



Quality of Service in an LTE network

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Introduction

The last decade has seen rapid evolution of mobile network technologies. Innovations in devices have enabled ubiquitous connectivity and extraordinarily interactive social reach in real time relevance. The industry in keeping up with this change has seen a blurring of traditional boundaries and the emergence of a digital sector with new value chains and business models. There is significant pressure on telcos to exploit the new profit pools and thereby reduce an **ever growing data monetization gap**.

The challenges are plentiful. Mobile broadband subscriptions are expected to reach 5.4 billion by 2020. Of this user base, the number of LTE subscribers is projected to reach over 3.1 billion¹. Correspondingly, the demand for user-experience and differentiated service levels continues to rise. In order to retain users and maximize average revenue per user (ARPU), telcos need to differentiate themselves through quality service packages that would each have unique traffic handling and QoE requirements. This model cannot be economically realized by over provisioning the network in the old fashioned way. In today's scenario, since effective QoS has to be delivered end-to-end across the network, the designer would need to include besides the wireless link, a variety of aggregation, switching and routing elements, applications and even devices between various communication endpoints.

1. Ericsson Mobility report, February 2015 (<http://www.ericsson.com/res/docs/2015/ericsson-mobility-report-feb-2015-interim.pdf>)

The new viewpoint to QoS

Early generation mobile networks introduced some complexity to voice Erlang when the hand-off between locations had to be handled as the user moved. But the overall rules and technologies stayed the same for some time, i.e. an end-to-end circuit from the user handset to the mobile-switching center (and from there to the call recipient) started at a predictable, low rate using a fixed capacity in a symmetric fashion on a single path. It stayed that way at least till we moved into 3G and LTE, and the definition of end-to-end took on an entirely new meaning.

Internet architectures are generally built around per-hop-behavior, whereas traditional wireless voice infrastructures were built around circuit-switching. As a consequence of these design choices there are trade-offs as we migrate to LTE. The most important set of trade-off comes in defining the 'ends' in end-to-end. The key relevant questions for a QoS designer remain the following:

- » Is upstream QoS important? (User-equipment towards Internet)
- » Are carrier-provided and over-the-top applications included?
- » Is a guarantee required, or is increased probability of quality sufficient?
- » Does the QoS have to work in 'in-network' or 'off-network' hand-off (roaming) scenarios between LTE and LTE/ non-LTE technologies?
- » If the quality cannot be guaranteed should the application be disallowed?
- » If a session is started in a region with sufficient capacity but the user moves to one without, is the session terminated?
- » Is it sufficient to perform the QoS only in the most-congested part of the network and assume the remaining network has adequate capacity to not need QoS configuration?
- » Is QoS being used as an 'improvement' or a 'degradation'?
- » Is mobile-to-mobile QoS needed (e.g., push-to-talk over cellular)?
- » Should QoS control delivery of some classes of application (e.g., video optimization, traffic management) to create additional capacity?

Cellular systems by nature have finite resources. Radio spectrum and transport (backhaul) resources are limited, expensive and are shared amongst many users and services. Additional transmission lines, fatter pipes, and improved efficiency are common responses to network congestion. However, this strategy works better for wired networks than for wireless networks. Increasing capacity with additional spectrum and improving spectrum efficiency are important steps in handling the substantial growth of mobile data. However, capacity improvements alone will not solve this challenge. Therefore, QoS assumes a greater role in the LTE network for satisfactory delivery of Internet applications to subscribers and management of network resources. To achieve this, the **LTE network elements must incorporate new techniques to manage diverse traffic characteristics of the applications and services. This would increase customer base and thereby monetize that critical gap.** As an example, while South Korea and Sweden lead the pack of LTE operators with 90% customer usage, Brazil's Claro with the best network throughput is still struggling to cross the 50% mark².



2. ZDNet (<http://www.zdnet.com/article/the-state-of-lte-4g-networks-worldwide-in-2014-and-the-poor-performance-of-the-us/>)

Effective QoS through Policy Management

Today's mobile broadband networks carry multiplay services that share radio access and core network resources. There is a need to consolidate QoS parameters relative to service using an optimal combination of packet delay tolerance, acceptable packet loss rates and minimum bit rates across both access and core elements. The 3GPP's access-agnostic policy control framework that standardizes QoS and policy mechanisms for multi-vendor deployments enables telcos to provide such service and subscriber differentiation by applying rules for resource allocation and network use including those for policy enforcement processes. Policy management has been found critical in three closely-related areas:

- Network congestion management
- Optimization of service quality
- Enhanced service monetization

Successful LTE QoS strategies are based on learnings from global network performance for satisfying and achieving targets like high data rate, low latency and high aggregate throughput for diverse customer requirements.

