

Martínez, Luis; Álvarez San-Jaime, Oscar; Markendahl, Jan

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Net Neutrality principles and its impact on Quality of Experience based service differentiation in Mobile Networks

Luis Martinez, Oscar Alvarez, and Jan Markendahl

Wireless@KTH
KTH Royal Institute of Technology
Kista 16440, Sweden
`lgmb@kth.se, oaa@kth.se, janmar@kth.se`

Abstract. The overall goal of the incorporation of QoE in the mobile networks deployment is related to optimizing end-user QoE, while making efficient use of network resources and maintaining a satisfied customer base that guarantees the commercial success of the provider's business model. However, the implementation of a QoE-based approach at the service provision, with the potential deployment of fast lanes for premium users, the prioritization of traffic, or the creation of user's categories, may affect the Net Neutrality principles. This paper presents an analysis of how the net neutrality principles will impact the implementation of QoE-based differentiation in the service provision at technical, business and market levels. We introduce a business model framed in the QoE-based differentiation approach analysing the implications of Net Neutrality in the proposed models.

Keywords: Quality of Experience, Net Neutrality, Mobile Networks

1 Introduction

Mobile networks have experienced phenomenal growth during recent year, as a result of the more frequent use of mobile applications and services fulfilling needs for information, communication, entertainment and leisure in our daily life. At the same, users are increasingly turning to interactive services and applications and are highly aware of service experience [31] [14]. In today's highly competitive environment, users have the option of choosing from a plethora of service providers and a poor customer experience can lead to a chain reaction of negative word of mouth, pushing customers into the arms of waiting competitors [5]. Today, users' expectations, perceptions and needs with respect to a particular product, service or application carry a great value [24] [5]. In that sense, it is not enough for a service provider to simply make the service available to users. Operators must deliver those services in such a way that users fully enjoy a rich experience at a reasonable price. Therefore, service providers that build high-performing infrastructures, meet users' needs, and offer more innovative services

will survive the competition[31][14]. This makes the need for evaluating services' quality more important.

Traditionally, service providers to evaluate and improve services' quality have focused on determining and managing Quality of Service (QoS), which centres on measuring performance from a network perspective [25]. However, intense and recent research in the area of Quality of Experience (QoE) has shown that QoS need to be complimented with more user-centric approaches in order to meet end-user requirements and expectations[1][50]. QoE is conceived as a multidimensional concept that consists of both objective (e.g., network-related parameters) and subjective (e.g., contextual, user-related aspects)[10]. Therefore, QoS is only a subset of the overall QoE scope. Higher QoS would probably result in higher QoE in many cases, but fulfilling all traffic-related QoS requirements will not necessarily guarantee high user QoE [50]. In this respect, QoE has to consider both the impact of network and application performance on user's quality perception as well as the individual users experiences derived from encounters with systems, impacted by expectations, prior experiences, feelings, thoughts, context, commercial offers, branding and so forth[47]. While the ITU-T has defined QoE as the "overall acceptability of an application or service, as perceived subjectively by the end user" [1], ETSI defines QoE as "a measure of user performance based on both objective and subjective psychological measures of using an ICT service or product" [15] and extends QoE beyond subjective to include objective psychological measures. A recent definition, proposed by the project Qualinet encompasses the discussed aspects and defines QoE as "the degree of delight or annoyance of the user of an application or service. It results from the fulfillment of his or her expectations with respect to the utility and/or enjoyment of the application or service in the light of the users personality and current state. In the context of communication services, QoE is influenced by service, content, device, application, and context of use" [25]. As stated by Laghari et.al., QoE is a blueprint of all human subjective and objective quality needs and experiences arising from the interaction of a person with technology and with business entities in a particular context [24]. Hence, service providers must look beyond the network toward a more holistic vision of QoE.

In today's a highly competitive environment, where providers price levels are decreasing and pricing schemes are becoming more similar[11], actors involved in the process of service provisioning need to work on alternatives to stand out from the competition, preventing customer churn and attracting new customers while minimizing provision costs[32]. In that sense, providers need to work towards meeting users requirements and expectations, maximizing users satisfaction with the overall perceived service quality. A superior service quality can help providers satisfy customers, sell more services and earn more customer recommendations. On the other hand, providers can potentially improve the usage of communication infrastructure by adapting and optimizing the resources based on the user requirements and user experience. As stated by Schatz et.al., "QoE is supposed to enable a broader, more holistic understanding of the impact of networked communication and content delivery systems on the end-user

and thus to complement management perspectives on quality and performance that have traditionally excluded the user perspective” [43]. Hence, successful QoE management at different levels (i.e., technical, business and market) can offer stakeholders a competitive advantage in the fight to prevent customer churn, attract new customers, and reduce the provision costs by doing a more efficient use of the infrastructure resources.

