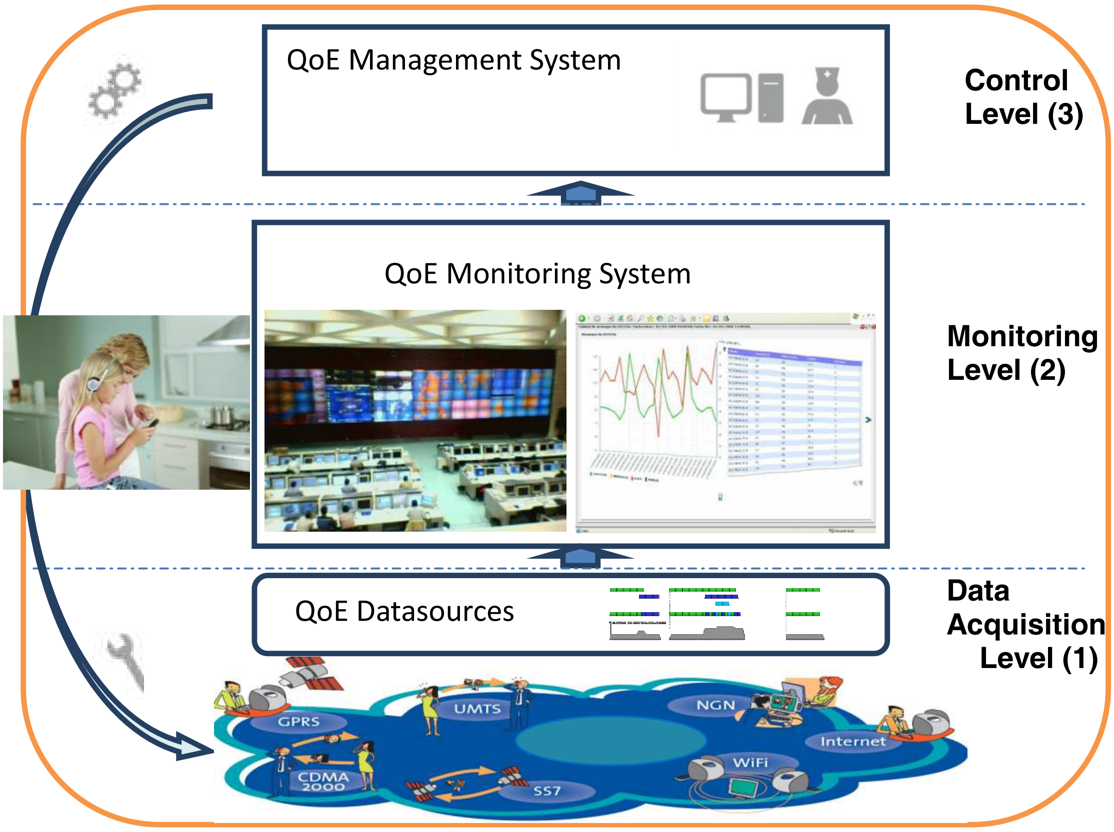

Figure 1: High Level CEMS Architecture

This architecture is modular and open to enable easy addition or removal of components, system parameters and features.

1. Data acquisition level (QoE Data Sources): This level gathers the information of the different datasources: active and passive probes, and other probing devices technologies such as embedded agents or Deep Packet Inspectors.

2. Monitoring level (QoE Monitoring System): The input from the datasources is correlated, empowered and transformed to supervise both QoS and QoE. This level comprises all the components that transform basic indicators into customer experience metrics. On the other hand a set of generic GUI tools are also considered in this level.

3. Control level (QoE Management System): This level handles the QoE delivered to the customers and is fed back from the monitored level in order to act proactively into the network to improve customer satisfaction.

Next sections explain each of these levels.

3. QoE Data Sources

Probe systems are becoming an essential tool to monitor Customer Experience as they gather traffic from real users and may reproduce their behaviour [3]. These devices can be placed anywhere on the network, thus providing greater versatility and flexibility than other systems based on mediation techniques, such as nodes and other network elements, and alternatively acting as real users installed into devices. The data obtained from probes, due to the deep detail with which they are developed, provide a real vision of the network behaviour and experience of services by customers. These systems allow measuring the quality in terms of customer satisfaction and optimizing service levels across the value chain.

Basically, there are two types of probes: active and passive ones. Active probes inject traffic in the network and send requests to services servers as an end user does. They provide an end-to-end view. On the other hand, passive probes do not as since they sniff the packets from the different services. They are able to provide a view of any part of the network at any protocol level.

