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Value Creation in a QoE Environment

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**Tobias Heger, Maximilian D. Schlesinger
Value Creation in a QoE Environment**

Abstract

User behavior of multimedia services currently undergoes strong changes. This is reflected in several recent trends, e.g. the increase of rich media content consumption, preferences for more individual and personalized services and the higher sensitivity of end users for quality issues.

These changes will eventually lead to strong changes in network traffic characteristics: rising congestion in peak times and less availability of bandwidth for the individual user. As a result, the quality as perceived by the end-user will decrease if network operators and service providers do not anticipate the required changes for the network.

Measurable network requirements such as available video and speech quality, security and reliability are addressed by technologies that are commonly summed up in the Quality of Service (QoS) concept. However, the end-users' perception of quality is only reflected in the wider concept of Quality of Experience (QoE). This takes the measurable network requirements into account as well as customer needs, wants and preferences. For the implementation of QoE technologies several network components need to be added or changed resulting in high capital expenditures. Yet, it is not clear if these costs can be compensated with efficiency increases. Thus, new revenue streams for the network operator are necessary to incentivize investments in QoE technologies.

In this paper we address four new value creation models that can serve as basis for more elaborated business models for network operators and other actors. We show how interest in QoE of the user, the content provider, the service provider and the advertiser induces new revenue streams. These models are embedded in five possible future QoE scenarios that reveal regulation, end user quality sensibility and end-to-end support as major issues for the future.

JEL codes: L86, L96, O33

Key words: Business Models, Quality of Experience (QoE), Quality of Service (QoS), Value Creation

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1 Introduction

Within the last decade the Internet has evolved from static HTML pages to interactive, graphic-driven services. The Web 2.0 evolution led to more and more social networks, blogs, interactive games and video services. Graphics and functionality of these services increased steadily and personalization and interaction became regular features. Today, especially for specialized premium services such as health services, financial services or other B2B services, technological evolution and more demanding requirements concerning service reliability are of particular importance. These services necessitate high-speed bandwidths and failure rates approaching naught. The recent rise of high definition (HD) videos, streaming and network games shows that high-quality Internet access will also be of increasing interest within the private sector.

Concurrently to steady growth of requirements in the Internet the actually available bandwidth increased. Today fast ADSL or VDSL or even fiber connections have replaced slow modem or ISDN connections from the beginning of the digital age. However, network operators still rely on overprovisioning to guarantee service availability. Overprovisioning means that the network is dimensioned in a way that every peak demand can be fulfilled. While this strategy renders more intelligent and costly network equipment unnecessary it nevertheless leads to more idle times of resources and thus to growing costs. Therefore increasing bandwidth demand also leads to increasing costs.

Within the last years, solutions to solve this problem and to create possibilities to guarantee quality levels were often subject to research. With the Quality of Service (QoS) concept quality classes were created and guarantees to satisfy specific technical parameters were introduced. The more user-centric concept of Quality of Experience (QoE) includes the subjectively perceived quality of the end user in addition to QoS. Both concepts require additions and changes of the network that have to be implemented by the network operator. However, the motivation for the network operator to integrate them is ambiguous: efficiency and quality increases to cope with growing bandwidth demand are compelling. High implementation costs, on the other side, might exceed the positive effects.

Until now, research in the area of QoE concentrated on technical solutions for QoE. The business impact and economic motivation especially for network operators was investigated to a lesser extent, yet.

The contribution of this paper is the analysis of the following issues:

- The motivation for different actors to strive for higher QoE for the end users.
- The requirements that need to be met for the successful integration of QoE enhancing technologies.
- Potential new revenue streams within the content delivery environment triggered by QoE technologies.

For the analysis of these issues we concentrate on content-centric services such as video, voice and music delivery. Content delivery is one of the major application areas for QoE technologies due to high quality sensitivity and very high bandwidth requirements.

In chapter 2 today's major problems are introduced, complemented by a brief literature review on QoS and QoE concepts. Chapter 3 proceeds with our methodological approach. Current value creation models are presented in chapter 4. The changes that QoE technologies induce are subject to discussion in chapter 5. These new value creation models are evaluated in different future QoE market scenarios (chapter 6). In the end, chapter 7 offers major implications and draws the conclusion of the analysis.

2 Content Delivery in Telecommunication Networks

2.1 Major problems of today's networks

Network operators are confronted with massive network traffic increases while seeking to reduce investment and operating costs for their networks. New service offerings such as video streaming and personalized services led to a steep increase of network traffic [1]. Five main trends can be identified that require more intelligent, adaptive network management mechanisms [2-6]:

1. *Rich media consumption.* The increasing availability of IPTV offerings, e.g. "Entertain" of the Deutsche Telekom AG, lead to surges in network traffic. Especially in the early evening hours high network traffic peaks can be observed.
2. *Service personalization.* Besides traffic neutral service personalization, e.g. personal settings in web platforms, other personalization can induce changes in the network. The latter is valid for Video-on-Demand (VoD) platforms such as Google's YouTube. Instead of broadcasting linear television without responses

from users, VoD services require dedicated connections – unicasts – to each user.

3. *Time, place and device sovereignty.* Smartphones and tablet computers pave the way for independent media offerings of the future. These will allow watching any video content at any time on any different devices. To realize such services, content needs to be streamed over unicasts in fixed and mobile networks.
4. *Quality expectations.* After years of low-quality video offerings in the web – mostly due to poor Internet connections – end users are becoming increasingly sensible to quality issues. Especially IPTV offerings need to maintain a perceived quality level similar to that of other television transmission technologies to succeed.
5. *Efficiency increases.* The network operators' wish to decrease the degree of overprovisioning, i.e. increase network efficiency. Currently, stable services are assured due to greatly overdimensioned networks. These networks operate at their capacity limit in peak times only. Most of the times resources are unused which is cost intensive and leads to unnecessary high environmental load.

Fibre-to-the-Home (FTTH) or Fibre-to-the-Cabinet (FTTCab) roll-outs will increase network capacity greatly [7]. However, these networks require massive capital expenditures into the infrastructure while postponing the impending problem only [8]. Additionally, fibre networks do not lead to efficiency increases. To the contrary, at the beginning the degree of overprovisioning will increase significantly instead of being reduced [5, 9]. Thus, other possible solutions for these challenges such as Quality of Service (QoS) and Quality of Experience (QoE) are currently subject to research.

2.2 Quality of Experience

Especially quality sensible services require high-speed broadband Internet connections with real-time, interactivity, security and reliability capabilities. Whereas the term Quality-of-Service is not used consistently in the literature, it usually implies the possibility to differentiate individual services and the possibility to allocate different quality parameters to services. Technically, usually four parameters are used to determine the quality of a data connection: the available bandwidth, delay time, jitter and packet loss [10]. With these parameters, different service classes or priority levels can be created, ranging from level 0 called "*best-effort*", to level 7 called "*layer 2 network control re-*

served traffic”, with latency and jitter less than 10ms [11]. However, QoS does not address the subjective end user perception of quality that is harder to measure.

