

Zhang, Nan; Hämmäinen, Heikki; Levä, Tapio

Conference Paper

Future scenarios of commercial internet content delivery

23rd European Regional Conference of the International Telecommunications Society (ITS), Vienna, Austria, 1st-4th July, 2012

Provided in Cooperation with:

International Telecommunications Society (ITS)

Suggested Citation: Zhang, Nan; Hämmäinen, Heikki; Levä, Tapio (2012) : Future scenarios of commercial internet content delivery, 23rd European Regional Conference of the International Telecommunications Society (ITS), Vienna, Austria, 1st-4th July, 2012, International Telecommunications Society (ITS), Calgary

This Version is available at:

<http://hdl.handle.net/10419/60386>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

Future Scenarios of Commercial Internet Content Delivery

Nan Zhang, Heikki Hämmäinen, Tapio Levä

Department of Communications and Networking, Aalto University

PO Box 13000, FI-00076 Aalto, Finland

{nan.zhang, heikki.hammainen, tapio.leva}@aalto.fi

Abstract

The Internet content volume is growing rapidly. As a consequence, the current Internet model struggles with scalability and usability requirements. To better meet the demand, technical solutions utilising caching and name-based routing are being developed. This paper aims at identifying the key forces, both trends and uncertainties that affect the evolution of the heavy commercial Internet content delivery. To bound the uncertainties, four possible future scenarios are constructed and their effect on the key stakeholders is described briefly. The value of identifying the future scenarios is to define the winning business roles and actors per scenario and, subsequently, the winners' preferences in choosing the most attractive content delivery architectures.

Key words: scenarios, Internet content delivery, commercial, video, information-centric networking, content delivery network

1. Introduction

The Internet traffic volume, especially video traffic, keeps growing (Cisco, 2011). As a consequence, the current Internet architecture is facing scalability issues in delivering the heavy content. The existing content delivery models, such as the Content Delivery Networks (CDNs) (Vakali and Pallis, 2003), cloud systems (Vaquero et al, 2008) and the peer-to-peer (P2P) networks (Schollmeier, 2002), aim at improving the scalability by placing replica servers closer to the end-users. However, CDNs, clouds and P2P networks operate as overlays to the underlying IP networks, which make the network structure more complicated. In addition, the existing solutions still operate in a host-centric network (e.g. globally unique host names), although the Internet is expanding towards a content-centric direction (e.g. globally unique content names).

A new information-centric networking (ICN) paradigm has been proposed as one potential solution for the scalability issues of the current Internet, which would not further complicate the network structure. The ICN concept (Jacobson et al., 2012) introduces routing based on content names instead of content locations. In addition, caching done by network elements, such as routers and servers, is part of the ICN solution. The different technical ICN implementations are discussed and compared in Ahlgren et al. (2011).

Other solutions utilising content replication closer to the end-users include licensed CDNs (Edgecast, 2012) and structured peer-to-peer systems (Castro, Costa and Rowstron, 2004). Additionally, research on better route optimisation, resource pooling and virtualisation, such as multipath technologies (Wischik, Handley and Braun, 2008), cloud networking (Gutierrez and Carapinha, 2011) and the SILO (Services Integration, control and Optimisation) architecture (Dutta et al., 2007) are gaining more attention. The relevant caching architectures and their basic characteristics for this paper are listed in Table 1.

Table 1. Characteristics of alternative caching architectures.

Characteristic \ Architecture	CDN	Cloud	P2P	ICN (new)
Cache location	Server-side nodes	Server-side nodes	Client-side nodes	In-network nodes
Routing decision	By host names	By host names	By host names	By content names
Level of standardization	Medium	Medium	Low	High
Content awareness	Medium	High	Low	Medium

With the introduction and adoption of new technologies also comes change in network and industry structures. But how the Internet content delivery industry will change is not clear. Thus, similarly to Enqvist and Casey (2010), who discussed the changes in the mobile communication industry, this paper aims at identifying the key trends and uncertainties of the Internet content delivery market. The main research question is as follows:

What are the alternative scenarios of heavy commercial content delivery over Internet for next 10 years?

In addition, the following supporting strategic research questions are also discussed:

What is the role of mobile Internet service providers (ISPs) in Internet content delivery?

Which scenarios drive the adoption of ICN?

The focus of this work is on heavy content, such as video, due to its growing importance in the Internet. As the majority of video content is produced for human and commercial use, the scope of this paper is limited to commercial and human usable heavy content. In addition, a socio-economic perspective is taken in this work, though the various technical forces are also considered.

The following structure is used in the paper. Section 2 explains the scenario construction process followed in this work. The identified key trends and uncertainties are presented in Section 3 and the resulting scenario space in Section 4. Sections 5 and 6 provide a discussion on the implications of the scenarios. Finally, Section 7 concludes the paper.

2. Scenario Construction Process

Schoemaker's (1995) Scenario Planning methodology is used in this work to solve the research questions and is briefly presented in this section. The goal of scenario planning is not to forecast the future but to envision the probable and improbable alternative scenarios by bounding the uncertainties. In practice, the aim is to find the forces that are shaping the future – both the certain and the uncertain ones. The scenario construction process consists of ten steps, which are listed in Table 2.

To identify the key forces, two brainstorming sessions were organised with senior experts in the field of Internet content delivery. These experts represent different stakeholders operating in the commercial Internet content delivery market: network operators, content providers, network infrastructure vendors, mobile device vendors and end-users. The first brainstorming session was organised in September 2011 in Germany with 9 participants from different European countries working for the SAIL project (SAIL, 2012). The second brainstorming session took place during February 2012 in Finland with 6 Finnish participants.

The most important results of the brainstorming sessions together with steps 6-8 are presented in the next sections. In step 8, Casey, Smura and Sorri's (2012) Value Network Configuration (VNC) method is utilised to analyse the key stakeholders' roles. In addition, the scope of the paper is on the construction and qualitative description of the scenarios. Thus, the quantitative modelling (steps 9-10) is not included.

Table 2. Scenario construction process (Schoemaker, 2000).