Combining the information provided for both types of probes can offer a new vision of the telecommunication perspective. The whole solution covers the centralized monitoring of the services offered to customers from their point of view: Customer Experience. The system architecture deals with:

- Subsystems that are devised to interact with the network and the different services by simulating the behaviour of real customers
- Remote systems, located next to the passive probes installed on the network, which receive information from them. These data would be initially pre-processed in the remote systems, and later on collected in a central subsystem in charge of the final processing.
- Central system where the results are stored in a database and a user interface is provided.

Traffic collected through probes, due to the detail with which they are elaborated, provides a real vision of the behaviour of the network and the experience that users have of the services [4]. Therefore, this architecture will allow SPs to guarantee the service and satisfy customer needs throughout the processed information. In addition, these systems of massive traffic capture constitute the main input for Service Quality Management/Service Level Management (SQM)/(SLM) services that are beginning to be established in main telecommunications networks. These systems - that are aligned with service assurance and customer care processes - allow operators to improve, on one hand, the quality in terms of customer satisfaction and optimization of service levels throughout the value chain. And on the other hand, to mitigate the risks which operators face guaranteeing the integrity of the network and the services. Flexibility and multiprotocol capabilities are two basic characteristics for monitoring and management through probes of new generation networks (NGN, UMTS, IMS, etc.) and new services as VoIP, IPTV, mobile TV, quadruple play offer, etc. Development of these technologies has been focused on a criterion of scalability based on an open architecture that allows monitoring of new emerging technologies. In addition it is independent of the services that supervises, and provides the customer point of view as far as quality and availability of all offered services.

3.1 Passive Probes

Passive probes will play a big part in the CEMS. They will be in charge of reading packets from network interfaces, analyzing them at different layers and generating the required KPIs for them. Depending on the probe type, some of the KPIs may be generated by the probe itself, and others will need to send raw data (headers, relevant information about the service contained in the packet, etc) to an aggregation software who will receive the information from all or some of the probes in the network, correlate them and produce the required KPIs.

For the purpose of monitoring the quality of IPTV service it is important to have a probe very near to the end user. This way the whole way from the IPTV head end (assuming that there is a probe in the operator network next to the server) to the end user device can be monitored and all network related impairments (including the access link) are visible for the monitoring system. The optimal location for such a probe would be the set-top-box (STB) or in the TV itself that is used for the IPTV service, which will then ideally also have access to the decoded video and then can take into account the effect of the decoder as well as when available the processing performed by the TV. In case the STB or the TV does not implement necessary probe features and does not allow running additional software, the probe should be located to another device in customer premises .e.g. residential gateway. The probe should be able to measure following parameters: throughput, latency, jitter, packet loss, and transport stream statistics and also if available other KPI's [5] on the decoded video performed by a standard decoder, which might not be the same as in the terminal but still will give an indication of how the errors have affected the video signal.

3.2 Active Probes

The CEMS will use active probes to inject appropriate traffic inside the network, collecting it afterwards and analyzing how the network behaved to these packets and whether the network is able to deliver it accurately at the other end or not. Like with passive probes, strategic placement of the probes in the network will be vital.

Typical need for an active probe in the case of IPTV service is troubleshooting of customer problems. Typically the customer can report that the picture quality is impaired, but this does not say much about the cause of the problem. To enable troubleshooting and locating the problems it is necessary to run active tests to and from an active probe that is located in the customer premises. As described in the previous section for passive probes, also the active probes should be placed as near to the user as possible. The following figure shows both type of probes (passive and active ones) deployed under different network topologies (UMTS, GSM, IP, IN-Intelligent Networks-, IPTV and PSTN –Public Switched Telephony Networks-).