In this scenario, operators have the opportunity to lead the market on service differentiation by delivering the appropriate users QoE with the speed, capacity, coverage and availability demanded by users of laptops, smartphones and other devices. However, the implementation of QoE-based differentiation at the service provision, with the potential deployment of fast lanes for premium users, the prioritization of traffic, or the creation of user’s categories, could affect the Net Neutrality principles that claim Internet service providers must not speed up, slow down or block Internet traffic based on its source, ownership, type or destination. In this context, it is important to understand how the interest of operators, content providers and users can fit with the concept of network neutrality, fairness and freedom of expression, while satisfying commercial demands, business models and personal interests. Internet broadband access is a two-sided business [12] where the network owner needs to provide connectivity access to the end users, which want to access contents on Internet. In this context, the relations between Content Service Providers, Internet Service Providers, regulator and Internet users should be the focus for innovation and regulation in order to assure Net Neutrality.

The proposed paper will focus its results on the analysis of how the Net Neutrality principles will impact the implementation of QoE-based differentiation in the service provision. Our intention is to evaluate the effect of this approach for the different actors involved in the mobile ecosystem (i.e., content provider, network provider, vendor, regulator and users). Here goes the chapter organization. Section 2 presents the challenges of incorporating QoE in Mobile Networks environment. Then, a description of the Net Neutrality concept and the relevant discussion points in the topic is introduced in section 3. An initial discussion about the impact of Net Neutrality on QoE is presented in section 4. Section 5 presents a discussion in the business models for QoE-differentiated services in the Net Neutrality context, including a description of the QoE ecosystem and the analysis of the implications of Net Neutrality in the business models. Finally, the conclusions section is presented.

2 Challenges of QoE in Mobile Networks

In order to successfully incorporate QoE to mobile infrastructures, it is necessary to understand and identify multiple factors affecting user’s perception (subjective and objective) from the point of view of various actors in the service provision, and how they impact QoE. With the implementation of QoE-oriented mobile networks, users will benefit with satisfied requirements and expectations and may be further inclined to adopt new services and new technology developments. For

the actors involved in the service provisioning chain (i.e., device manufacturers, network providers, service and content providers, cloud providers, etc.) understanding and managing QoE is needed in order to respond quickly to quality problems, at different levels, before customers perceive them.

QoE is a multidisciplinary field based on social psychology, cognitive science, economics, and engineering science, focused on understanding overall human quality requirements [24]. Therefore, development of mobile networks with a user-centric approach supported by the management of QoE requires an interdisciplinary view from user, technology, context, and business aspects, with flexible cooperation between all players and stakeholders involved in the service providing chain. In that sense, the implementation of a user-centric approach, and therefore the deployment of QoE-based mobile networks, will imply attention to different challenges, which we have grouped in the following way: technical, business and market challenges.

2.1 Technical challenges

Satisfying user service quality expectations and requirements in a mobile environment implies the challenge of performing successful QoE management by addressing three fundamental aspects: QoE modelling, monitoring and measurement, and control and optimization.

1. **QoE Modelling.** There is a need for a deep and comprehensive understanding of the influencing factors and multiple dimensions of human quality perception to successfully implement QoE management in mobile networks. QoE modelling aims to model the relationship between different measurable QoE factors and quantifiable QoE dimensions (or features) for a given service scenario. Such models serve the purpose of making QoE estimations, given a set of conditions, corresponding as closely as possible to the QoE as perceived by end users. A QoE management approach will then aim to derive Key Quality Indicators (KQIs) and their relation with measurable parameters and quality thresholds, for the purpose of fulfilling a set optimization goal (e.g., maximizing QoE to maximize profit, maximizing number of satisfied customers).

While actual user's perceived quality may be obtained only via subjective assessment methods the goal is to build objective QoE models capable of estimating QoE based solely on objective quality measurements, so they can provide an indication that approximates the rating that would be obtained from subjective assessment methods. QoE estimation may require active inspection of the packets running within the network in order to extract input information for the QoE models, or the use of big data analysis addressing the estimation of user's behaviour, expectations and perceived quality.

QoE modelling in the context of mobile networks becomes more challenging due to additional issues posed by the particular conditions of wireless environment. Wireless channels are exposed to various phenomena such as noise, fading, or interference. This can generate packet losses, long and variable delays, which affect metrics such as Round Trip Time (RTT), Server

Response Time (SRT) or throughput. In addition, the wireless access can be a bottleneck in data transmission between the user's device and the gateway due to several other features such as wireless capacity in terms of speed, coverage radius, or limited bandwidth, and channel sharing with other users or signal strength levels. Another aspect to consider is the impact of hand-over on QoEsession. Delay and the increased amount of signalling traffic exchanged in session set-up, modification, or tear down procedure does not only affect radio and signalling resources, but also affects applications and device performance. This can generate different types of distortions in the content reception but also faster battery consumption due to the overload of computational resources on the mobile device. Finally, the size of the mobile device screen, as well as position and location can impact overall usability and lead to different user behaviour in the wireless context. Users are able to access services via various available wireless technologies and different mobile devices, which expose them to dynamic environments. It is particularly important to address the various usage contexts in wireless environments, since they may change the users perceived quality.

2. ***QoE Monitoring and measurement.*** QoE monitoring and measurement within the network may include data collection at different points such as the base stations within the various access networks, the gateways or routers within the core network, or the servers in the service/application, content, or cloud domains. The decision regarding data that should be acquired considering the wide spectrum of QoE indicators is challenging, but it is the prerequisite for any QoE monitoring and measurement approach. Secondly, choosing a location where to collect data is another critical issue in the QoE assessment process, that is, determine the location of monitoring probes. Thirdly, one should determine when to collect data: (1) before the service is developed; (2) after the service is developed, but not delivered; and (3) after the service is delivered. Additionally, how often data should be monitored and measured needs to be considered.

