From Service Level Agreements (SLA) to Experience Level Agreements (ELA): The Challenges of Selling QoE to the User

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***Abstract*—In contrast to the rather network-centric notion of Quality of Service (QoS), the concept of Quality of Experience (QoE) has a strongly user-centric perspective on service quality in communication networks as well as online services. However, related research on QoE so far has largely neglected the question of how to operationalize quality differentiation and to provide corresponding solutions tailored to the end users. In this paper, we argue that the introduction of Experience Level Agreements (ELA) as QoE-enabled counterpiece to traditional QoS-based Service Level Agreements (SLA) would provide a key step towards being able to sell service quality to the user. Hence, we investigate various ideas to exploit QoE awareness for improving SLAs (ranging from internal aspects like SLOs by service providers to completely novel definitions of ELAs which are able to characterize QoE explicitly), and discuss important problems and challenges of the proposed transition as well.**

***Index Terms*—Quality of Experience; Service Level Agreement**

I. Introduction

For a long time, the question of how to define, provide and measure service quality for end users has been of utmost interest for network operators, application and service providers, as well as their customers. With the advent of packet-based communication, this has led, already in the early nineties, to several attempts at thoroughly defining Quality of Service (QoS) [1], [2]. In the two decades to follow, the primary research directions have followed a rather technology-driven understanding of QoS [3], [4], leading among other things to the definition of clearly specified network parameters as a prerequisite for arranging service-related binding contracts between providers and users, i.e., Service Level Agreements (SLA).

However, in recent years a remarkable focus shift could be observed in the industry as well as the research community, (re-)establishing a more user-centric perspective on service quality around the notion of Quality of Experience (QoE) as an augmentation of QoS[1]. The reason for this can be found in the realization that QoS measures do not trivially translate into quality as experienced by the users. Pursuing this idea, recent research has achieved remarkable progress on corresponding metrics and measurement methodologies as well as the relationship between QoS and QoE for a broad variety of services and applications [7], [8].

In this paper, we argue that the time has come to apply those results also on the business domain. Therefore, we propose to complement the mentioned paradigm change from QoS to QoE by the analogous step from Service Level Agreements (SLA) towards a novel type of contracts between providers and end users which take the user-centric perspective on service quality into explicit account, and which we propose to call "Experience Level Agreements" (ELA).

Such a concept, to the best of our knowledge, so far has been only vaguely mentioned in very few rather specific contexts, for instance facility management[2] and cloud computing services[3]. We posit that the idea of guaranteed service levels has to be prominently introduced to the area of QoE, where it can play a key role for bringing QoE into the networks and services. On the other hand, we identify two main issues with currently available SLAs, from the end-user's point of view (be they consumer or business users). Firstly, SLAs are often non-existing, or when available, very IT services-oriented (ticket response times, recovery times, availability), but do not convey

[1]In fact, while for instance ITU-T defines QoE as *"the overall acceptability of an application or service, as perceived subjectively by the end user"* and further mentions that this *includes the complete end-to-end system effects and may be influenced by user expectations and context* [5], other researchers went even further, for instance characterizing QoE as *"the degree of delight or annoyance of the user of an application or service…"* [6]

[2]see http://www.experiencelevelagreement.com/

[3]cf [9] mentioning the need for "experience-oriented SLA"

much in terms of how well the service actually performs for the user. Secondly, when SLAs are present and service performance is a part of them, they mostly deal only on low-level metrics, which do not (except in some specific cases) easily relate to the quality experienced by the users.

We therefore introduce the notion of a QoE-oriented SLA — an Experience Level Agreement — motivating it from a business perspective, and discussing the main challenges associated with implementing them in different types of services.

We will start with a short overview of classical SLAs (Sec. II), and how QoE can interact with them in certain contexts. We will then introduce and motivate their QoE-driven ELA counterpart (Sec. III), following with a discussion of the challenges, both technical and business-related for making them operational (Sec. IV). Finally, we will give concluding remarks and an outlook on ELA in Sec. V.

II. A Brief History of SLAs

Service Level Agreements (SLAs) are a broad and well-studied topic with a long history in the ICT domain. In this section we will briefly cover the basic concepts and key references related to the ideas presented later in this paper, and will especially focus on the case of telecommunications and online (over the top) services.