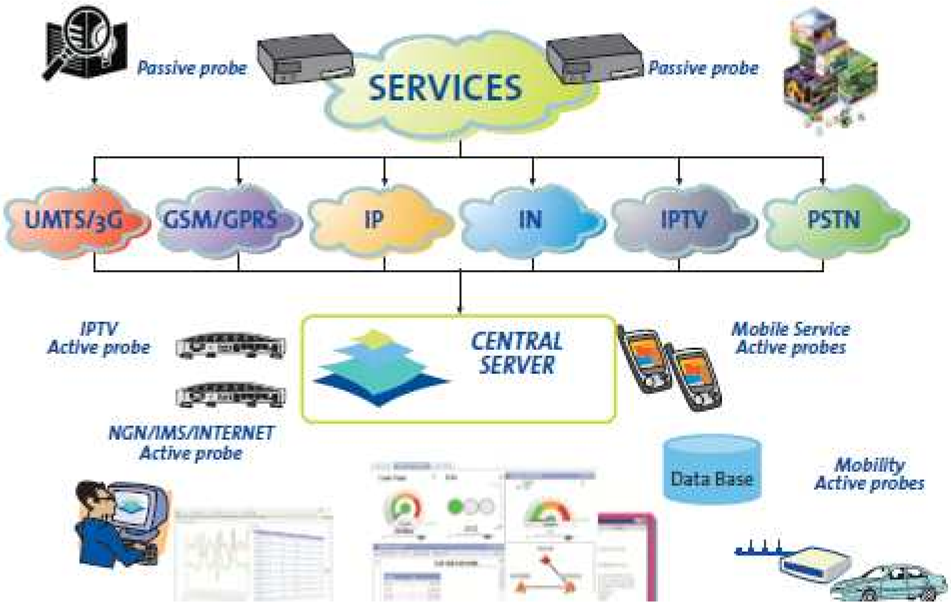

Figure 2: Active and Passive probes to contribute CEMS Architecture

3.3 Other network data sources

The system may have other data sources different from active and passive probes. We can classify them in different categories.

1. Embedded agents - These will be software capable of generating relevant information regarding network use. This information will probably be heterogeneous by its nature and will need pre processing before being able to be ready for use for upper levels of the management system.

2. Network elements - Routers, switches and other network equipment can produce also interesting information that may be worth to include in the system, treating it as yet another network view.

3. Customer data sources - BSS (Business Support Systems), CRM (Customer Relationship Management), User model (residential, SoHo, etc. | Gold, silver, bronze | prepaid | triple play, grand slam, etc.), and other Data repository

4. QoE Monitoring System

The QoE monitoring element is described in this section, and is composed of the traffic monitor –which transforms the information gathered by the data sources into monitoring data- and the QoS/QoE engine –which converts monitoring data into quality figures- .

4.1 Traffic Monitor

A network-monitoring module should fulfil some basic requirements in order to provide an accurate analysis of the traffic flow for QoS/QoE measurements [6]. For instance, the monitoring platform must be able to capture packets from a highly utilized link under a high traffic volume without missing a significant portion of packets, thus providing a high capturing performance.

IPNQSIS will design and implement all the elements required to build the Customer Experience Management System (CEMS) that will be based on the traffic monitoring and service supervision system [7]. For the Monitoring Component, IPNQSIS will use enhanced hardware and software probes that operate at different levels, ranging from the network core to end-user applications, so that the QoS measurements can be extracted from the captured flows.

IPNQSIS will particularly focus on IP traffic monitoring in access networks by using deep packet/flow inspection tools. The purpose of the Monitoring Component is to model the traffic parameters related to content distribution, traffic trends, and user characterization. Parameters of interest include, e.g., popularity of content (by time, location, access type, etc), locality of traffic, traffic mix, and traffic variation (by household, household type, etc).

The Monitoring Component comprises passive probes, active probes, and traffic classification modules. The active and passive probes will be adapted to multimedia services such as IPTV applications, where QoE measurements will be defined and implemented. The traffic classification module makes use of Deep Packet Inspection based methods and may include Bayesian classifiers, which are based on the inherent features of the network traffic such as inter-arrival times, packet sizes, etc. The traffic classification module will be integrated into the management solution by providing means of detecting popular services for which QoE requirements exist, and providing relevant information to the Control Module.

4.2 QoS / QoE engine

QoE is a measure of customer's experience with the vendor. It is related to but differs from QoS, which is usually concerned with lower-level network performance metrics. It becomes a real challenge to address all relevant QoS issues and provide the QoE expected by end-users in emerging heterogeneous wireless/wired access networks. With the emergence of high-speed new services among heterogeneous networks, manufacturers and providers need to evaluate and control QoE in order to continue to generate differentiated and added value products and services.

One of the main advantages of statistics extracted from end-to-end QoS measurements is that when they are combined with data from controlled experiments of human experience under the same circumstances, they can be used to better understand how user's QoE is affected. If this relationship is clearly understood [8] the information offered by QoS can be used to improve the decision criteria used in the network systems and to optimize the user's QoE [9]. However, further research is still needed to fully understand these relationships. The communication network should provide sufficient end-to-end QoS in order to obtain the desired quality level of QoE. The relation between the QoS and QoE has to be defined such that the network layer metrics can be used as performance indicators for the QoE.