#	Step
1	Define the issues you wish to understand better in terms of time frame, scope, and decision variables.
2	Identify the major stakeholders or actors who would have an interest in these issues, and their current roles, interests, and power positions.
3	Identify and study the main forces that are shaping the future within the scope, covering the social, technological, economic, environmental, and political domains.
4	Identify trends (forces, whose outcome is agreed on by experts) or predetermined elements that will affect the issues of interest from the list of main forces.
5	Identify key uncertainties (forces deemed important whose outcomes are not very predictable) from the list of main forces. Examine how they interrelate.
6	Select the two most important key uncertainties, and cross their outcomes in a matrix. Add suitable outcomes from other key uncertainties, as well as trends and predetermined elements to all scenarios.
7	Assess the internal consistency and plausibility of the initial scenarios, revise.
8	Assess how the key stakeholders might behave in the revised scenarios.
9	See if certain interactions can be formalized in a quantitative model.
10	Reassess the uncertainty ranges of the main variables of interest, and express more quantitatively how each variable looks under different scenarios.

3. Key Trends and Uncertainties

The two brainstorming sessions generated 94 key forces that affect the evolution of the Internet content delivery market in the next ten years. After grouping and prioritising, ten key trends and eight key uncertainties were singled out. This section discusses the results and proposes four possible scenarios for Internet content delivery's future. In addition, the key roles involved in the Internet content delivery process are listed in Table 3.

Table 3. Key roles.

Role	Description
End-user	End-users decide which services and content to consume and thus affect the outcome of each uncertainty.
Content owner	Content owners produce content to meet the end-user's demands.
Content provider	Content providers aggregate the different content owners' content into one platform and offer easier content access for the end-users.
Internet service provider (ISP)	ISPs generally provide Internet access to both the end-users and the content providers. In this paper, ISP refers to the access side ISPs and especially to the mobile access ISPs, i.e. mobile operators. In addition, the ISPs are divided into small and large ISPs, where the small ISPs are defined as national actors operating within one small country and the large ISPs are typically international actors providing access to end-users in several countries.
Cache operator	Cache operators offer a content replicating service to content providers and content owners. For example, a content delivery network (CDN) provider can be a cache operator, but also ISPs in an in-network caching case can be a cache operator.
Bank	Banks and (bank owned) credit card companies offer billing services to content providers.
Advertiser	Advertisers offer income to some content owners and content providers.
Advertisement aggregators	Advertisement aggregators collect revenue from the different advertisers by displaying their advertisements. Typically, big content providers, such as Google, are also advertisement aggregators.

3.1. Key Trends

The identified key trends are presented in Table 4 and mainly revolve around four themes: the growing content volume, the increasing demand for connectivity, the increasing importance of mobility, and personalisation of content. This section briefly discusses each of the themes and their corresponding trends.

The growing Internet traffic volume is one of the main reasons the Internet content delivery industry and architecture are changing. This belief is further confirmed in the brainstorming sessions as the first three trends deal with the growing content amount. The first trend states that more user-generated content will emerge into the market, which means that in general more content will be produced. The first trend together with the predicted more connected devices leads directly to more metadata. As a consequence, how the increasing volume of metadata is processed becomes important and one of the drivers for the changes in the Internet content delivery market.

Table 4. Basic trends.

Theme	Trends
Growing content volume	More mini content producers and user generated content will emerge into the market.
	More than 50 billion devices will be connected in 10 years.
	More metadata will be created and big data harvesting is becoming an important economic driver
Increasing demand for connectivity	ISPs have more pressure to offer access.
	Connectivity is becoming a commodity.
Increasing importance of mobility	End-users' content demand and increased QoE expectations should be met at any time and place.
	4G, higher processing power and high definition screens in mobile devices are becoming more common.
Personalisation of content	Context, e.g. location, aware services will increase.
	Personalisation of content is becoming more important.
	Personal identity increasingly sold by the end-user as a product to content providers or service providers.

When the traffic volume grows, more pressure is put into network capacity, which is the second identified theme. In addition, Internet connectivity in many developed countries is becoming a part of the universal service requirements (FICORA, 2010). As a consequence connectivity is becoming a commodity and the Internet service providers have more pressure to offer high quality access to end-users.

In addition to expecting faster Internet connections, the end-users' expectations on quality of experience (QoE) is also increasing. The QoE also includes meeting the end-users' demands at any geographic location and at any time, which puts more emphasis on mobility. The importance of mobility is further augmented by the development of faster 4th generation mobile networks, faster processing and higher definition screens in mobile devices.

More user-generated content means also that more of the content is targeted at smaller audiences and more content will be personalised. In addition, more context aware devices and services add to the personalisation of content. Lastly, because the end-users are increasingly selling their preferences and personal identity to content providers, the produced content will increasingly accommodate the users' preferences and be more personalised.

3.2. Key Uncertainties

The eight key uncertainties of Internet content delivery market's future are listed in Table 5. The identified main themes include how content is accessed, who controls the content and the network, and how caching is done. This section explains each uncertainty and makes a correlation analysis on each pair of uncertainty. In addition, a scenario matrix with four possible future scenarios is proposed.

Table 5. Key uncertainties.

U1	Mobile ISP bundling: strong ISP bundling or no ISP bundling?
U2	Content provider revenue model: advertiser revenue or consumer revenue?
U3	Content delivery control: content provider or the network?
U4	Content provision aggregation: aggregated vs. fragmented?
U5	Cache ownership: a) independent or bundled b) bundled to ISP or CP?
U6	Content exclusivity: exclusive or not exclusive?
U7	Dominating cacheable content: global or local?
U8	Driver for cache location optimisation: low cost or fast response time?

U1. Mobile ISP bundling: strong ISP bundling or no ISP bundling?

The cost of building the network is now borne by the ISPs and the costs are passed onto the end-users and content providers through charging for network access. However, due to the increasing traffic volume and the competitive consumer prices, network access and connectivity is becoming less profitable for ISPs. In addition, the network is becoming more content-centred. Consequently, bundling mobile devices together with the network subscription has become common practice, because service providers wish to lock-in the end-users. Furthermore, the end-users may perceive the cost of a bundle to be lower than using the services separately and thus may consume more. Will the situation stay the same in the future or will ISPs attempt to increase revenue by playing a

bigger role in the Internet content delivery process and offer also content? For example, Orange (Orange, 2011b) in Europe and Comcast (XFINITY, 2012) in the U.S.A offer triple-play bundles that include certain amounts of films or TV channels, the Internet broadband and a mobile connection.