The acquired parameters may be derived from application level (e.g., content resolution, frame rate, codec type, media type), network level (e.g., packet loss, delay, jitter, throughput), or a cross-layer combination. Measurement and monitoring can contribute to the overall QoE management process in the context of improving the applications performance and the network use of resources. However, the challenge lies in reporting QoE feedback obtained at the client side back to the network for optimizing network performance. Finally, users privacy may be an issue when it comes to behavioural monitoring.

3. ***QoE Control and Optimization.*** From an operator point of view, the goal of controlling and optimizing QoE would be to maintain satisfied end users (in terms of their achieved QoE) in order to limit customer churn, while efficiently allocating available wireless network resources. QoE optimization in mobile networks is a very challenging task due to considerations such as limited bandwidth and its variability, the growth of mobile data traffic, the heterogeneity of mobile devices and services, the diversity of usage contexts,

and challenging users requirements and expectations, as well as the strive to achieve cost efficiency.

In this context, it is challenging for network elements responsible for resource management to adapt the constrained uplink and downlink wireless resources by assigning or periodically reassigning them to different service providers and users such that all resource competitors are satisfied. Therefore, QoE-driven resource allocation and scheduling mechanisms should incorporate the sensitivity of the human perceived quality. This requires a strategy to include the mapping of users opinions into resource allocation and scheduling algorithms in various wireless access technologies[50][39]. Also, QoE-driven resource management that would result in higher users satisfaction may be performed by implementing QoE-aware routing and packet controllers which give preferential treatment to certain types of packets, according to priority-based policies that may differ depending on operators interests. However, in resource variable and constrained systems, such as wireless networks, the priority to gain resources is primarily given to users having good channel condition and accessing low-demand applications that result in his/her satisfaction for a small amount of limited resources[49]. Furthermore, one has to account for users that may be given priority for paying more, although they may not have the above mentioned communication conditions [3]. Additionally, the impact of optimization on other parameters must be considered, since in certain cases improvements of one set of parameters may result in other parameters degradation (e.g., web browsing a high quality media content may prolong a web page response time).

2.2 Business challenges

Business domain directly affects the final intention of purchasing a service and the price at which a service provider can offer the service. From the service provider's point of view, it is very important to know how business characteristics such as advertisement, pricing, and billing aspects should be designed to satisfy customer needs. In broader terms, the service provisioning chain consists of customer model characteristics, and intra and inter enterprise business characteristics. Customer-centric characteristics include advertising, pricing, promotion, customer care, and brand image. Intrabusiness characteristics include a multimedia provider's goals, business strategies (sales, marketing), available resources, and their utilization. Inter-enterprise characteristics are vital characteristics for service providers because today the service provisioning chain is not within the monopoly of one provider, but is shared between different business entities (e.g., content provider, service provider, and network operator). Inter-enterprise business characteristics are related to legal, financial and service level agreement (SLA) aspects to fix the responsibilities between different stakeholders[24]. For providing superior QoE to customers, there must be an alignment of these three broad business characteristics with customer QoE requirements. Furthermore, it is also essential to bring the technological and business characteristics closer in order to create an integrated technical and business solution.

A key aspect of the analysis is how the business roles and responsibilities are distributed among actors. In this context, it is important to identify the business impact of implementing this approach in mobile networks service provision. This means an analysis and definition of business models that can/should be used to incorporate QoE-oriented types of services to be commercially available in the mobile market. Therefore, the business modelling analysis need to focus on the vital actors of the QoE ecosystem in order to find relevant aspects in the market; the most important challenges they will face regarding QoE improvements and user-centric design; and how their commercial strategies design and deployment infrastructure plans might consider QoE and user's perception.

2.3 Market challenges

With the implementation of a user-centric approach in the mobile networks, the priority is to measure and control the entire end-to-end experience of a customer when using a service or accessing a content. Therefore, this new approach requires a greater focus on the customer perspective; the performance of a service is not only measured based on having an infrastructure of systems and network elements working correctly, but also based on customers perception. Moreover, in order to reduce the churn rate, mobile operators have to focus more in the user's QoE [14] and scale down their efforts to the individual client level [25][31]. In that sense, operations need to be more focused on the business and client perspective, shifting from the measurement of service performance in terms of network reliability, to the final result of their effort on customers QoE. Consequently, implementing a Customer Experience Management system (CEM) is necessary to manage the user experience and the associated business aspects of the provisioned service.

The development of a CEM system will require providers to move from a static communication paradigm to a dynamic and interactive approach. In order to achieve this goal, priority must be put on improving the communication flow between the technical area and the various business functions (e.g., IT processes, post-selling area, management, customer support, etc.). This approach requires to effectively communicating the results of each area's internal operations to other stakeholders, including other departments and the customers themselves. In order to adapt to the new approach, providers should collect data from the different network and service elements and transform it into Key Quality Indicators (KQI), which can be correlated to QoE metrics. In this way, the organization's internal processes can be matched against the end-to-end customer service experience in order to measure their specific impact on customer's satisfaction. This approach provides a more reliable view of faults and service issues and their impact on service. Precise information about customers experience, and the impact of faults on it, will enable companies to better define their goals in terms of performance or service levels.