A. SLA Definition and Related Concepts

SLAs have been defined by ITIL [10] as an *"agreement between an IT Service Provider and a Customer. The SLA describes the IT Service, documents Service Level Targets, and specifies the responsibilities of the IT Service Provider and the Customer. A single SLA may cover multiple IT Services or multiple Customers"*. The TM Forum [11] provides an alternative definition as *"a formal negotiated agreement between two parties. It is a contract that exists between the Service Provider (SP) and the Customer. It is designed to create a common understanding about Quality of Service (QoS), priorities, responsibilities, etc. SLAs can cover many aspects of the relationship between the Customer and the SP, such as performance of services, customer care, billing, service provisioning, etc. However, although a SLA can cover such aspects, agreement on the level of service is the primary purpose of a SLA"*.

Both definitions convey the same basic ideas; SLAs provide, among other things, an agreed-upon understanding of the performance targets of a service. SLAs can cover a wide variety of service aspects, ranging from performance (e.g., network QoS) to maximum response times for service tickets, and can also be applied to non-ICT services.

An SLA commonly has a set of Service Level Objectives (SLO[4]) associated with it. These are the targets for the service level to be attained, and are often measured by a set of Key Performance Indicators (KPI).

In general, SLAs can be characterized by:

- A set of KPIs for the service in question, often averaged values over a time period (e.g., monthly packet loss averages), or dependability metrics (MTTF, MTTR, etc.) [12], [13]
- A clear way to measure those KPIs by either the customer or the provider (or both).
- Penalties for the cases where violations occur (e.g., service refunds, or fines).

Common KPIs used in SLAs are related to the availability of the service (e.g., mean time to failure, mean time to recovery), or to technical QoS parameters in the case of network services, for example. However, those KPIs can only be related to the end users perception of the system performance, much less to its actual QoE. Hence, recently the term Key Quality Indicators (KQI) has been used to describe user-perceivable quality aspects of a service via certain KPIs that directly affect the perceived quality (e.g., packet losses for IP telephony services) [14]. KQIs are in some cases very close to KPIs (e.g. the number of sessions in which the start up delay of the service is higher than a certain threshold), but for some services (notably media) the can also be estimates of perceptual quality (e.g. listening MOS for VoIP, or some estimation of audiovisual quality for video) [15]. These latter KQIs would provide a good basis for an ELA (cf. TM Forum recommendations for KQIs [16]). There is a plethora of literature related to SLAs, both regarding research and best practices. A recent survey of European research efforts related to SLAs [9] provides an excellent overview of on-going work in the domain (with a focus on cloud services), as well as a meta-model for an SLA life-cycle. With a more general focus, the TM Forum has produced a comprehensive handbook covering basic notions and concepts of SLAs [11] and SLA management [13].

B. SLAs and QoE

Within the technical domain of SLAs, QoE models can be a valuable tool for service providers, for example to use as SLOs, e.g., ensuring that the MOS of a given service remains above a given acceptability threshold. Having sufficiently accurate parametric models for QoE [17]–[19] or even less accurate dimensioning models [20], allows in some cases to derive performance bounds for some of the QoE-affecting service parameters, enabling for example the choice of optimal (e.g., in terms of cost/quality ratio) SLAs. In [21], the authors present a scenario in which quality models provide an optimal choice of SLAs between a SaaS provider and its upstream (IaaS, network) providers, in order to attain the desired performance levels to ensure the users' QoE is sufficient, considering budget constraints.

QoE-based SLOs can also be used as part of inter-carrier SLOs, or for OTT services, agreements between

[4]Note that our usage of the term SLO is in line with most of related work, except for ITIL, which has defined the concept of SLR (Service Level Requirement) for this purpose, while SLO is used with a rather different meaning.

content providers and network providers, for instance by setting quality targets over a set of agreed upon (e.g., standardized) quality models for different service types.

III. ELA: User-centric Quality Level Agreements

When buying a service today, consumers commonly face two issues: firstly, the service is provided on a *best-effort* basis with no guarantees of any kind (a typical example of this would be an ISP's tiered data plans, which are sold, e.g., as "100Mbps", followed by copious amounts of small print that indicate that what it really means is "up to 100Mbps, under optimal circumstances, which will probably never occur in practice"). In other cases (e.g., cloud services), performance or dependability guarantees of any kind are rarely made. Secondly, when performance or dependability are described to the end user, they are described in technical terms that are not really relatable to the quality experienced by the user when using the service.