Although the main issue in this uncertainty is whether content is bundled to the mobile ISP's service offer, the device bundling is also important. For example, big content providers are offering their content together with devices with which to access the content in order to bypass the ISPs (e.g. Sanoma, 2012). Thus it is important for the ISPs to also control the devices in addition to the access and content.

U2. Content provider revenue model: advertiser revenue or consumer revenue?

In the past, Internet content providers have mainly earned revenue from advertisers. However, several payment-based content providers have emerged into the market recently, e.g., Spotify (Spotify, 2012), Sony Music Unlimited (Sony, 2012) and Voddlar (Voddlar, 2012). Thus, how will the dynamics evolve: will paid content, i.e. consumer revenue model, become more popular than the advertiser revenue model?

U3. Content delivery control: content provider or the network?

The different stakeholders in the Internet content delivery market may exert several types of control on the content delivery process. For example, to guarantee the revenue flow, a payment based content provider may wish to limit the content access to paying consumers. In addition, geographical restrictions can be imposed by the content providers or even regulators. This uncertainty also relates to the responsibility of misconduct: who will be liable for, e.g., illegal content?

The most obvious stakeholder to exert content control is the content provider. If the content is served from the origin server, the content provider can easily control who has access and where the content is routed to. Additionally, the network, i.e. the network providers and the storage providers, can practice control. For example, the CDN provider can control content access and limit the content distribution by authenticating each user at the CDN server. The uncertainty, however, arises in the transparent caching case. With distributed storage, it is not clear who has the ability to control the content and its delivery. The cache owner or the network provider could be possible candidates for making the routing decision. In addition, the authentication mechanism could be implemented into the data object itself.

U4. Content provision aggregation: aggregated vs. fragmented?

The Internet has enabled content owners to establish direct connections with content consumers, especially on a global scale, leading to a more fragmented content provision market. On the other hand, the market has showed signs of aggregation. For example, the usage of platforms that connect several content owners to the end-users has increased in the recent decade, such as YouTube (YouTube, 2012). Thus, what will be the balance between content provision aggregation and fragmentation in Internet content delivery?

On a related matter, the power struggle is also between the content owners and the content providers. In this work, the content owners are defined as the stakeholders producing the content and gaining direct monetary benefits from consumed content, whereas content providers are defined as platforms aggregating content produced by different content owners.

U5. Cache ownership:

This uncertainty is divided into two levels. The upper level questions the independence of the caching system, whereas the lower level is about who operates the caching system.

a. Independent or bundled?

The independence of the caching system mainly is a struggle between the horizontal and vertical network structure. CDN providers are examples of independent cache owners, i.e. horizontal network structure. On the other hand, if the cache system is bundled to a stakeholder, who's also offering other services, the network structure is vertical.

b. Bundled to ISP or CP?

Two dominant players, who can bundle the cache system into their existing services, are the network operator and the content provider. For example, network operators have already implemented web proxy caches in their network and few bigger operators (AT&T, 2012; Telefonica, 2012b) are even building their own CDNs. In addition, big content providers also have a willingness to build their own caching networks, e.g. Google Global Cache (GGC, 2012).

U6. Content exclusivity: exclusive or not exclusive?

Content exclusivity in this context means whether the content is provided by several ecosystems or only one ecosystem. For example, TV shows are distributed only by one TV channel and its website, whereas movies sell distribution rights to several channels. Mobile applications are usually first developed for only one ecosystem and the popular ones expand later to other ecosystems.

U7. Locality of cacheable content: global or local?

With the increase of Internet usage, it has become easier to establish connections to the other side of the world. With all the content of the world only a few clicks away, people are more likely to find what they want from the global Internet rather than from the local network. On the other hand, a substantial amount of content is consumed only locally. For example, folk songs of a certain country or movies in certain languages are unlikely to be requested by people outside that particular country or who do not understand the language. Which, therefore, is more important – global or local content? This uncertainty affects the development of the industry structure as more global content will drive the bigger content providers to be even bigger, whereas local content supports smaller content providers.

U8. Driver for cache location optimisation: low cost or fast response time?

The incentive to cache is usually to either lower the transit costs or to offer better QoE with faster response times. In addition, the location of caching is also dependent on which incentive is

preferred by the different stakeholders. For example, if a stakeholder wish to increase the response time, caches should be installed as close to the end-users as possible. On the other hand, if cost minimisation is the goal, the trade-off between transit costs and costs for building the cache servers should be estimated and a location between the end-user and the origin server is chosen. However, usually a mixture of the two incentives is driving the cache location decision rather than one or the other.

3.3.Scenario Matrix

The purpose of identifying the key uncertainties is to construct possible future scenarios by crossing two most critical uncertainties in a matrix. The potential key uncertainties should be uncorrelated with each other. Hence the correlations between each pair of uncertainties are shown in Table 6, where 1 shows that a pair of uncertainties is correlated with each other and uncorrelated pairs are marked with 0. The correlation is analysed through a causality analysis between each pair of uncertainties. In other words, how one uncertainty’s outcomes affect another uncertainty’s outcomes is evaluated.

Table 6. Correlation of uncertainties; where 0 means uncorrelated and 1 correlated.

	U1	U2	U3	U4	U5	U6	U7	U8
U1	1	0	1	1	1	0	0	1
U2	-	1	1	0	0	0	1	1
U3	-	-	1	1	1	1	0	1
U4	-	-	-	1	1	1	1	0
U5	-	-	-	-	1	0	1	1
U6	-	-	-	-	-	1	1	0
U7	-	-	-	-	-	-	1	1
U8	-	-	-	-	-	-	-	1

The correlation analysis yields ten pairs of uncorrelated uncertainties for constructing the scenarios. Several pairs were crossed in a matrix, such as the content provider revenue (U2) with content aggregation (U4), cache ownership (U5) with content exclusivity (U6), and cache ownership (U5) with content provider revenue (U2). However, due to the scope of the work and based on expert interviews, the final pair of uncertainties and the resulting four bounding scenarios aim at answering the research questions and attempt to map the ISP’s position in the Internet content delivery. The final scenarios are illustrated in Figure 1.