The notion of Quality-of-Experience (QoE) is more user-centered than QoS. It aims at linking together the technical parameters described above and the users’ perception of quality. Several definitions of QoE exist:

- Mostly used is the definition of ITU-T SG12 that describes QoE as “*overall acceptability of an application or service, as perceived subjectively by the end-user*” that “*may be influenced by user expectations and context*” [12].
- Lopez et al. describe QoE as “*extension of the traditional QoS in the sense that QoE provides information regarding the delivered services from an end-user point of view*” [13].
- Soldani et al. define QoE as “*how a user perceives the usability of a service when in use – how satisfied he/she is with a service in terms of, e.g., usability, accessibility, retainability and integrity*”[14].
- And rather recently Fiedler et al. defined QoE as a concept that describes “*the degree of delight of the user of a service, influenced by content, network, device, application, user expectations and goals, and context of use*” [15].

All definitions except for the very broad one by Lopez et al. have in common that quality levels are defined by the user’s *perception* in addition to measurable network parameters. The user’s perception may be influenced by the *network*, the *context* (i.e. the kind of service used, prices and content), *usability* of services and applications and his/her *expectations*.

The extended set of influencing factors can be addressed on very different levels. In the context of QoS, network improvements were mostly developed on the lower OSI levels to improve and control the QoS service parameters. When taking into account user perceptions, improvements need to be realized on higher levels as well, i.e. optimizations up to OSI layer 7 – the service layer – need to be addressed. Table 1 summarizes the three concepts.

Concept	Description	Realized on OSI Layers	Measures
QoE	Extension of QoS understanding with user perceptions, quality optimization up to the service level	Layer 1 – 7	<ul style="list-style-type: none"> • Network • Context • Usability • User expectations
QoS	Classification into quality classes based on measurable parameters, pricing according to quality classes, quality optimizations on the network level	Layer 1 – 4	<ul style="list-style-type: none"> • Bandwidth • Delay • Jitter • Packet Loss
Best Effort Internet	Basic availability of Internet connectivity and services	Layer 1 – 7	<ul style="list-style-type: none"> • Bandwidth (no assurances)

Table 1: Quality concepts, potential improvements and measures.

Several research projects address QoE, ranging from systematic QoE measurements [16] to the development of a set of technologies that aim to improve different aspects from the network to the service layer [5]. The latter found a multitude of possibilities to improve the perceived quality. The following six selected techniques show the range of possibilities that exist exemplarily [17-23]:

1. *Monitoring and traffic estimation mechanisms.* Allow forecasts of congestion situations and triggering adequate reactions to congestion problems at occurrence.
2. *Scalable video.* Can be used in at least two cases. First, the variety of end user devices can be served with the correct resolution, minimizing CPU load on the devices. Second, downscaling of video in case of traffic peaks allows continuation of streaming instead of complete failures.
3. *Routing, notification and admission control mechanisms.* Increase network efficiency by optimizing link usage, provide technical solutions to trigger reactions in case of service failure, allow notifying end users about current and estimated problems.

4. *Caching*. Caching within the access network, often referred to as microcaching, allows answering similar requests fast and without causing traffic in higher network aggregation levels.
5. *Video streaming based on Mean Opinion Scores (MOS)*. Studies (e.g. [24]) found that the Mean Opinion Score fluctuates depending on the kind of the movie despite of the same bit rate, resolution, etc. By implication this means that the perceived quality on a certain level can be achieved with different video parameters, potentially allowing either improving or economizing video streaming services.
6. *Policy-based EPGs*. Electronic Program Guides (EPG) can be improved based on manually or automatically generated user policies. These can be created based on previous user behavior, manually selected preferences etc.

Summarized, research already shows that QoE improvements are technically possible. It also shows that most QoE improving technologies need to be implemented or supported by the network. Thus, the network operators need to adapt their network accordingly. Whereas the different approaches promise to increase customer satisfaction and increase network efficiency these benefits cannot be expected to cover capital expenditures and operating costs for the network operator [25]. Thus, new revenue streams are necessary to incentivize the adoption of QoE technologies by network operators.

3 Methodology

This paper follows a six-step logic for the development of new value creation models in the QoE environment. The results are based on different experts' insights within the EUREKA CELTIC project "RUBENS"¹. Further results of the project can be found in [25-27]. In this project several European telecommunication operators, one network device manufacturer, universities and research institutes partnered up to investigate and develop technologies for QoE improvements and to assess their economic impact.

Figure 1 shows the logic of value creation process, architecture, models and business models that is followed in this paper.

¹ For details about RUBENS see <http://wiki-rubens.celtic-initiative.org/>.

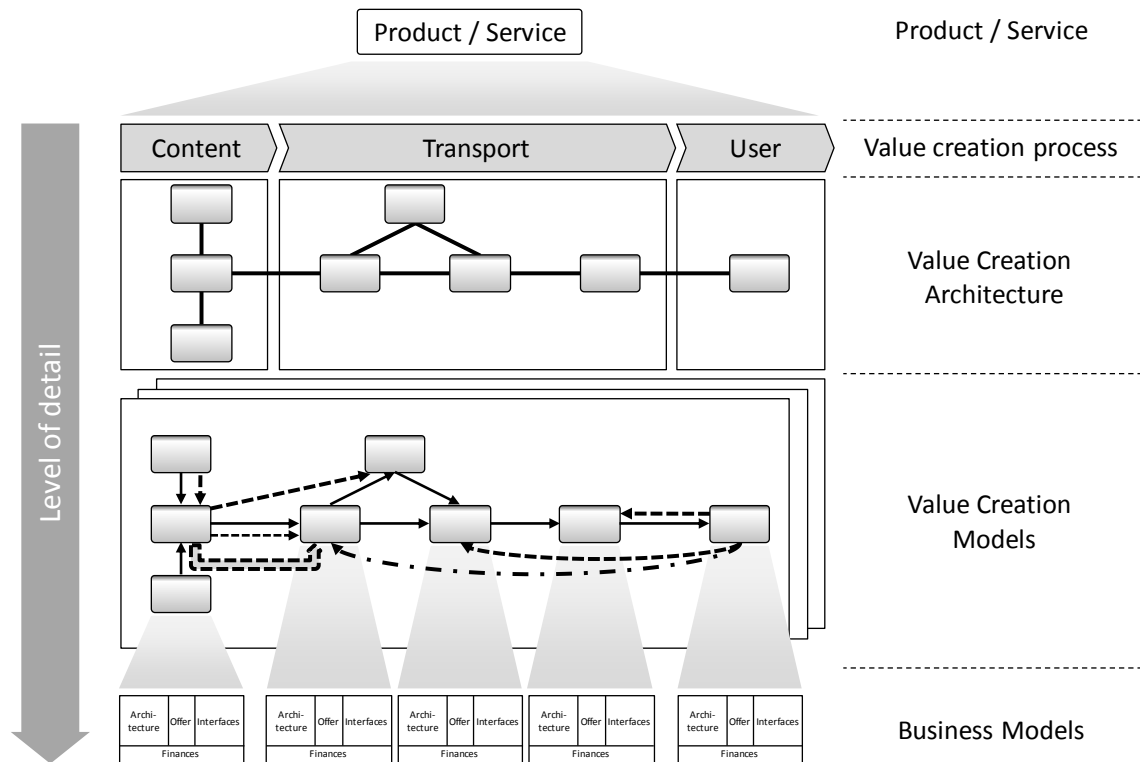


Figure 1: Definition of terms used in this paper.