Aligned with the above, the implementation of a CEM will require the company to move from a traditional reactive model, in which they only track customers complaints and the companys subsequent response, to a predictive one.

A predictive model will require the service providers to collect and analyse data from business, technical and even social media, in order to predict customer expectations and habits and effectively focus investments in mechanisms and strategies to improve customer's experience.

3 Discussion on Net Neutrality Principles

Net Neutrality literature has become a quite extensive research field after its appearance in early 2000s, after initial calls from advocates, independent Internet Service Providers (ISPs) and academics related to open cable access in the US [28] [46] [59] [62]. The initial research has been mainly conducted in the fields of law and economics, analysing the different economic and market issues related to Net Neutrality. A common concept used in Net Neutrality is the public interest paradigm, where it is assumed that regulation will protect consumers from market failures such as monopoly [6] [40] [51] [53]. This is also an ideological debate that has arisen in many sectors of society, whether regulation is an efficient tool and what are its strengths and weaknesses. The key aspect in which Net Neutrality literature has focused is whether the ISPs have or not economic incentives to discriminate traffic, and how consumers and the economy will suffer from such behaviour. Going in more detail, circumstances like regulatory intervention, monopoly situation and the effects of market power are central in the discussion. On the other hand, regulators have so far responded differently towards Net Neutrality. The U.S. Federal Communications Commission (FCC) has rules oriented to preserve the Internet's openness and broadband providers' ability to manage and expand their networks. These rules are supported on four principles: transparency, no blocking of content, no unreasonable discrimination, and reasonable network management. Meanwhile, the European Commission believes that the existing rules on transparency, consumer switching and quality of service are sufficient to ensure competitive outcomes [35]. However, the European Union (EU) has recently stated that the Internet could be split in two, internet access services (IAS) and specialized services (SS). Internet access services should be open without traffic management. With specialized services operators may offer QoE for the end-user and manage the networks how they want. However, the splitting point between these two networks has not yet been decided [4].

Finally, we can see Net Neutrality literature offers studies on the potential behaviour of ISPs inducted from economic and business theory and observation from economic constraints. Commonly, scholars have offered recommendations on regulation but quite few attempted to explain why they do what they do [7]. One key concept to keep in mind is Institutionalism, which refers to the idea that institutions matter in shaping human behaviour and decision-making. Researchers on regulatory activity and behaviour theory have explored how formal institutions affect market outcomes. Based on this general introduction we have based our literature review in two main blocs: Technical and Economic arguments on the Net Neutrality debate. Within the economic arguments we will make a differentiation between economic rationales for discrimination, in-

centives in market power situations and effects of competition on incentives to discriminate [7].

3.1 Technical arguments

The basic argument in favour of Net Neutrality regulation starts with the idea of the technical principles articulated about the Internet's early architecture. From this perspective, Internet's technical design based on the best effort principle has provided for an unmatched platform, enabling flourish of new applications in the edges. Legal research has asserted that the nature of non-discrimination on the Internet was already introduced in the nature of its technical architecture, and that ISPs potentially treating traffic differently would be against this end-to-end design [17] [28] [26] [44] [59]. The main strength of Internet's design is that it enables innovation on the edges with great speed and low barriers of entry, which creates a very good competitive environment. Traffic discrimination could potentially end-up this environment by turning ISPs into gatekeepers, with decision power on which applications succeed or fail [27]. A contrary line of thinking states that traffic discrimination improves network by allowing ISPs to discriminate traffic with specific needs, making communication services more valuable to consumers. In addition to that, some scholars state that traffic management not only increases performance but it is also essential to efficient operation of broadband networks [9] [18] [41] [42] [45]. From performance point of view, prioritization schemes are mostly useful when networks are experiencing congestion. Therefore, those against discrimination argue that the best solution for congestion is expanding capacity. Changing network usage patterns that create performance problems may be one key driver for discriminatory traffic management [27] [29] [36] [16]. However, theoretical economic literature also states that traffic discrimination may lead into bandwidth inefficiency. The model from Economides and Hermalin shows that discrimination increases demand on high priority services leading to re-congestion in this lane [23] [57] [12].

3.2 Economic arguments

Technical arguments are relevant and needed to be taken into account, however ISPs decisions are mainly seeking increasing benefit. ISPs must justify their decisions in front of the stakeholders based on economic arguments and there are some researches that can provide insights on the economic rationales behind traffic discrimination. Economic literature on Net Neutrality has focused on how traffic management can make broadband services more valuable to final users and thereby increase subscription fees. Researchers have found that discrimination can enable a new market in which broadband offerings can better suit consumer demands. These observations rely on the basic idea that differential pricing has the potential to enhance user experience and value perceived [54] [62]. Discrimination is also considered to reduce costs, since ISPs pay interconnection fees based on the amount of traffic exchanged therefore we can find an incentive to reduce high volume applications via extra-fees [33] [44]. From a

welfare perspective, researchers defend the fact that discriminatory management creates the potential bandwidth to provide better services for all users. From the economic perspective, operators are nowadays constraint into offered flat rates and single price but by introducing traffic discrimination they would be able to charge based on specific type of consumption, which potentially could increase their benefit [30]. In the background of these reasoning lays the concept of a two-sided market, in which ISPs are in the middle charging and having relationships with both final users and content providers. This well-known market model has been studied in deep in literature [13].