The first axis in Figure 1 is chosen to represent the two outcomes of mobile ISP bundling (U1), where the mobile ISP can either provide access, device and content as a service bundle or not bundle at all. The second axis represents the content provider revenue model (U2), where the content provider can either choose to charge end-users for the content or use the advertising based revenue model. The resulting bounding scenarios present the dominant end-user type, whose decisions will lead to each of the scenarios. The dominant end-user types include the comfort buyers, the quality buyers, the indifferent savers and the demanding savers. In addition, each of the scenarios show which actor will rule the Internet content delivery market and make the decision on

the used caching system. The dominant actors in each of the scenarios are the local ISP, the global ISP, the advertisement content provider and the payment based content provider.

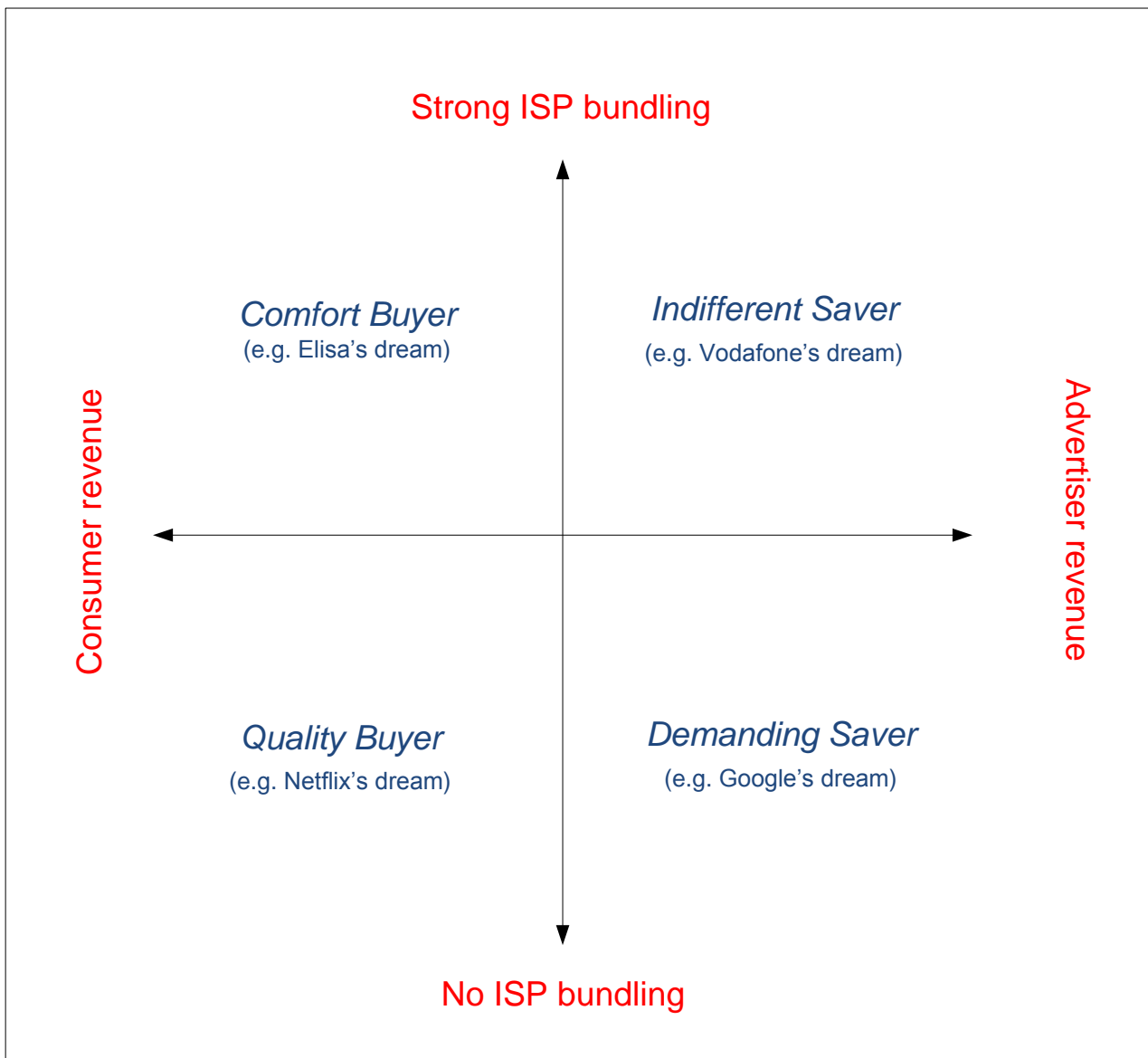


Figure 1. Scenario matrix.

4. Scenarios

The four constructed scenarios are described in more detail in this section by illustrating the role configurations as well as the actors that control the critical roles with VNCs. The VNC's notation is shown in Figure 2. In addition, several parameters relevant to Internet content delivery, such as the existence of network effect or easiness for end-users to pay for the content, are used to analyse each scenario.

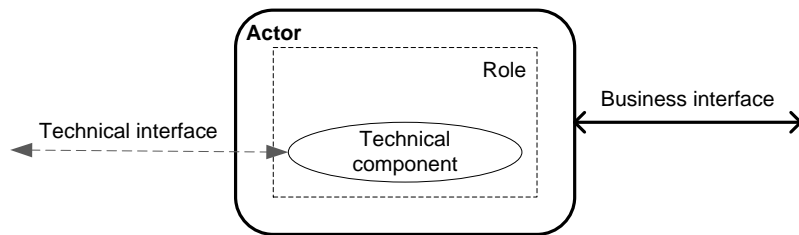


Figure 2. VNC notation.

4.1. Scenario 1: *Comfort Buyer*

In the *Comfort Buyer* scenario, the end-users are willing to pay for their comfort and thus prefer bundled services and to pay for the content. Therefore, the local ISPs are dominating the Internet content delivery process by providing service bundles to end-users. For example, Elisa (Elisa, 2012b) in Finland is a local ISP, who offers content and service bundles to the end-users under the name Elisa Viihde (Elisa, 2012a). The value network configuration for the *Comfort Buyer* scenario is illustrated in Figure 3.