Whereas the *Value Creation Process* structures the service delivery process roughly, the *Value Creation Architecture* shows the relevant actors and undirected data links among the actors. In the *Value Creation Models* several distinguishable revenue flows are added: for connectivity and transport, for service use and for QoE improvements. Finally, *Business Models* are focused on single actors. Here, different aspects such as financial aspects, value proposition, channels and interfaces and product and production architecture of one actor are addressed [28].

In this paper we will focus on value creation models deduced from the more abstract value creation process and architecture.

The six steps taken in this paper are as follows: First, Quality of Experience is described and defined based on a literature review and the common understanding of QoE that was developed in several talks with experts in the RUBENS project. Second, the value creation process and third the value creation architecture for content delivery over common networks are reproduced. The simple value creation process was mostly added for structuring reasons. The value creation architecture shows the involved actors in content delivery and necessary links for data transport between them. However, no revenue streams are involved at this stage. Based on the knowledge about the relevant ac-

tors for content delivery current value creation models are shown and discussed in the fourth step. Technologies for QoE improvements that are currently under development or planned allow anticipating additional revenue streams in the future. Therefore, in the fifth step, the resulting new value creation models are presented and shown. Finally, in the sixth step, the newly designed models are evaluated under prospect of five future scenarios that were developed in the RUBENS project [27].

4 Present Value Creation in the Content Delivery Market

In this chapter today's situation is described. The value creation architecture is outlined including descriptions of the involved actors in section 4.1, followed by the present value creation models in section 4.2. Besides the major data transport links among the actors' payment streams are included as well. They are split into classic downstream services, Peer-to-Peer (P2P) services and a special case for an IPTV service without regular Internet connectivity.

4.1 Value Creation Architecture

The present value creation architecture is divided in three steps: "content & services", "transport" and "user" (see Figure 2).

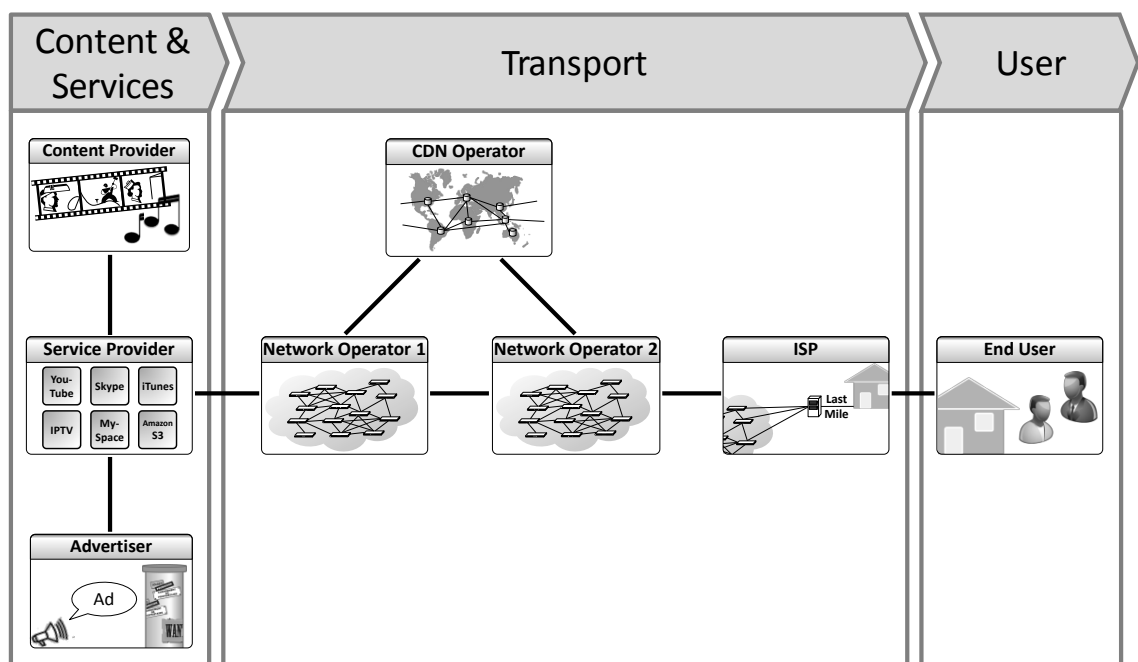


Figure 2: Description of present value creation architecture

The latter represents the end user of services and the consumer of content. The end user is connected to the Internet by an Internet Service Provider (ISP).

ISPs are part of the transport section as well as network operators and Content Delivery Network (CDN) operators. The ISP in our definition mainly manages customer relationships and is not necessarily in possession of a network. These fixed and mobile networks are operated by network operators. Basically, two kinds of network operators exist currently: telecommunication operators and cable operators. Large telecommunication operators are Deutsche Telekom AG, British Telecommunications Group, France Telecom, Telefónica and KPN. Examples for cable operators are Telenet, Kabel Deutschland and Ono.

Globally many network operators coexist. They are connected at some point and together account for the global telecommunication network. Additionally, specialized companies distribute content and services in a very efficient way. The Content Delivery Network (CDN) operators peer with different local network operators and therefore bridge the normal Internet connections with their own highly efficient network and caching systems. In our model CDN operators mainly act globally. Currently, the largest CDN operator is Akamai. It distributes content for Apple's iTunes and Google's YouTube, for example.

The content & service value creation step consists of the service provider, the content provider and the advertiser. The service providers offer various services, e.g. video services, VoIP or online applications. The aforementioned iTunes and YouTube are well-known examples as are Skype, Facebook, MySpace and Google Docs. The content for many of these services is provided by content providers (e.g. TimeWarner, BBC, RTL). Content providers own rights to content, e.g. music, movies and books. They do not necessarily have to produce the content themselves. Often, they act as intermediary between service providers and content producers. The important aspect in our model is that they provide and control the access to the content and try to bring it to the market. The advertisers provide ads and mostly serve as financing option for services.