Incentives in market power situations The idea that ISPs with Market Power situations may be willing to leverage its dominance is something familiar in the telecommunications sector. A dominant player in the telecommunications sector may have the incentive to exploit and control its network in order to foreclose competition reducing service options to consumers [34]. This can be done by simply raising prices or reducing the quality of independent applications, actions that will lead to market monopoly. This is the main concern of those who advocate in favour of Net Neutrality regulation, which in a situation of lack of competition ISPs would act on these incentives to discriminate [2]. However, everybody does not hold this idea that market monopoly may lead to traffic discrimination and there are scholars defending that there is not a cause-effect relation. Another important aspect to bear in mind is the network effect; the fact that the more users Internet has the more value it has as a platform. As a consequence of this network effects, ISPs would be against limiting the usage of the Internet in order to avoid reducing the value of the platform itself. Finally, the Internet is the ultimate communication platform that services a number of services and functions but, at the same time, increases current productivity and helps development of non-internet services. In this line, many scholars have highlighted the importance of internet in terms of its beneficial impact on society [26] [27] [29] [52] [55] [56] [59] [60] [61] [20] [52].

Effects of competition on Incentives to Discriminate A big part of Net Neutrality literature discuss over on whether competition can detain ISPs from traffic discrimination. Competition among ISPs is said to avoid independent service providers from being foreclosed from the market. In a broadly approach, competition generally reduces the ISPs incentives to traffic discrimination because discrimination causes loss of broadband users. The big question here is to which extent can competition reduce the incentives to discrimination and if it is enough or regulation is needed. This question remains unclear, and may be central for future research on the topic [8] [19] [22] [26] [28]. Defenders of competition as a sufficient tool to avoid discrimination, also identify that the bigger problem is the lack of competition in some broadband markets, such as the U.S. In addition to this line of thinking, there are scholars stating that intense competition is not a sufficient tool in order to prevent discrimination. Technical incentives remain relevant and ISPs could potentially use discrimination to enhance their

own services. Finally, the ones considered about stopping innovation state that competition based only on customer preferences is not enough as closure to create a cost of innovation that it is not reflected in consumers purchasing decisions [26].

4 QoE and Net Neutrality Principles

As show above, the implementation of QoE-based service provision will impact the mobile networks ecosystem at different levels. Therefore, to analyse the impact of Net Neutrality on QoE-based service differentiation, it is necessary to identify how the challenges of QoE in mobile networks, at technical, business and market level, will relate to the Net Neutrality principles. This contrast is presented in Table1. From a technical point of view, in order to implement QoE-based services it is necessary to understand, design and deploy suitable technical solutions to provide the user with the best possible experience. When deploying these kinds of solutions usually monitoring, filtering and prioritization of traffic may be involved in the process, creating a conflict with Net Neutrality. One of the key tools to provide awareness and activate traffic management policies is deep packet inspection (DPI). This technique digs into a packet to determine precisely what it is delivering and how various elements measure up against a predetermined norm. These granular assessments, combined with machine intelligence and big data analytics, will produce a tremendous amount of data that can help to improve QoE in a number of ways. Beyond that, the placement of sensors in the field and their assessment of QoE at strategic points can help in root cause analysis of problems, aid in the planning of system upgrades and even support sales efforts. However, it remains to be seen how deeply operators can leverage it. The uncertainty about Net Neutrality is causing some operators to move a bit more slowly on QoE in general and DPI in particular.

In addition to DPI, provider can also implement traffic management techniques in order to meet user's demands and expectations. Traffic management is a collection of technologies and policies which lead to different types of traffic being treated differently, which in principle goes beyond the best effort principles that support the original Internet idea. Without traffic management, different data packets are treated more or less equally, which means that under congested conditions traffic management would cause some data to have a greater chance of being delivered than others. Traffic management can be implemented in different ways, which include:

- Guaranteeing delivery of data or reserving bandwidth for that data;
- Prioritizing certain types of data in the event of queuing;
- De-prioritizing certain types of data;
- Restricting certain types of data or the bandwidth allocated;
- Blocking certain types of data.

In one hand, the traffic management could guarantee or prioritize data for sensitive applications and reduce the congestion to manageable levels, allowing fair

Challenges	Quality of Experience	Net Neutrality
Technical	<ul style="list-style-type: none"> – Qoe modelling. – QoE monitoring and measurement. – QoE control. 	<ul style="list-style-type: none"> – End-to-end internet design is protected - No traffic discrimination is allowed – Efficient Traffic management – No discrimination based on the Classification by types of user/device/content
Business	<ul style="list-style-type: none"> – Personalized/QoE adapted services. – Coordination/cooperation of different business entities. 	<ul style="list-style-type: none"> – Zero-rating services (developed on the use cases section). – Prioritized services via commercial offering.
Market	<ul style="list-style-type: none"> – Implementation of Customer Experience Management system (CEM) – Improving the communication flow between stakeholders. – New processes and tools to monitor Key Quality Indicators (KQIs). – Proactive resolution of QoE problems. 	<ul style="list-style-type: none"> – NN regulation more focus on protecting competition between OTT/Content and not protecting communication providers.