On the other hand, for any user paying for a service, there is an expectation that the service should work reliably and properly, which is not currently addressed by most service providers. This lack of quality guarantees in most services, together with recent significant advances in QoE modeling, opens an opportunity for service providers to differentiate themselves from their competition and increase their margins by offering customers minimum QoE guarantees, or different types of guarantees based on tiered subscription models. Depending on the nature of the service in question (e.g., network connectivity vs. online media vs. cloud services), the options available to the providers in terms of what they can promise to customers can vary significantly. In the case of media services, for example, the tiers can include different base quality levels based on resolution and encoding, but also different assurances on the delivered quality itself. For non-media services, the tiers could be based on guaranteed resource allocation or response times.

For the successful selling of any kind of product, the information disclosure process is key, whether it refers to advertisement activities or clearly conveying the essence of the product itself to the customer. Today's network and service market is dominated by figures and notions that are difficult to communicate or even measure. In common SLAs, network performance aspects may be conveyed in terms of QoS metrics or may even only be specified by aggregate bandwidth estimates or best effort rates. These are not terms that end users understand or necessarily care about, as they are not easily relatable to their experience when using a given service. So far, there are no means to market services with QoE guarantees to end-users. We propose the concept of Experience Level Agreements (ELAs) to both enable the effective communication of the QoE to be expected for a set of services and to foster new business practices based on providing a minimum QoE guarantees to the users in terms they can actually comprehend.

A. Definition

In line with the SLA definitions given above, we can define an ELA as *a special type of SLA designed to establish a common understanding of the quality levels that the customer will experience through the use of the service, in terms that are clearly understandable to the customer and to which he or she can relate.*

Syntactically the ELA can be very similar to a common SLA[5], i.e., a product in a defined quality — availability, consistency of performance, or resources — and price is sold for specified period of time from a provider to a customer. The existing frameworks for defining SLAs should suffice to formally specify ELAs as well. However, whereas SLAs comprise a set of low-level performance metrics (e.g., QoS, availability), the ELA conveys the performance of the service in terms of QoE (and QoE only); possibly as a set of QoE indicators to which the user can readily relate. These could be, for example, some representation of MOS scores as star ratings, though as we will discuss later, it is likely that new means for conveying QoE information to users will be needed.

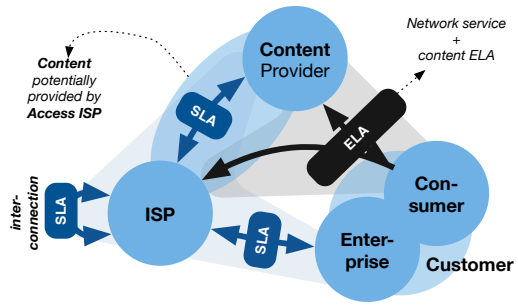
B. Scope

It is important to distinguish between consumer and professional customer markets (expert users, wholesale customers, corporations, etc.). ELAs, as proposed herein, provide a clear way to convey the complex nature of network and service quality to consumers and some enterprise-type customers, and their exploration may indirectly assist other commercial users through the availability of the QoE monitoring tools or experience simulation facilities required to operationalize ELAs.

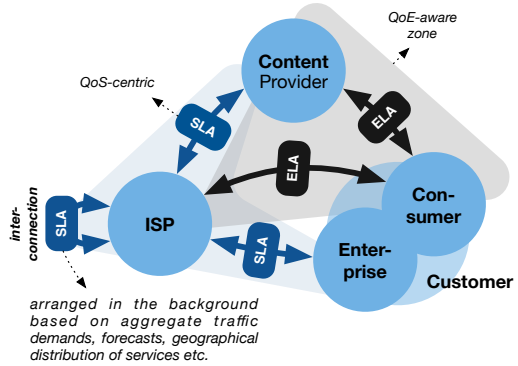
Another restriction concerns the general applicability of QoE-differentiated services and thus ELAs. Due to the complexity and risk when providing service experience guarantees between any destination pair of a certain service type (e.g., due to transit service agreements), the service usage needs be geographically narrowed down, e.g., a small region involving a limited number of ISPs.

This line of thought also leads to focusing on services for which we are capable of both measuring the QoS and/or QoE (e.g., active monitoring) at the user premises at peak times for this service, and simulating the effect on the QoE through "preview" capabilities, i.e., translating QoS parameters to an experience. The actual ELA is then handled via the client software used and is specific to this service. Thus from the current point of view, a focus on specifically selected Over-The-Top (OTT) services eases the transition towards QoE marketisation via explicit ELAs—see Fig. 1(a). More generic arrangements may be

[5]In what follows we will refer to thos SLAs that are not ELAs simply as SLAs



(a) Specific service contracts



(b) Service-independent agreements

Fig. 1. The ELA ecosystem making use of SLA and QoE concepts.

enabled at later points in time (cf. Fig. 1(b)), as the challenges are overcome.