4.2 Current Value Creation Models

Each actor class within this value creation architecture can pursue several different business models. Especially for service providers a large number of different business

models can be observed. However, they all have in common that the service or content is offered by the service provider, transported by the network operator and requested by the user.

Network operators apply a large variety of business models and follow different technology strategies (fixed line copper, fixed line coaxial, different wireless networks, etc.). Nevertheless all network operators are connected and transport data in some way. ISPs manage the customer relationships and differ only in service parameters (cost per month, available bandwidth, extra services, etc.). CDN operators build their business around offerings for fast, reliable data availability and content providers sell their content in multiple ways.

The core of the business models of different companies that we summarized in generic actors is quite similar. Thus, we chose a rather abstract level for a first analysis of the activities and consequences for revenues in the developing QoE environment.

Based on these generic actors and the interaction in between the following elementary, simplified value creation models can be deduced:

- Classic downstream services (section 4.2.1)
- P2P services (section 4.2.2)

In both cases transport and services or content are detached. As common today, users pay for Internet connectivity. Services are either used on a pay-per-use basis or for free financed by advertisements.

In addition to these rather universal value creation models we also looked into a special case:

- IPTV without regular Internet access (section 4.2.3)

Here, the service is financed by the user as well as advertisement as before. But in contrast to both other models, the transport is financed indirectly. Users have contracts with the service provider only (and might have to accept advertisements additionally). The service provider manages transport and connectivity to the end user. Thus, the service provider handles the contact to network operators and ISPs.

4.2.1 Classic Downstream Services

This value creation model describes all scenarios where the user requests a service or content from the service provider (see Figure 3). The services are either pay-per-use services or for free. In case of the latter the services are financed by advertisements. In both cases the service providers acquire content in advance.

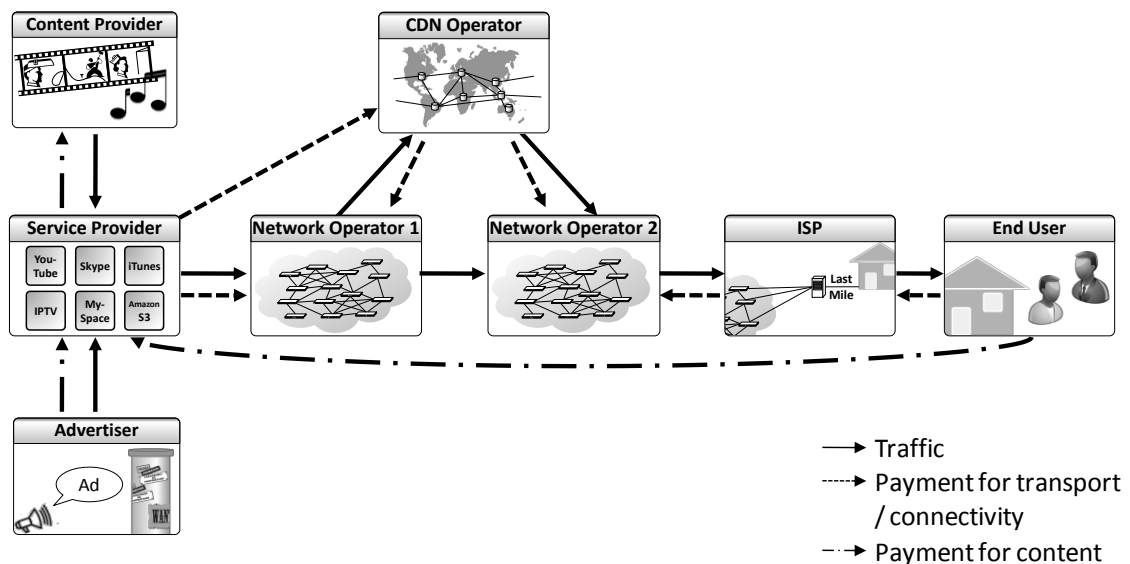


Figure 3: Value creation model: classic downstream services

The content is delivered from the content provider to the service provider. The service provider supplies the content to the network of its local network operator. The content can then be distributed in two different possible ways. Either it is transferred through multiple networks of local network operators or a CDN operator is responsible for the transfer. In both cases the ISP manages the customer relationship between end user and its local network operator (in many cases not the one the service provider is connected to). Thus, the ISP connects the network operator to the customer.

Payment for transport and connectivity is split between network operator and ISP. The user pays the ISP for his personal Internet connection. The ISP itself has to pay for access to the network of the network operator. On the other side of the value chain the service provider pays its local network operator and – in case it uses a CDN – the CDN operator, too. CDN operators have to pay for the connection to the network as well.

A real world example for the user-financed case is iTunes again, in this case the iTunes Movie Store. The customer is charged by Apple for the access to movies. Apple pays TimeWarner, Disney, 20th Century Fox and other Studios for the rights to sell their con-

tent. Additionally, Apple is charged by Akamai for the distribution of the content via its CDN. As a precondition, the customer needs to have Internet access. Accordingly, the customer is charged by an ISP for the Internet access.

4.2.2 P2P Services

P2P services follow a fundamentally different notion. Instead of classic downstream content distribution – content is hosted by service providers and sent to the end user on request – users themselves host and distribute content (see Figure 4). Today's P2P services usually have a central entity that controls up- and downloads between users, thus they are mostly hybrid forms. However, there are only minor control transport streams between the service provider and the end user whereas the large part of the traffic is between the users and their corresponding local ISPs and network operators. A well-known example for this kind of service is Skype. When a phone call with the VoIP service Skype is set up the users are directly connected and only control information for authentication, authorization and accounting is transferred to Skype itself.