Table 1. QoE challenges and Net Neutrality principles

use for all the users, increasing their satisfaction levels. On the other hand, the traffic management can restrict or block certain applications and make other peoples traffic take priority, which can generate a negative impact on the users perception. However, it is important to consider that at an individual connection or device, a user cannot necessarily observe traffic management directly. The amount of traffic management and its effects on users can differ according to the level of congestion on the network. Both the amount of traffic management and its impact depend on the level of traffic at the time. User can observe the performance of an application and decide whether the performance is acceptable or not. If the application works as expected, he or she can infer that the data have arrived in a timely manner. But it is impossible to tell whether the data have arrived only because they have been prioritized, or whether they have

arrived because best efforts are perfectly adequate. Full transparency would involve providing data that describe the effects of policies over time and therefore the resulting quality of experience for users. This implies the need for diagnostic tools to help users understand whether and in what way traffic management is affecting them. Net Neutrality stands for the equal treatment to all communication packets on the Internet, meaning that any kind of filtering can clash with these rules. The details of the concrete regulation in each country can define in different ways of relevant is this conflict and how it is regulated.

One of the potential business applications of QoE-based service differentiation is the definition of a number of price-tiers, offering different QoE levels connected to the pricing. This policy may redound on prioritizing some products over others or prioritizing certain types of services over others. This type of prioritization would not be done at a technical level, but at a commercial level. Initially, one can not say if this pricing strategy will redound on breaking Net Neutrality principles with certainty, however it is potentially possible that this prioritization is done based on favouring services offered by the communications providers and therefore hurting competition on the content provider side. In some of the existing regulations on Net Neutrality, pricing and zero-rating is clearly defined as a factor breaking Net Neutrality principles, pointing out the need of regulation on it.

Finally, Net Neutrality regulation is been another reason of conflict between Mobile Network Operators and Over-The-Top services, with the latter being favoured in terms of regulation supporting competition between over-the-top (OTT) actors and not that much between mobile network operator (MNO) and OTT. In this sense the regulation on Net Neutrality will shape how the telecom market and the content provider market develop.

5 Business Models for QoE in the Net Neutrality Context

5.1 QoE end-to-end Ecosystem

QoE is an assessment of the human experience when interacting with technology and business entities in a particular context[24]. In that sense, an analysis of the QoE ecosystem should consider different players interacting with each other at different levels (technical, social, business) and with different approaches. For understanding the structure of the QoE ecosystem it is important to define/identify a framework that describes the main interactions between users, business, and technology in a communication service provision. This is illustrated in Figure 1. The framework includes two actors that have independent aims: customers who want to maximize their happiness, and content and network providers who want to maximize their income. Services are offered and networks are built only if service providers have opportunity for profitable business and customers have possibility to obtain real benefits. On the other hand, any commercial company shall make their operational decisions based on clear business objectives. A typical objective is to maximize Return of Investment (ROI). In the proposed

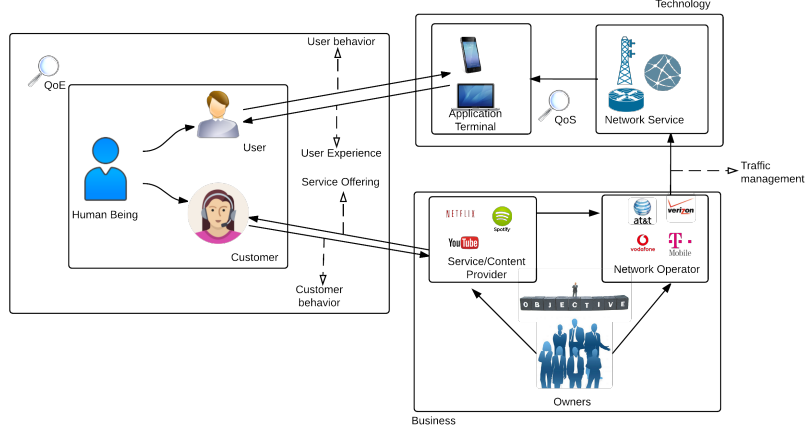


Fig. 1. QoE Ecosystem

framework it is also possible to identify different interactions. For instance, content, services and network providers try to provide a better user experience by ensuring network and service performance based on QoS models. From a business side, these actors need to develop economic models and business models for their technological infrastructure. This business interaction also implies an identification of how effectively the operators can utilize their resources to increase their profit by retaining customer as well as attracting new ones. The interaction between user and providers develops customer experience models to understand customer requirements with respect to business aspects. Customer care, cost, promotion and brand image may influence customers to develop positive or negative feelings about a service. Therefore, QoE is a convergent concept that combines the influences of all these aspects to produce QoE requirements. The question here is how changes in the user experience of the offered service or application impact the value that the user perceives from the service. By offered service we mean here the part of service providers offering that is able to satisfy one type of need.