C. ELA vs. SLA

ELA and SLA need to coexist in an end-to-end system, where the SLA is the interface with the service and content provider whereas the ELA is the interface with the end users (cf. Fig. 1). The relationship between ELA and SLA is analogous to that between QoE and QoS, forming a chain from users to their back-end realization. One commonly-studied research question in QoE relates to the creation of mappings to translate QoS to some dimensions of QoE (usually perceptual ones) and vice-versa. An analogous mapping will be needed to derive SLA parameters from the ELA, and conversely, to bound ELAs based on the SLA parameters. In this sense, ELAs cannot in general directly involve QoE (i.e., as experienced by the user and including emotional, socio-economic and other user factors) but rather an objective representation of it, agreed upon by both providers and users.

D. In Operations

Operationally, experience levels need to be captured and transferred to a contractual form. This could for example be achieved by experience simulators that allow to measure the user's quality sensitivity for different service types. Based on this assessment, users could choose their desired experience level on a quality scale depicting the available quality tiers (olympic model, ACR-5, star ratings, or other), price, and typical service usage scenarios. This would yield an ELA choice reflecting both quality sensitivity and service preferences, which would then be automatically translated to QoS parameters, via the QoE models used, as done for instance in [21]. Whenever service-aware QoS parameters cannot be explicitly defined, QoS indicators may provide descriptors for aggregate QoS bounds—e.g., peak bandwidth up to 10Mbps, latency smaller than 150ms for the specified set of services at the tested location. QoS parameters are essentially required in the core network and across network domain borders due to absence of direct customer contact and the requirement to aggregate the demands of individual usage flows. For the business side of ELAs, both customers and ISPs will require the certainties about the imminent contract, for which several strategies may exist: Firstly, ISPs may not only aim at assisting customers to understand the product offer (e.g., via experience simulators), but they may also do active network measurements in order to understand the network at the customer premises, i.e., probing the QoS at peak times. By studying the performance of the underlying network and infrastructure, a set of services can retrieved in this way for which QoE guarantees can be provided. The validation of an ELA, moreover, requires reliable and trustworthy information accessible to both contract parties. In practice, the measured QoS could be reconstructed for a service to a QoE level estimate (i.e., an implicit QoE monitor) on whose account the contract satisfaction is assessed.

Secondly, ELA validation and QoS-to-QoE transition could be treated based on the closest access speed and QoS measurements and crowd-sourced QoE ratings (by actual customers). On that account, a less cost-intensive solution may be constructed. For example, ISPs, regulators or another objective third party could use existing network QoS monitoring infrastructure in order to publish aggregate results (possibly with regional granularity) for QoS at peak times. The results would then automatically mapped to aggregate QoE levels for commonly used services, e.g., YouTube, Netflix, Skype, and may feed ELA validation mechanisms. Particular solutions for the operationalization of ELAs are beyond the scope of this paper.

In any case, penalties, as compensations for not matching the agreed QoE standards and the lost free or working times, may then be issued on the basis of monthly paybacks or vouchers for future service usages. Those refunds may (partially) be covered by insurances or may directly affect the business figures. It is implicit in this framework that on average, the added costs for operators, related to penalties, will be offset by adequate pricing strategies. That is, more demanding ELAs will carry heftier prices, and possibly larger expected margins than best-effort service tiers.

E. But, Why ELAs?

As discussed so far, and further in the following Section, it seems pertinent to address the main reasons for introducing the concept. A large majority of connectivity options and services marketed today to consumers share one of both of the following characteristics: they are provided on a best-effort basis, and they are mostly sold on a flat-rate pricing model[6].

This has led, in many services, to a "race to the bottom" effect in terms of pricing, which in the long run does not benefit service providers, who see lower margins, or customers, who are stuck with whatever quality of experience the provider is able to deliver on this pricing model. On the other hand, some studies [22] indicate that a non-trivial percentage of customers are indeed willing to pay more for better quality, with varying degrees of enthusiasm, ranging from conservative spending, to higher levels of spending which may even seem irrational. This, in principle, enables new business opportunities for the service providers, who can better address different segments of the market by offering different QoE levels at suitable price points.