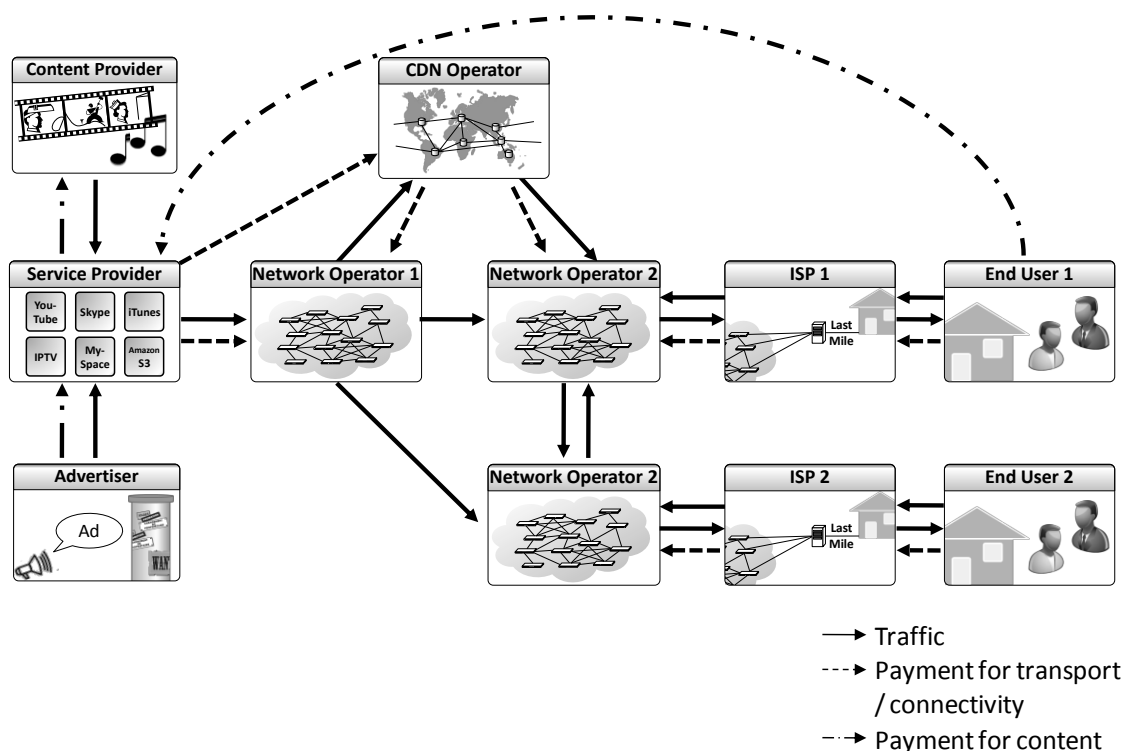


Figure 4: Value creation model: P2P services

Other service providers use P2P systems to distribute content in an efficient way. In this case service providers do not depend on their own server performance. Especially for

almost-live events the hosting servers are usually the bottleneck. P2P distribution between connected end users helps to increase efficiency and reliability. This method was used by the video service Joost until the end of 2008.

Today P2P services are often paid by advertisement. The user only has to pay if premium services are accessed, e.g. phone calls to fixed line or mobile phones in the case of Skype.

4.2.3 Special-case: IPTV without regular Internet Access

This special case changes some basic assumptions of the value creation models discussed above. Here, the customer does not have regular Internet access and therefore does not have to pay for transport and connectivity. Instead, the service provider offers an IPTV service including all connectivity fees.

While the user has a direct connection to the service provider only, the latter manages the Internet connection. Thus, the service provider pays an ISP and network operator to set up the connection to the end user. The service is financed by the service fee that the end users pays – similar to present cable TV services.

Additional revenues for the service provider emerge from advertisement options. Especially for IPTV services advertisement appears to be suitable based on the fact that TV is a familiar environment for advertisement.

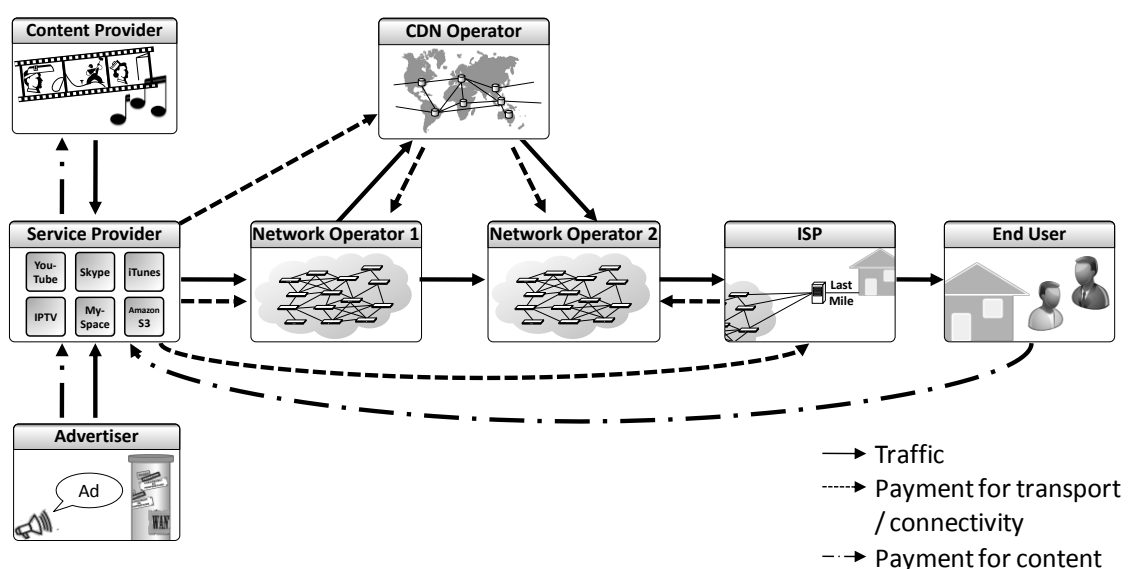


Figure 5: Value creation model: IPTV without regular Internet access

As before content is obtained from the content provider. Data is transported over networks operated by network operators and CDN operators might be involved for efficient and fast delivery of content as described in the previous value creation models.

5 Changes in Value Creation induced by Quality of Experience Technologies

In order to achieve considerable improvements in QoE, end-to-end support needs to be ensured. Some QoE enhancing technologies require physical additions within the network, e.g. additional caches, some require replacements or updates of network hardware, e.g. new routing algorithms, and some necessitate new software and updated end user devices. Whereas the changes built upon the existing network architecture in general, the degree of necessary additions varies for network architecture, services and end user devices: service providers need to update their services to make use of new mechanisms and end devices need to support new codices. The largest part of necessary expenditures – however – has to be borne by the network operator due to changes on the network equipment.

Due to the required end-to-end support the network operators need to cooperate. This is not expected to pose a problem since their cooperation is a prerequisite for the functionality of the worldwide network anyway. CDN operators that optimize traffic near the end user might become obsolete since network operators themselves might include (micro-) caches within the network, especially in the access network. The CDN operators that will prevail are those operating worldwide caching networks at the edge of the network bridging traffic that would otherwise pass networks of several different operators. The fundamental structure of the network does not change and the existing value creation models as shown in section 4.2 will continue to exist. Precondition is that congestion does not prohibit conventional service delivery. However, to refinance the integration and operation of QoE technologies new revenue streams for network operators have to be exploited. Accordingly, additional revenue streams for network operators based on the possibilities of QoE technologies are identified in the following section. The different models originate from several possibilities to initiate quality increases.