5.2 Business Model mapping to Osterwalder's framework

QoE-awareness in mobile networks might be the solution and a new way to improve the service provision, resource management and generate new revenue streams for content and network providers. However, the business opportunities for actors generated by this new approach are still unexplored. A tentative illustration of Osterwalder's business model framework [38] applied on QoE differentiation is shown in Figures 2 and 3 and described as follows.

<u>Key Partners</u> <ul style="list-style-type: none"> Content providers Users' generated content 	<u>Key Activities</u> <ul style="list-style-type: none"> Platform management Development & maintenance Service provisioning Service promotion Software development Billing 	<u>Value Proposition</u> <ul style="list-style-type: none"> Improved user experience QoE differentiated services Customized content (QoE levels according to expectations: Basic and Premium QoE plans) 	<u>Customer relationships</u> <ul style="list-style-type: none"> Automated services Personal assistance Communities Retention Acquisition Membership 	<u>Customer segments</u> <ul style="list-style-type: none"> Consumers interested in a specific type of content service SME Enterprises (In SME and enterprise cases they are interested on priority to type of content of their interest)
<u>Key Resources</u> <ul style="list-style-type: none"> Network brand Customer base Content agreements IT staff Billing system 			<u>Channels</u> <ul style="list-style-type: none"> Retail network Mobile operator web Partners ecosystem 	
<u>Cost structure</u> <ul style="list-style-type: none"> Marketing Network Platform development Personnel costs 			<u>Revenue streams</u> <ul style="list-style-type: none"> Service revenue attached to a subscription fee Basic subscription for a basic profile service Customized subscription based on profiles Fees for ads in content Revenue share with partners 	

Fig. 2. QoE Business model from a mobile operator perspective

<u>Key Partners</u> <ul style="list-style-type: none"> Payment providers Distribution partners Mobile operators 	<u>Key Activities</u> <ul style="list-style-type: none"> Service provisioning Service promotion Software development Billing 	<u>Value Proposition</u> <ul style="list-style-type: none"> Improved user experience QoE differentiated services Customized content (QoE levels according to expectations: Basic and Premium QoE plans) 	<u>Customer relationships</u> <ul style="list-style-type: none"> Automated services Communities Membership 	<u>Customer segments</u> <ul style="list-style-type: none"> Consumers interested in a specific type of content service SME Enterprises (In SME and enterprise cases they are interested on priority to type of content of their interest)
<u>Key Resources</u> <ul style="list-style-type: none"> Software developers Software Billing system 			<u>Channels</u> <ul style="list-style-type: none"> Content provider web Partners ecosystem 	
<u>Cost structure</u> <ul style="list-style-type: none"> Software development Complaint management 			<u>Revenue streams</u> <ul style="list-style-type: none"> Service revenue attached to a subscription fee Free Fees for ads in the content 	

Fig. 3. QoE Business model from a content provider perspective

- **Offer:** QoE differentiation will offer several specific value propositions for mobile operators and content providers customers. First, customized content oriented to guarantee/provide QoE levels according to users' expectations. The fulfilment of customer demands and user experiences are becoming more the main differentiator for the effectiveness of mobile operators and service providers. In this era of competition, poor customer experience leads to a chain reaction of negative word of mouth, pushing customers into the arms of waiting competitors. For instance, a customer who pays for online video on demand service may have stricter video quality requirements than a user who uses free video on demand service.

Mobile operators and content providers may learn if a particular demographic is more interested in pricing and off-peak promotional rates. They can use this to inform decisions on pricing plans and investments in technology/service they should make for the future. If they determine that off-peak pricing has only a limited impact on QoE for their main demographic, they may choose to market aggressively to another demographic, investigate alternative pricing mechanisms, and/or upgrade their delivery infrastructure to improve QoS. Additional could be added to the product offered to enterprise customers segment by including more advance type of content. QoE differentiation will allow customers to enjoy more flexible and rich services improving the user experience adjusted to their expectations.

- **Customer:** The QoE differentiation value proposition could be directed to different segments-consumers and businesses. The former would include youths and adults consuming mobile data traffic on video, VoIP, gaming, etc. According to Ericsson, mobile data traffic is expected to grow at a compound annual growth rate (CAGR) of around 45% over the next 5 years [14]. In this segment, music, movies, games and online TV based services might be the key type of content. For the business market, QoE might start with communication related services followed by collaboration and videoconferencing based services.

With regard how the mobile operator communicate the value proposition to the customers, this would happen through mobile operators retail network, mobile operator web platform and through partners channels. On the other hand, content providers can reach their customers using their web channels as well as using partners ecosystem.

- **Infrastructure:** From mobile operator perspective, the network asset is important for offering end-to-end services. To deliver QoE differentiated services, it will be necessary to develop/implement prioritization systems. Together with the infrastructure, mobile operators already have an important customer base and a network brand build after years of experience in the market. They also have billing solutions and marketing competences that will be important at the moment of launching QoE differentiated services. From the content provider perspective, strategic partnerships with leading mobile operators are necessary to establish in order to develop and operate competitive QoE differentiated services. Partnership with 3rd party developers is then an important asset. For this role, partnerships with marketing

and sales are also needed. The billings systems and competence along with network assets are important key resources.