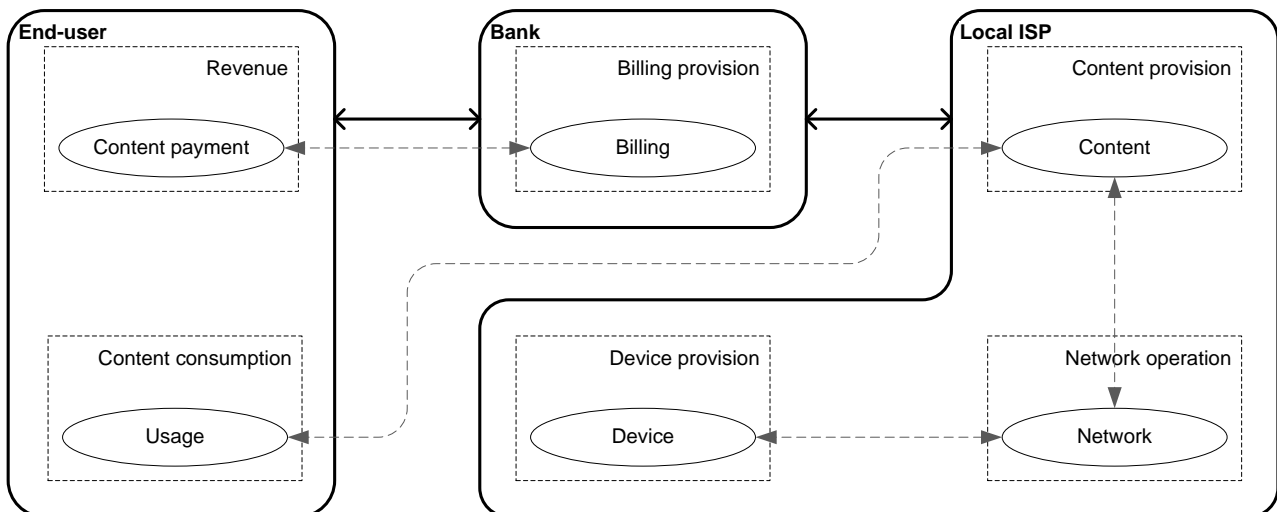


Figure 3. Value network configuration of *Comfort Buyer* scenario.

This scenario is ideal for a local ISP because the ISP controls the content delivery platform as well as the content itself. In other words, the local ISP takes control of the content provision role, as is shown in Figure 3. In addition, unlike the advertiser revenue model, the consumer revenue model does not require a large customer base. On average, each country has one to three local ISP and United Nations (UN, 2006) distinguishes 192 countries in the world. From these figures, the number of local ISP can be estimated to be close to 400. Thus, though some local ISP can grow to be quite big, they are still small players on a global scale.

Because the local ISPs are small players, they benefit very little from economies of scale. The local ISPs in this scenario may experience network effects from increasing numbers of customers and content. However, despite the increasing local market power, the market is usually too small for the network effect to have any significant impact globally.

The billing mechanism and process is important to both the service provider and the consumers. From the ISP's perspective, the decision is about whether to build its own billing system or use a third party's services. If the local ISP is too small, it may be unprofitable to develop the billing system. On the other hand, by using a third party charging system, such as banks or credit card companies, the ISP is partially forgoing control over the content delivery process to the third party. This can be seen from Figure 3, where the billing role is controlled by the bank instead of the local ISP. However, as mobile ISPs use the standardised SIM technology for identifying and billing consumers for the access, the same system can also be used for billing the content usage. From the consumers' perspective, the most important criterion is the easiness of paying. In this scenario, the content will be billed together with the access bill, which does not require any extra effort from the consumers. In addition, if a flat-rate billing system is adopted for the bundled service, the consumers do not have to worry about the size of the bill.

From a content owner's perspective, the most important thing is its control over the content and the knowledge on end-users' preferences. In this scenario, content owners' only way to control their content is through requirements stated in contracts signed with the ISPs. Thus, bigger content owners or content providers can have more bargaining power over smaller ISPs. The statistics on user preferences can be more difficult to obtain in this scenario, because the ISPs are mainly interested in the amount of traffic rather than which content pieces are requested, especially if the service bundle uses flat-rate pricing. In addition, the smaller ISPs may even have limited resources to build systems for collecting content usage statistics. However, in content-aware networks, the preferences of end-users can be easily collected without any extensive investments into data collection systems and the network operators can sell the collected data.

Because the local ISPs are small players in the market, they need to interconnect with each other to offer better connectivity and content access for their subscribers. This means that at least network equipments and protocols used should be standardised between the interconnecting operators. For example, if caching is to be utilised, the caching servers should use the same algorithms and protocols for communicating with each other. On the other hand, some ISPs may use caching only for optimising their internal traffic and thus does not need any standardised solutions. However, building own caching systems for internal traffic optimisation when the ISP is relatively small may not be feasible.

4.2. Scenario 2: *Indifferent Saver*

In the *Indifferent Saver* scenario, the end-users are relatively indifferent about the service quality and prefer to have bundled services but are not willing to pay for the content. This means that the access, device and content are still provided by the ISP, but the ISPs receive content revenue from advertisers. Because advertisers attempt to reach a wide audience, the ISP in this scenario should have a large subscriber base and thus the global ISP dominates the content delivery process. Telefonica (Telefonica, 2012), Orange (Orange, 2012a) and Vodafone (Vodafone, 2012) are examples of global ISPs and due to the large size, approximately only tens of global ISPs exist worldwide. In this scenario, the global ISP among its other roles also acts as a content provider, as is shown in the VNC of the *Indifferent Saver* scenario in Figure 4.

Because of the international operations, the global ISP is not limited by the population of one country. Thus, when the global ISP gains more customers, it will attract more content providers, which in turn attracts more end-users. On the other hand, more end-users also attract more advertisers and more revenue for the global ISP.