5.1 User-Initiated Quality Increases

In this first new model (Figure 6) we assume that users desire to increase the quality of their services. In this case, this wish is not centered on one single service but on all online activities of the user. Thus, the ISP might offer a connectivity packet with increased quality to the user for a premium compared to best effort connectivity. Then, the links to the premium customers would be improved. Prerequisite is, of course, that the network operator integrates QoE enhancing technologies into the network. Since the major bottleneck today is the access network improvements can be achieved without the support of service and content providers. For the same reason this model can be applied to both, classic downstream services and P2P services.

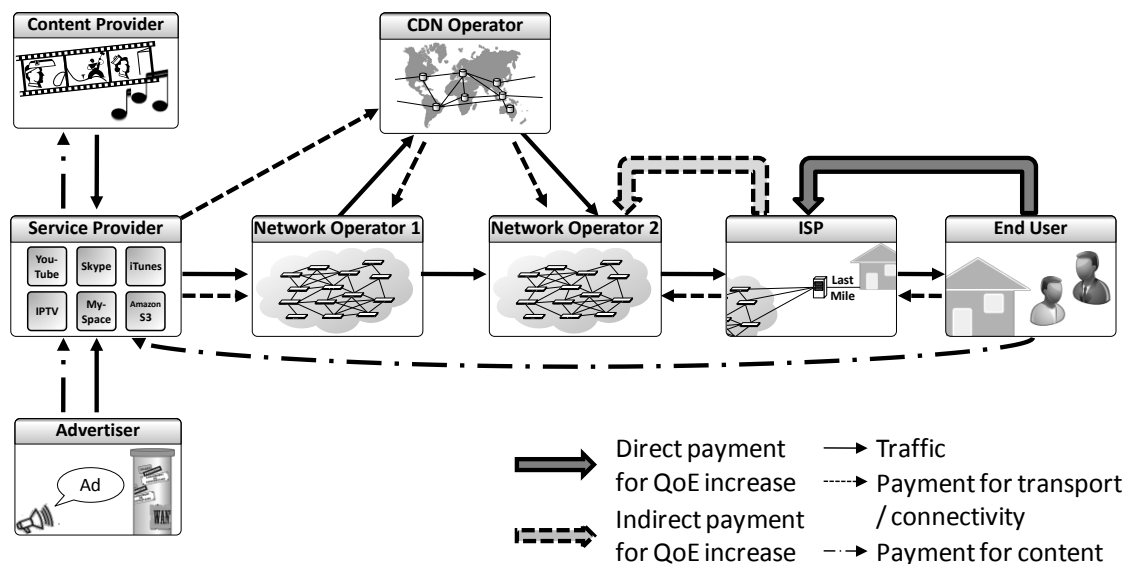


Figure 6: Revenue streams with user-initiated quality increases.

Common services – be they user-financed or advertisement-financed, downstream or P2P based – are not affected. All revenue streams of the original value creation models remain intact. The user pays a premium to its ISP that offers the connectivity packet with increased quality. Since the network operator needs to integrate the necessary technologies into the network, the ISP will have to pass a share of the revenue generated by the premium packets. Here, different models are possible: payments depending on generated “premium” traffic, depending on the use of different QoE technologies, flat rates, etc.

5.2 Quality Increases Initiated by Content Providers

Today, online video services often lack quality in terms of connection reliability, speed and usability. Ultimately, this redounds on the content. In times of massive illegal file sharing and slipping revenues, proactive content providers might choose to counter the quality problems by initiating quality improvements and creating unique user experiences themselves.

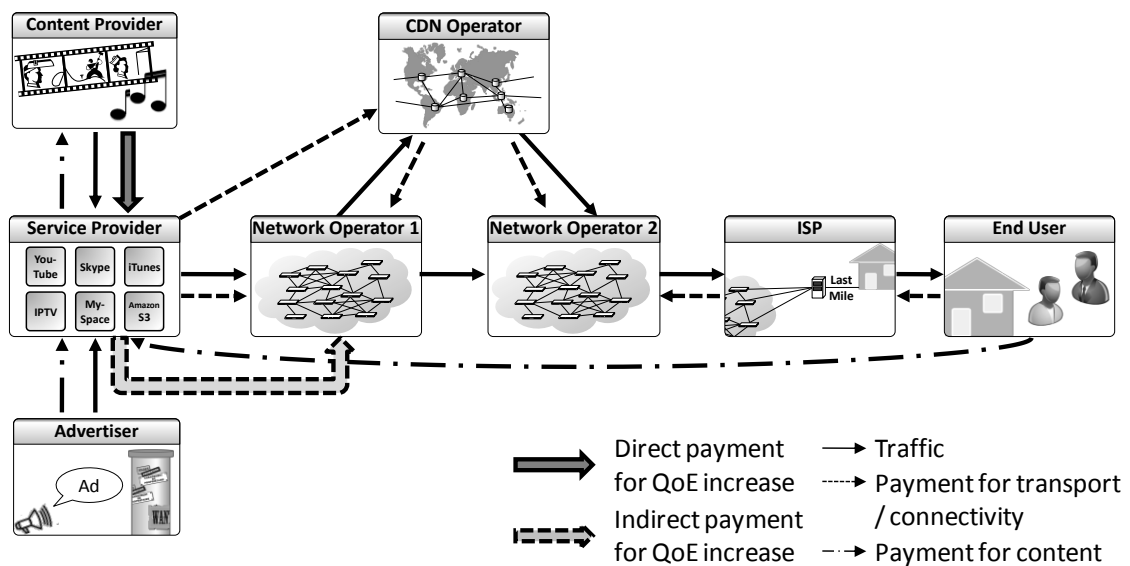


Figure 7: Revenue streams with increased quality initiated by the content provider.

In that case, they might choose to subsidize service providers to make use of QoE technologies offered by network operators. Thus, service providers might either close cheaper deals for content access or might gain additional revenues independently of content access. In both cases under the precondition that they use their operator's QoE enhancing technologies. In any case the service provider will have to pass a share of the saved means or won revenue on to their local network operator for access to its QoE technologies (see Figure 7). Again, this model is applicable to classic downstream services and P2P services and independently of the revenue model so far.

5.3 Quality Increases Initiated by Service Providers

Service providers can meet the fierce competition for online services with different strategies. Most likely, most of them will continue to rely on the most common web business model: free services with no quality assurances financed by advertisements. However, some might choose to go for a differentiation strategy. One possibility is to offer premium quality services, independent of the underlying business model, hoping

to win additional users. In addition to enhanced service usability, for example, they might increase quality by QoE technologies offered by network operators.

Here, the service provider will pay its network operator directly for access to the QoE enhancing technologies (Figure 8). The underlying notion is that refinancing can be ensured in different ways: 1) more paying users will be attracted; 2) content providers can be attracted by increased quality and 3) advertising will be attracted. This case appears to be of high interest for the previously presented “Special-case: IPTV without regular Internet Access” in order to ensure a reliable, high-quality service which is comparable with conventional TV services in terms of availability.