- **Finance:** Major cost categories are related to start-up investments connected to establishing the new business unit and running personnel cost. A mobile operator will typically have costs related to running the QoE differentiation, billing systems and for IT personnel. The latter two are relevant also for the content provider. Other relevant cost would be related to administrating the customer base, support and marketing of product offerings. The revenue streams for network and content provider are service revenue attached to a subscription fee or alternatively from subscription. It might be possible to generate revenues by charging fees for ads in content. For the content provider, and due to required services provided for by 3rd party developers and other partnering vendors, revenue split with these partners is necessary.

5.3 Implications of Net Neutrality in the Business models

Net Neutrality has two potentials impacts on the Business Models defined previously; these changes are focused both on the mobile operator (MNO) and on the content provider.

The impacts on Net Neutrality principles we considered are based on the Net Neutrality regulation proposed and implemented in countries like U.S., Slovenia and the Netherlands. The main impacts of respecting Net Neutrality principles defined in these regulations are: traffic prioritization and commercial offerings.

Traffic prioritization affects in a crucial way how the key activities of the mobile operator or communications provider are performed. Following Net Neutrality regulation, throttling, speeding or blocking content and therefore traffic is strictly forbidden. MNO have claim that they are facing an increasing challenge with the "revenue gap" issue, where traffic prioritization is one of the potential solutions. However, this clashes directly with the Net Neutrality principles and therefore MNO should find new ways to improve network performance.

The second aspect impacted by Net Neutrality regulation is the potential commercial offerings by the MNO's and Content Providers. In one hand, offering differentiated services would be clearly uncertain considering the aspect commented in the previous paragraph. In the other hand, the commercial offerings known as "zero-rating" can also be considered as breaking Net Neutrality principles. However, as stated in the section "zero-rating" use cases in this paper the authors consider that for this type of commercial offering this is not completely clear and that the cases should be reviewed in an individual process taking in account the regulation and the impacts of this service.

5.4 Zero-rating cases

Zero-rating (also called toll-free data or sponsored data) is the practice of mobile network operators (MNO), mobile virtual network operators (MVNO), and Internet Service Providers (ISP) to not charge end customers for data used by

specific applications or internet services through their network, in limited or metered data plans [58].

Zero-rating commercial offerings have been at the centre of the Net Neutrality discussion from the beginning. As we have described previously, Net Neutrality aims to treat all bits and packets in the same way without prioritizing one type of traffic over other. In this context, zero-rating commercial offerings clearly creates an incentive on the user to stay using the zero-rated service therefore creating an unfair competitive situation. The ultimate consequence of zero-rating could be harming competition on the content providers side, by limiting competition among them and limit consumer choice. This situation can be even more relevant in situations where operators also offered integrated content services.

Some of the current regulations on Net Neutrality, like Slovenia and Netherlands, include banning zero-rating offerings. This shows the relevance of considering both technical and market aspects. Within this concept we can find two different ways of providing zero-rating services: zero-rating for concrete services and zero-rating for a category of services.

Zero-rating for specific services We consider zero-rating for specific services, the kind of zero-rating that refers only to a concrete service. For instance, an example of this type of commercial offering is zero-rating offered in Brazil by the operator Claro [21], which offers zero-rating for Whatsapp messaging app and Facebook social network.

This is the most common case of zero-rating commercial offering and clearly creates an incentive for the user to continue using the offered services, in this case Whatsapp and Facebook. In these situations users will tend to continue using these services because of the economic saving obtained and this situation would harvest competition on messaging and social network platforms.

Zero-rating for a service category Zero-rating for a service category refers to the zero-rating commercial offering connected to a complete service category, an example of the this offering is zero-rating to all streaming music services. This offer has been offered in the Swedish market by 3 [37] and in the American market by T-Mobile [48].

While zero-rating for specific services is clearly affecting competition, in this case it is not that clear. This offering clearly creates an incentive on the user side to use and consume more music streaming services, while at the same time seems to not affect competition. Competition on music streaming services will remain unaffected, and competition with other types of content services will remain similar. However, this is still a relatively new offerings and more observation needs to be done.

6 Conclusions

In this paper we have introduced an initial analysis of how the net neutrality principles will impact the implementation of QoE-based differentiation in the

service provision. In our study we focus on the identification of the Challenges of QoE in mobile networks, at technical, business and market levels, and how they can be impacted by Net Neutrality principles. We introduce the concept of Net Neutrality, where one of the main discussion points is whether the ISPs have or not economic incentives to discriminate traffic, and how consumers and the economy will suffer from such behaviour. Going in more detail, circumstances like regulatory intervention, monopoly situation and the effects of market power are central in the discussion. We could see that Net Neutrality may influence QoE in two ways: how deeply operators are allowed to examine the packets flowing through those networks in order to use the extracted information to feed mechanisms to improve users QoE, and the transparency about the prioritization policies implemented to fulfil users expectations and requirements. Finally, we propose business models based on the QoE-differentiation of mobile services, and analyse how they can face Net Neutrality principles.

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