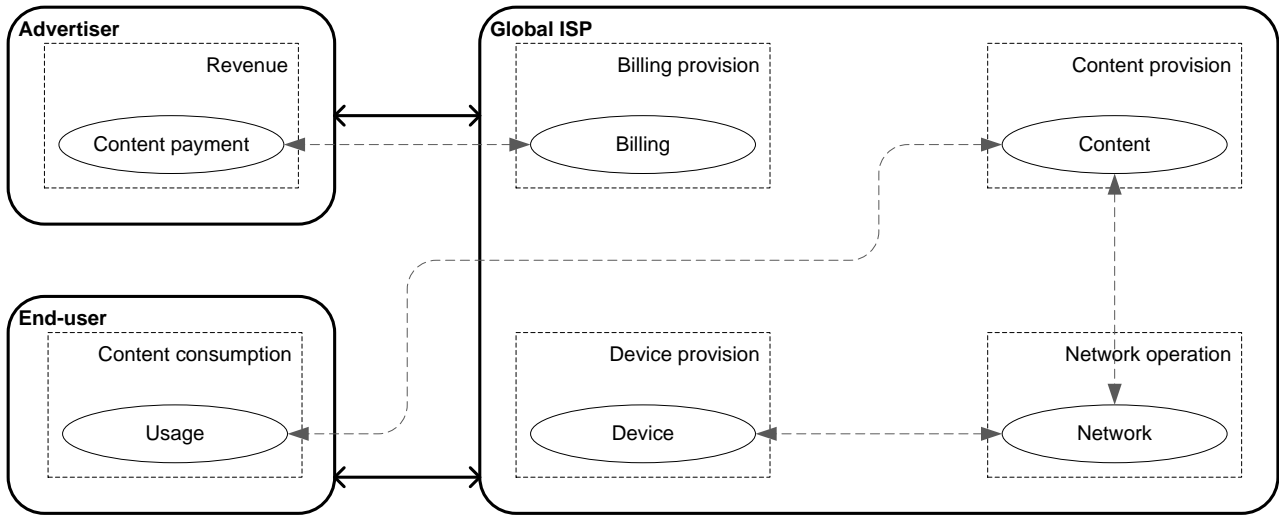


Figure 4. Value network configuration of *Indifferent Saver* scenario.

Due to the large customer base, the global ISP should experience economies of scale from building its own billing and caching systems. Thus the global ISP will have full control over the billing and caching systems, which diminishes the role that banks can play in this scenario. From the end-user's perspective, no extra effort is needed as the charging for the content is done together with the access bill.

The content owners in this scenario will have limited control over their content, because the global ISP, with its large customer base, has more bargaining power than the smaller content owners in the agreement making process. On the other hand, the global ISP has the capability to collect usage statistics for both the content owners and the advertisers. However, the global ISP may not have the incentive to collect too detailed content usage statistics if it utilises also other revenue models than advertising.

From an interconnection point of view, the global ISP has pressure to interconnect with its own networks in other countries and with other global ISPs for offering better connectivity to its customers. Thus standardisation of technical equipments is strongly recommended. However, in the global ISP's case, building an own caching system for internal traffic optimisation is more feasible than in the local ISP's case. Thus, the caching systems may not be standardised solutions in this scenario.

4.3.Scenario 3: *Quality Buyer*

In the *Quality Buyer* scenario, the end-users know exactly what they want and thus choose to take the services separately and pay for the content. Therefore, the content provider, who employs the consumer revenue model (i.e. payment-based content provider), has the power to decide which

Internet content delivery system to use in this scenario. Netflix (Netflix, 2012) is an example of such a content provider.

Though, the payment based content providers are still small players compared to the ISPs in the first and second scenarios, they still experience strong network effects. Thus, as the number of a content provider's customers grows, the number of connected content owners will also grow, resulting in a large content provider platform. However, as can be seen from the *Quality Buyer* scenario's VNC in Figure 5, the content provider does not control all the roles in the Internet content delivery process. As a consequence, the other actors in the market may take over the content provision role if not enough network effect is experienced by the payment based content provider.

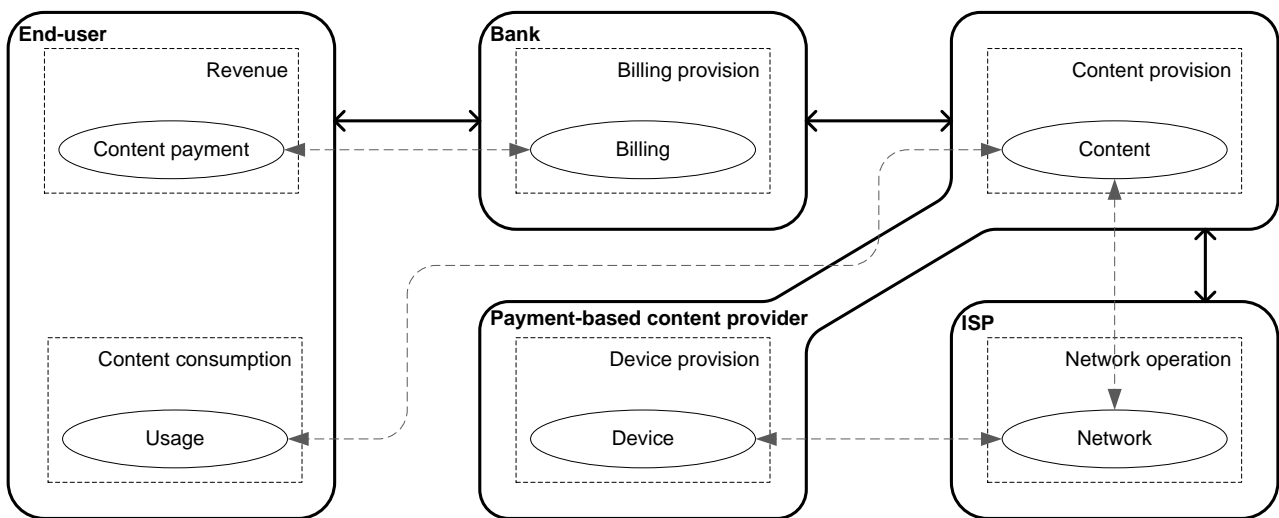


Figure 5. Value network configuration of *Quality Buyer* scenario.

Additionally, because the payment based content provider does not control all the components of the Internet content delivery and its small size, building its own billing and caching systems may not be feasible, especially when economies of scale are not fully exploited. Smaller content providers typically use third parties for handling their billing, such as credit card companies, banks and PayPal (PayPal, 2012).

From the end-users' perspective, the used billing system is also important, because credit cards are not available for everyone and third party billing systems always add few extra steps in the payment process. In addition, the pricing scheme used impacts the popularity of a service. For example, Netflix employs flat-rate pricing, which is easy to use from the end-user's perspective. However, some content providers charge on a per view basis, which requires more effort from the end-users and can act as a barrier for the end-users to start using the service.

In this scenario, the content provider can easily control who has access to the content because end-users are paying for the content. In addition, content usage statistics can be easily collected because each end-user has to register with the content provider. However, content usage statistics collection is not as important in the consumer charging revenue model as in the advertiser revenue model, especially if flat-rate pricing is used. Thus, the importance of collecting usage statistics is in gaining knowledge on user preferences, so that the content providers can better meet the end-users' demand.