It stands to reason, then, that if such type of pricing differentiation is put in practice, there will be a need for users to make sure that they get their money's worth of QoE, and for providers to be accountable when they don't. This is precisely what an SLA is meant to do. However, the traditional approach to SLA definition and monitoring is not necessarily a good match for end-users, hence the proposed ELA concept.

IV. The Challenges of ELAs

The idea of integrating QoE into SLAs, either implicitly or as user-facing ELAs seems, as argued above, like a natural progression in the same vein as how QoS has evolved towards QoE. There are, however, a number of open issues that need to be worked out before this transition can take place. In this section we discuss the main research challenges and questions we have identified in this area.

A. Framework

Today, SLAs for communication services are not widely spread for consumer-level use. Because of this, ELAs can not yet build upon an existing and sufficient infrastructure involving consumers, all involved ISPs, and potentially also content providers. In particular, automatic mechanisms for simplifying the contractual negotiations and agreements cannot be assumed to be present. In 2013, the EU FP7 project ETICS[7] has concluded with the proposition of an automated end-to-end QoS agreement concept based on SLAs [23], that does, however, not include consumers. Despite this restriction, the complexity of the proposed mechanism potentially explains the limited endeavors for adopting similar concepts in the industry. Apart from this, services and their customers are in general spread around the globe, thus introducing location considerations and requiring fine-grained end-to-end service quality monitoring in order to attribute contract breaches to subcontracting ISPs.

This entire range of SLA issues are very likely inherited by ELAs, which mainly differ in their parameter selection and semantic interpretation. Proper mechanisms have to both understand the background transactions required to enable ISP cooperation (binding contracts, revenue sharing etc.) and their automated translation to consumer-facing contracts. For this reason, ELA frameworks should

- be based on automatic mechanisms (for end-to-end solutions);
- be based on agreed-upon, measurable, technically valid, communicable, and understandable metrics;
- be resistant to regional usage variations, e.g., switching service caches or service providers requires statistical modeling or other kind of treatment;
- come with a cooperation framework among providers as envisioned by [23].

Likewise, a standard set of APIs and a suitable monitoring architecture is also needed, in order to simplify the inter-domain (not only between carriers, but also between carriers and service/content providers) interaction required. For the QoE monitoring aspects, an architecture such as the one recently proposed by ETSI [24] could be a good starting point.

B. Language

It is challenging to describe ELA in a single language that can express technical quality requirements (e.g., QoS) while being easily understood by customers. ELAs should, thus, be

- be expressed both formally and in terms understandable by customers, the latter in terms of QoE. This poses some non-trivial questions on how to convey what certain quality (e.g., a score of 4 on a 5-point ACR scale) actually feels like.
- convenient to measure by both service providers and customers, i.e., it should be able to be quantified, guaranteed, validated and maintained (e.g., in order to also reduce complaint management efforts);
- consistent across users and platforms, i.e., it should be applicable to a range of user profiles in the service domain, and to all the devices with which they access the service in question[8].

C. Marketing

One significant challenge in implementing ELAs lies not in the technical aspects, but rather on the marketing

[6]Network services do often have pricing tiers based on speed or data transfer caps; higher speeds and higher transfer caps are more costly. However, these tiers provide bounds as to how well the connection can perform, rather than guaranteeing that it will perform "at least this well" for any particular service.

[7]https://www.ict-etics.eu/, last accessed: 2015-01-29.

[8]This may actually vary depending on what service is under consideration

side. The prevailing "best effort / flat rate" approach to selling online services and network connectivity creates a strong inertia, which may prove difficult to overcome. For example, while sophisticated pricing schemes for connectivity with differentiated QoS have been studied for a long time [25], [26], their implementations remain elusive.

Similar issues are likely to occur when considering differentiated QoE levels, unless effective marketing strategies can be developed to address this problem.

V. Conclusions and Future Work

In this paper we have introduced the concept of Experience Level Agreements (ELA), as a QoE-oriented augmentation of SLAs, with the aim of enabling new business models based on providing different QoE guarantees for users of online services. While the concept is easy to motivate from the business / economic perspective, and some studies suggest that users are indeed willing to pay more for better quality, we describe several significant challenges — both technical and business-related — to address before ELAs can become operational.

Future work on this domain will address the challenges explored in this paper, as well as expand the scope of ELAs to business applications, e.g., for SaaS-type use cases.

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