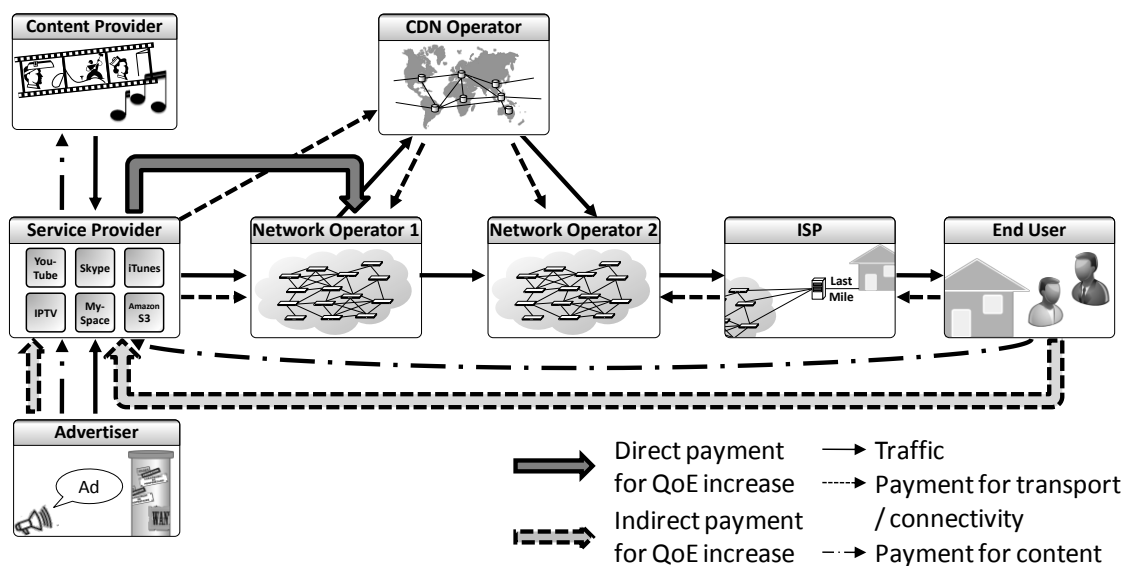


Figure 8: Revenue streams with increased quality initiated by the service provider.

5.4 Personalized Advertisement

Finally, user profiles and policies are an essential part of many QoE technologies. Advertisers can benefit from this information significantly: users cannot only be narrowed down into more specific groups, in extreme cases advertisements could be personalized even to individuals.

Since more specific advertisements promise to initiate higher sales eventually, companies are expected to be willing to pay higher fees for it. Thus, advertisers can be expected to be willing to purchase user data, i.e. network operators can open up another revenues stream this way (see Figure 9). Obviously, since the legal regulation is quite volatile when it comes to sensible user data, possible interventions by regulatory authorities need to be observed carefully.

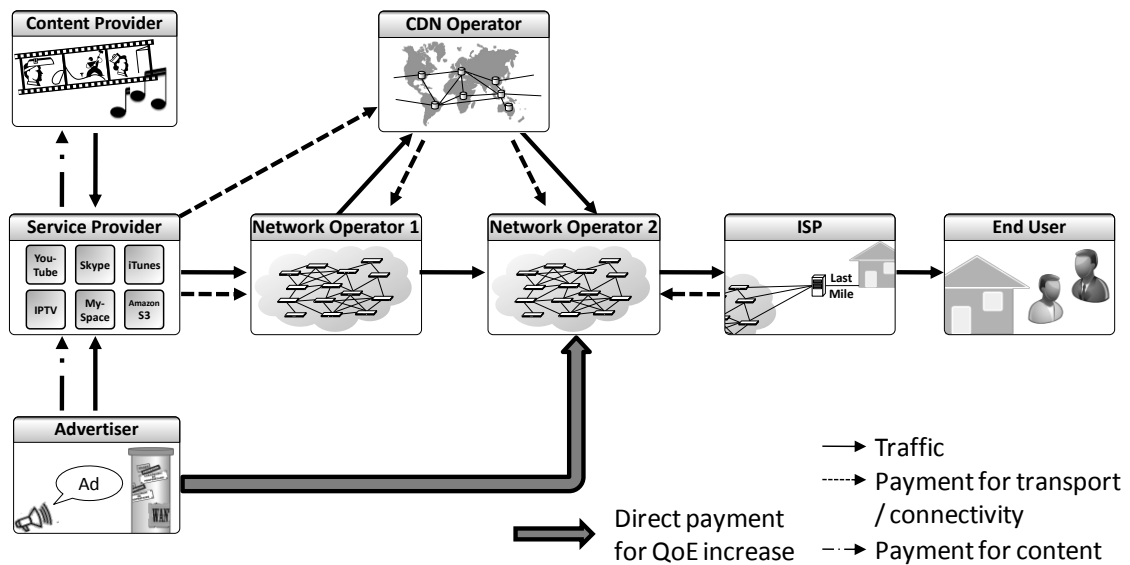


Figure 9: Revenue streams with increased quality initiated by personalized advertisements.

6 Future Perspectives for the Value Creation Models

History has shown that the environment in the ICT industry and the business models are subject to constant change. Thus, the sustainability and probability of occurrence of the value creation models developed in the previous chapter might be challenged. Therefore we seek to briefly evaluate the models with the assistance of scenarios that were created in the RUBENS project in this section.

6.1 Five Scenarios for the Future of QoE

Scenario analyses allow identifying consistent future market scenarios, drivers, barriers and threats for the focal research topic. They are commonly used in industry and research as strategic instrument to prepare and to anticipate future developments [29-30]. In [27] the scenario analysis that was conducted in the RUBENS project for QoE is briefly introduced. In [31] drivers, barriers and threats for the integration of QoE enhancing technologies within the access and aggregation network are discussed.

Summarized, five major scenarios for the year 2020 were identified along two orthogonal dimensions *feasibility* and *demand* as can be seen in Figure 10. They are not mutually exclusive, i.e. they may follow upon each other and can be summarized as follows:

1. *QoE Heaven*: The network capacity meets its limits. The regulatory environment and customer behavior is in strong favor of quality improving technologies. All involved companies are adequately prepared for the situation, the value network is aligned and cooperation is widespread.
2. *Industry Failure*: The network capacity meets its limits. Whereas end users are willing to pay for quality boosts or just reliable services, the QoE technologies are neither fully developed nor standardized and the actors failed to prepare for this situation in advance.
3. *Dead Zone*: Politics and regulators promote network capacity increases. While strong subsidies for FTTH expansions are granted, the public opinion is influenced against intelligent networks. Additionally, security scandals challenge the end users commitment to online services.
4. *New Offer*: Whereas QoE technologies are ready and already introduced into the network, the network capacity is mostly ample. Hence, customers do not see the value and necessity of QoE improving mechanisms accompanied by a low willingness to pay for them.
5. *Regulation Crashes the Party*: Whereas the capacity meets its limits, customers are willing to pay for quality improvements and the technology could be integrated into the network on short notice, politics and regulators disapprove of the mechanisms. Instead, they promote the increase of network capacity.