The QoS/QoE engine will analyze the relation between QoS and QoE parameters and how they can be used to supervise the network, so strategies can be developed to maintain the expected quality.

5. QoE Management System

In order to exploit the QoE and QoS models and monitoring solutions presented in previous sections, a QoE-based management system is needed. The system takes the QoE monitoring information and QoE/QoS models, along with policies and other constraints, as an input and performs network control actions as necessary. The goal for these actions may be to maximize the user perceived quality or, more likely, to keep the quality on acceptable level while optimizing the use of network resources [10].

The possible network control mechanisms and algorithms vary from traffic shaping, traffic prioritization, and provisioning actions to admission control and access network selection. In addition to the network actions, control may be performed on application level, e.g. adapting the bitrate of a video stream to match the available link capacity by dropping frames, changing codec parameters.

6. Conclusions

This document constitutes the architecture specification of the Customer Experience Management system (CEMS) considered in IPNQSIS project. On one hand a generic overall CEMS architecture is introduced, and on the other hand it's been particularised for IPNQSIS scope, enforcing specific areas such as monitoring level as it's the core of the project.

A general introduction to QoE concepts has been included to settle a common environment. This way, the different chapters describe the modules inside IPNQSIS architecture: Data acquisition level, Monitoring level and Control level.

The data acquisition level deals with the datasources available in the SoA that is being developed by the consortium partners, the Monitoring level will gather all the information to feed a Control level introduced in the last section, which will allow to establish a first approach to the Intelligent Management of the Customer Experience.

The architecture shown in this paper is currently being developed to cover IPTV services, the focus business case that will be implemented inside IPNQSIS project. This way future works will gather the final achieved results and show how CEMS implementation will help to handle the QoE delivered to IPTV end users.

Acknowledgments

This work is carried out in the framework of the Celtic and EUREKA initiative IPNQSIS (IP Network Monitoring for Quality of Service Intelligent Support) and has been partially funded by CDTI under Spanish PRINCE (*PRoducto INdustrial para la gestión de la Calidad de Experiencia*) project, meanwhile the Swedish part of the project is co funded by VINNOVA and the work of Finnish partners has been partially funded by Tekes.

References

[1] A. Aurelius, M. Kihl, F. Mata et al, "TRAMMS: Monitoring the evolution of residential broadband Internet traffic", Future Network and Mobile Summit, 2010.

[2] P. Engeldrum, "Psychometric Scaling: A Toolkit for Imaging Systems Development, Imcotek Press, Winchester; MA, USA (2000).

[3] A. Cuadra, S. Fleece, S. Shamir, D. Milham, "Lighting up the quality of experience", ETSI Workshop on QoE, Sophia Antipolis, France, September 2010.

[4] TeleManagement Forum TR 148 Technical Report "Managing the Quality of Customer Experience", September 2009.

[5] N. Staelens, I. Sedano, M. Barkowsky, L. Janowski "Brunnström, K., and Le Callet, P., "Standardized Toolchain and Model Development for Video Quality Assessment - The Mission of the Joint Effort Group in VQEG", Proc 3rd QoMEX, (2011).

[6] A. Cuadra, J. Lopez de Vergara, M. Cutanda, J. Aracil et al. "Traffic monitoring for assuring quality of advanced services in Future Internet", Conference on Wired/Wireless Internet Communications (WWIC), June 2011, Barcelona, Spain.

[7] A. Cuadra, M. del Mar Cutanda et al. "OMEGA-Q: A platform for measuring, troubleshooting and monitoring the quality of IPTV services", Symposium on Integrated Network Management (IM), May 23-27 2011, Dublin, Ireland.

[8] M. Fiedler, T. Hossfeld, P. Tran-Gia, "A generic quantitative relationship between quality of experience and quality of service," Network, IEEE , vol.24, no.2, pp.36-41, March-April 2010

[9] A. Cuadra, M. Cutanda, "The role of the Quality of Experience in Human-Computer Interaction", XXI Conference Telecom I+D, September 2011, Santander, Spain.

[10] M. Varela, J-P. Laulajainen, "QoE–driven mobility management - Integrating the users' quality perception into network-level decision making", Workshop on Quality of Multimedia Experience (QoMEX) Sep 7-9 2011, Mechelen, Belgium.