Standardisation in this scenario is not necessary and proprietary solutions can be used, because the different payment based content providers do not need to interconnect with each other. On the other hand, because building one's own network infrastructure is not feasible for a small payment based content provider, an access network provider with good connectivity is preferred. To offer good connectivity, standardised network solutions, such as caching systems and routing protocols, should be used.

4.4.Scenario 4: *Demanding Saver*

Content providers that use advertising as their revenue model (i.e. advertising content providers), such as Google (Hagiu and Yoffie, 2009), are dominating the Internet content delivery market in the *Demanding Saver* scenario, because the end-users know what they want and choose each service separately but are not willing to pay for the content. The VNC of this scenario is illustrated in Figure 6. Due to the large size and the need for usage statistics, the advertising content provider gains economies of scale from building sophisticated content management and billing systems. In addition, similarly to the payment based content providers, an advertising content provider experiences strong network effects, resulting in the advertising content provider becoming bigger. Thus, globally, only a few advertising content providers dominate the market.

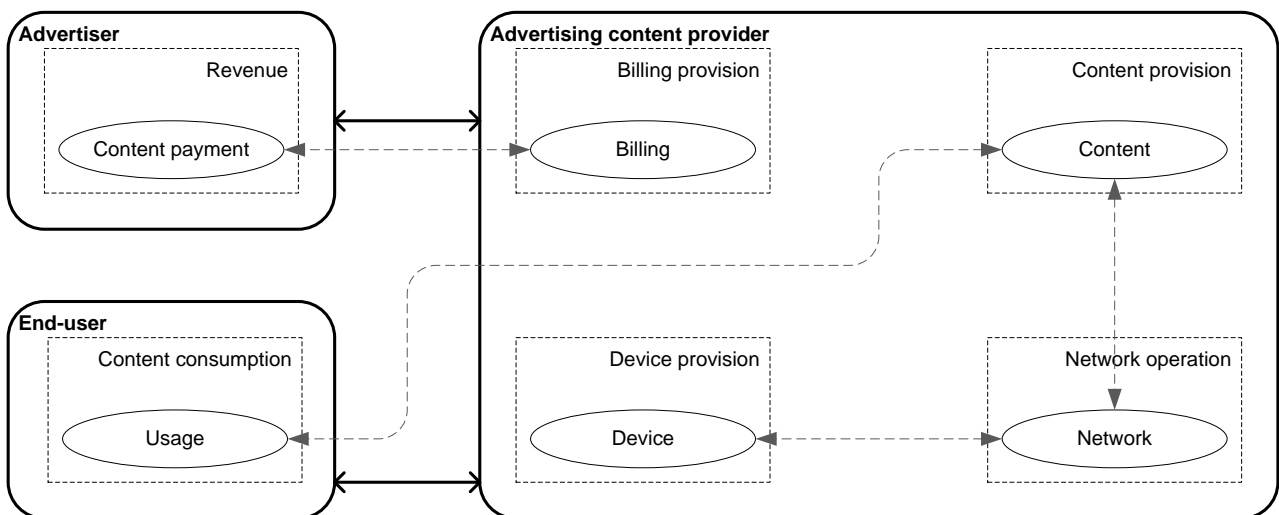


Figure 6. Value network configuration of *Demanding Saver* scenario.

The billing system in this scenario is simply the content management system, which calculates how many times each piece of content is being used. Based on the usage, the advertisers are then billed. Thus, this scenario is the easiest for the end-users from the payment perspective. In addition, because of the billing system, content provider's control in this scenario is the highest. On the other hand, because the advertisements are embedded into the content, end-users' quality of experience may be lowered due to the mandatory advertisements.

The large scale of advertising content providers may lead to the technology they use to become de facto standards. For example, if a large advertising content provider builds a caching system, that caching technology may become the standard for also other smaller content providers. However, advertising content providers may also choose to use CDNs rather than build own systems.

4.5. Scenario Comparison

This section summarises the descriptions of each scenario into a comparison table (Table 7). The parameters may affect the outcome of the scenarios. For example, the existence of network effects or economies of scale can drive big companies to be even bigger and thus to dominate the market. Thus, the *Indifferent Saver* and *Demanding Saver* scenarios seem to be natural outcomes based on these two parameters. However, the reactions of the other stakeholders in the Internet content delivery market should be taken into consideration as well.

Table 7. Comparison of scenarios.

Parameter\Scenario	Comfort Buyer	Indifferent Saver	Quality Buyer	Demanding Saver
Economies of scale	Low	High	Medium	High
Network effect	Low	High	Medium	High
Probability of own billing mechanism	Medium	High	Low	High
Ease of paying for end-users	Medium	Medium	Low	High
Bank's role	Medium	Low	High	Low
Content provider control	Medium	Low	High	High
Amount of content usage statistics	Low	Medium	Medium	High
Importance of standardisation	Medium	High	Low	Medium
Winning actor	Local ISP	Global ISP	Payment-based content provider	Advertising content provider

5. Strategic Impact on Market Roles

Whether some parameter values in the scenario comparison in Table 7 are perceived as positive or negative depends on the market roles in question. In addition, the success of a scenario does not only depend on the parameter evaluation, but also on each of the roles' and their associated actors' preferences and how they react to the changes. Thus, this section aims at giving the perspectives of different market roles and discusses the impact the scenarios have on each role. Because the first four parameters have the same impact on all roles, the focus in this section is on bank's role, content provider control, content usage statistics, level of standardisation and caching systems used.

5.1. Mobile Internet Service Providers

The mobile ISPs would prefer to control the Internet content delivery market, because it is a large source of revenue and cost. Thus, from a mobile ISP's perspective, bank's role should be small and content providers should have less control over the content delivery process. Mobile ISP bundling is, thus, an efficient method to maintain the control over both the end-users due to lock-in and the

content delivery process. In addition, for even better control over the content delivery process, in-network caching should be adopted by the network operators instead of using third party caching systems, such as CDNs or cloud servers.

Full and good connectivity is a key issue for the mobile ISPs and to ensure interconnectivity, the level of standardisation should be high. Lastly, the content usage statistics requirements put pressure on the mobile ISPs to provide a network with content management capabilities. Thus, the mobile ISPs prefer a situation, where no or very little content usage statistics are required.