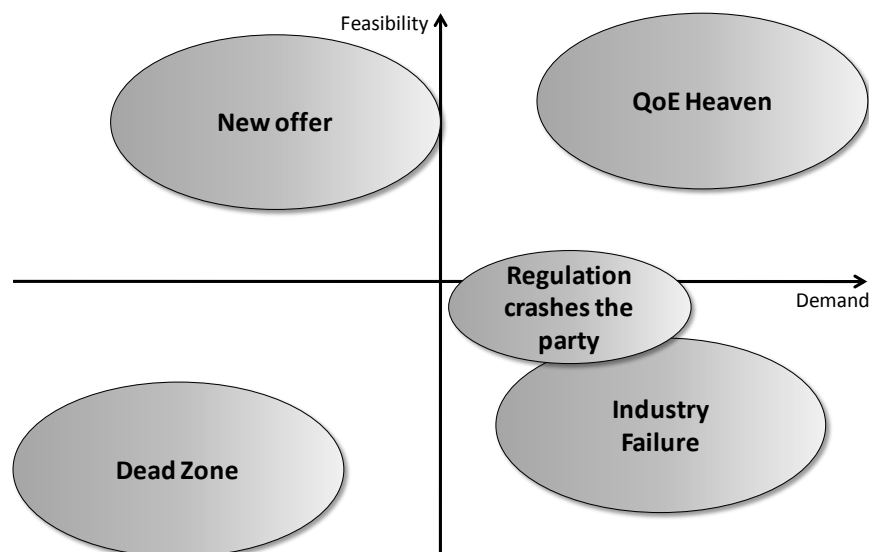


Figure 10: QoE scenarios on the way to 2020.

In the analysis' evaluation phase it was found that a chronological order is likely to occur. The experts' opinion was that we are currently near the *Industry Failure* and *Regulation Crashes the Party* scenario. Provided that the market actors act now, they predict an evolution towards *New Offer*, possibly followed by *QoE Heaven* in case technical and market developments are beneficial.

6.2 Implications for the Value Creation Models

The scenarios show different possible and consistent futures for the QoE technology and market. While the value creation models do not provide support for the technological developments, they foster the economical progress towards beneficial scenarios, i.e. ultimately the QoE Heaven scenario.

Apart from the fundamental requirements that need to be ensured for QoE to prevail (e.g. technological feasibility, increasing traffic / increasing demand and supply of online services, etc.), three major issues emerge from the scenario analysis as being crucial for the value creation models.

1. *Net neutrality, regulation*: the possibility to differentiate data packets is necessary to allocate data to services or requesting parties. Three of the four models presented in this paper (all apart from the personalized advertisements) depend on this. An active part in the discussion is necessary to dissipate doubts by politicians, regulators and end users.
2. *Quality sensibility*. Quality is commonly equated with bandwidth. Customers need to be sensibilized for other aspects that have effects on the quality of online services. That way it might be possible to initiate demand for quality offerings that are detached from the ever growing "maximum bandwidth" offerings.
3. *End-to-end support*. Many QoE technologies require end-to-end support. Incomplete support along the value creation process complicates QoE offerings significantly. Thus, interfaces between the major actors need to be defined. Additionally, standardization of seminal technologies can ease cooperation significantly.

Whereas these three issues have major influences on value creation in a QoE environment, the value creation models help guiding the way in a beneficial direction. They reveal potential revenue streams and provide a foundation for the development of more

sophisticated business models. They unveil the basic interfaces (economically and technologically) and foster cooperation necessary for successful implementation of several QoE technologies. Finally, potential cooperation partners in the QoE environment are shown.

7 Conclusions

Current developments in terms of increasing bandwidth demand severe requirements on reliability and needs to increase efficiency and thus reduce power consumption pose new challenges for the content delivery ecosystem. Particularly network operators will be affected. Solutions to ramp down overprovisioning and to increase the perceived quality of services are demanded. The Quality of Experience concept promises to bring possible solutions.

Most of the costs for the introduction of QoE technologies occur within the network. Because the network operator bears most of the implementation and operating costs, its motivation becomes ambiguous. New re-financing models for QoE technologies are needed.

In this paper we showed four new or complemented value creation models that reveal new revenue streams for the network operator:

- *User driven:* Users want to increase the quality for all their used services. QoE technologies can help to solve the access bottleneck. Therefore some users will be willing to pay a premium for higher quality Internet connections.
- *Content provider driven:* To increase the experience with their content and differentiate it from illegal file sharing, content providers can be interested to pay for preferred handling of their content.
- *Service provider driven:* To attract more customers and content providers and to enable more personalized advertisements, service providers can widely benefit from QoE technologies. Due to the necessary end-to-end support QoE support has to be bought from network operators.
- *Advertiser driven:* QoE monitoring functions and user policies will deliver a better environment for personalized advertisement. Network operators can deliver the needed information and open up a new revenue stream.

While we believe these models to be promising, five major challenges remain:

- *Challenge 1:* Network operators have to combine different QoE technologies to specific QoE bundles which have a clear benefit for the addressed actor.
- *Challenge 2:* Network operators need to define usage fees for QoE technologies that attract new customers on the one hand and that re-finance the up-front investment on the other hand.
- *Challenge 3:* QoE technology research and development has to deliver solutions for the access network. The bottleneck of the present network is near the end user.
- *Challenge 4:* QoE technologies address more than bandwidth issues. All these benefits have to be communicated equally. Otherwise QoE could be displaced by FTTH easily.
- *Challenge 5:* Regulation, especially concerning net neutrality, and political discussions have to be observed carefully. Public relations need to address security and privacy concerns to avoid user rejection and tough regulation.

As our analysis is a first step on an abstract level, further research should assess network operators' business models in detail. The challenges 1 and 4 are mainly subject to marketing and public relations whereas challenge 3 clearly needs to be addressed in technical research. Challenges 2 and 5 could possibly be approached with game theoretical considerations.

Conclusively, we believe that QoE technologies should not be reduced to bandwidth improvements or an extended QoS approach due to the difficulty to measure customer delight or managerial challenges that emerge. They promise to deliver much higher levels of satisfaction to end users. Based on this, new business models will almost certainly emerge in the future. We hope that our research work is a first step towards QoE-based business models and contribute to their development.

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