Operator Controlled Service and User Differentiation: Service and user differentiation requires a limited set of well-defined QoS classes. It would be of importance for a telcos to increase the number of QoS classes supported within the network since it would reflect on the granularity of differentiation provided. Operators should define the mapping of the service data flows of offered services to the QoS class indicators (QCIs). Best practices of measuring and reporting KPIs for each QCI will help define the ideal baselines associated to specific bearers. This in turn would enable setting of thresholds to ensure enforcement of parameters related to network packet loss, bit error rate, maximum and average jitter along with voice and video quality scores for each QCI.

Minimize Terminal Involvement in QoS and Policy Control: In the interest of telcos, user equipment (UE) should be regarded as a non-trusted device which can be 'hacked'. E.g., for the purpose of receiving higher QoS than subscribed and charged for. Therefore, the control over a QoS bearer's QCI should be located within the network. In principle, there is no reason for a UE to have knowledge of a bearer's QCI. Also, in order to ensure consistent exception handling across terminals from different vendors, exception handling control should be located within the network.

Subscriber Modelling and Fast Session Set-up: Subscriber modelling is essential to validate service quality by defining subscriber types (for example, corporate user vs. casual user), associating applications to a subscriber (such as Internet browsing, email, voice, video, and P2P) and modeling subscribers' usage of applications and their mobility on the network. This would help customize design parameters of real time services using Guaranteed Bit Rate (GBR), Minimum Bit Rate (MBR) and those of network resources like Allocation and Retention Priority (ARP). Once the QoS design is created, telcos would need to replicate real traffic types and usage patterns to understand the capacity limits of the network, how multi play services interact with one another and the network's ability to differentiate services and subscriber types. An integrated lab infrastructure for this validation is essential to ensure fast session set up in production network.

Support for Access Agnostic Client Applications:

Telcos need to support vendor agnostic APIs (Application Programming Interfaces) for client applications. These QoS-APIs can be used to request the establishment of a QoS bearer and thereby create the binding between a service data flow of the requesting client application and the QoS bearer. This would enable any client application to be programmed towards the ubiquitous socket-API that is supported by virtually every device operating system, thereby enabling desired QoS. Strategies could also be designed, for instance, on-demand service enhancement by controlling forwarding of services according to user preferences, thereby allowing telcos to function as a QoS broker and enable a new revenue stream.



Phased deployment: From a user's point of view, it makes sense to help 3G customers experience 4G through a simple transition path. Since upgrade of network equipment cannot be assumed to be carried out overnight, backwards compatibility with LTE based equipment needs to be ensured by an evolved 3GPP QoS concept. Successful telcos have taken a phased approach in not just migrating 2G/3G core to EPC without waiting for eNodeB deployments to be completed, but also exploring reduction in signaling traffic through integrating SGSN and MME functions, co-locating SGW and PGWs and enforcing policy management to their networks, starting with congestion reduction for applications such as P2P services. Aggregate-level policy could probably also be introduced in the first phases. Designs should be developed on the assumption that network crashes might happen. Hence, the advance planning.

Conclusion

Telcos do not have unlimited resources and capital. The radio spectrum is finite and gains from improved spectrum efficiency can only go so far. Even if we increase capacity, bandwidth-hungry applications and video will eventually consume it. Providing high service quality by over-provisioning network capacity will eventually leave telcos at a competitive disadvantage to providers that offer the same or better QoS at a lower cost. A solid policy strategy maintains network performance during peak traffic times and spikes in user demand, removing the need to carry excess capacity.

It is unlikely that per-subscriber policy management will be needed for implementation early on in LTE deployments due to its high complexity. We can however expect detailed definition and implementation of policies to become more paramount as the networks evolve and congestion mounts. Proactive management policies, combined with other packet strategies such as network offloading and demand calibration would help networks with finite resources meet the demand for multiplay services. In order to be ready for the expected technology evolution, telcos need to be ready with business partnerships and frameworks to ensure seamless QoS across the network.

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