The above analysis shows that the *Indifferent Saver* scenario is the most preferable for a large international mobile ISP. In addition, the *Comfort Buyer* scenario can also be a positive outcome for the national mobile ISPs, whereas the *Quality Buyer* and the *Demanding Saver* scenarios can be quite harmful for the mobile ISPs.

5.2. Content Providers

Similarly to the mobile ISPs, the content providers would want to have full control over the Internet content delivery process and thus also prefer the bank's role to be small. However, the content provider's preferences for all the other parameters' values are opposite to the mobile ISPs'. For example, the content providers prefer high content usage statistics, so that they can better serve the content consumers' demand. In addition, if the used solutions are not standardised, each content provider can be an isolated entity and offer exclusive content to end-users, which improves their competitiveness in the market.

Lastly, the best caching system for a content provider is to install its own cache servers, such as Google's Global Cache (GGC, 2012). On the other hand, in-network caching is the worst case scenario for a content provider, because the ISPs may be less willing to agree on the terms set by the content providers. In addition, the CDN providers are paid for meeting the content providers' demands and thus may be more easily controlled by the content providers.

Based on the parameters, *Demanding Saver* scenario is the best outcome for a content provider, in which the advertising content provider will become a global content provider platform. On the other hand, the *Indifferent Saver* scenario is the least optimal for a content provider due to the large scale of ISPs, who will control the global content provider platform role instead of the content providers.

5.3. CDN Providers

The CDN provider's revenue source is dependent on the content providers and thus the CDN provider would prefer the content providers to have high control in the Internet content delivery market. In addition, as the services offered by CDN providers are designed for meeting the demands of content providers, the CDN provider's preferences for the different parameter values are mostly the same as the content providers'. For example, when content usage statistics are required, the CDN provider has a competitive advantage compared to the network operators or any other stakeholder in the content delivery market. On the other hand, the CDN providers are increasingly offering CDN technology licenses to ISPs (Edgecast, 2012) and some smaller ISPs also buy CDN

services from CDN providers. Thus, the CDN providers' business model is quite flexible and the CDN's business model can adapt to each of the presented scenarios.

In terms of standardisation, when caching systems are not standardised, the CDNs have a competitive advantage compared to in-network caching, which requires more standardisation than CDNs. The only difference to the content provider's preferences is that the CDN provider prefers the caching system used to be CDN rather than cache servers owned by the content providers.

Based on the parameter analysis, the CDN provider prefers both of the scenarios ruled by content providers. However, it can be argued that the *Quality Buyer* scenario is better for a CDN provider as it is the only scenario, where the caching system is CDN, whereas the advertising content provider may deploy an own caching system.

5.4. Banks

The only two parameters that make a difference from a bank's perspective are bank's role and content provider control. The bank, like any other stakeholder, would like to have a bigger share from the Internet content delivery market. Content providers' control is relevant, because the content providers are more likely to use banks as billing systems than network operators. However, though the advertising content provider has higher control over the content, the revenue model employed does not need a billing system. Thus, from the bank's perspective, the best scenario would be the *Quality Buyer*, especially if the payment based content providers are small enough so that building an own billing system is not feasible.

5.5. Advertisement Aggregators

The parameters discussed in this section are mainly irrelevant for an advertising aggregator. The only one that makes a difference is the content usage statistics, because advertising relies on knowing the end-users' preferences.

In general, the advertising aggregators prefer a scenario, where the advertiser revenue model is used. Thus, the most optimal outcome for an advertising aggregator is the *Demanding Saver* scenario. The *Indifferent Saver* scenario is a close second, but because the global ISPs may not rely wholly on advertising as the revenue source, the global ISP may not become an advertising aggregator.

5.6. End-users

End-users are the most important actors to shape the future of the Internet content delivery market, because they decide which content to request and their willingness to pay determines the revenue model for the content providers. As a consequence, their choices directly affect the outcomes of each uncertainty. However, the scenarios do not have a strategic impact on the end-user. Thus, this section only aims at identifying the factors that the end-users value in Internet content delivery.

Service usability is highly valued by the end-users, where usability combines the easiness of paying and the actual user experience. The user experience can be degraded by the mandatory advertisements inserted by the advertising content providers. From the two scenarios utilising the

consumer revenue model, the end-users may prefer the *Comfort Buyer* scenario, because the payment system is easier to use. On the other hand, the end-users may have low willingness to pay and thus prefer one of the advertising based scenarios. Advertising based scenarios, however, require the collection of usage statistics, which some end-users may perceive as privacy violations. Thus, these end-users may have a higher willingness to pay for the content.

The end-users tend to prefer a large selection of content over limited choices and the selection size may differ in the different scenarios. For example, the smaller ISPs and content providers may have a more limited selection of content compared to the bigger actors. Thus, the selection size may affect how end-users perceive each scenario.

Lastly, the freedom of choice is also important for an end-user. For example, access to certain content can be limited to only premium subscribers or geographic areas. In addition, the regulators may also restrict the access to certain content for certain end-user groups. Thus, international players may stand in a better position with regard to the geographical and local regulatory restrictions. On the other hand, the advertising content providers do not wish to limit the access to their content and thus premium subscription limitations are not available.

6. Strategic Impact on Caching Architecture

After determining the end-users' preferences and actions, the critical roles of each scenario has been identified. As a consequence, the actors controlling these critical roles in each scenario have a high chance of dominating the scenario. These actors, in turn, determine the winning caching architecture in each scenario. Each winning actor's preference for the four caching architectures is summarised in Table 8 and explained in this section.

Table 8. The probable caching architecture choices of the winning actors.

Actor\Architecture	CDN	Cloud	P2P	ICN
Local ISP	High	High	Low	Medium
Global ISP	Medium	Low	Low	High
Payment-based content provider	High	Medium	Low	Low
Advertiser aggregators	High	High	Medium	Low

The CDN and cloud architectures are preferred in the *Comfort Buyer* scenario, because the local ISP is small and typically does not have the ability to build its own caching networks. On the other hand, ICN may become more feasible for a local ISP, if it becomes the standard solution in the future.

On the contrary to the *Comfort Buyer* scenario, the large scale ISPs in the *Indifferent Saver* scenario have the ability and incentive to build its own in-network caching systems. In addition, because standardisation is important for a global ISP, ICN is a probable solution in the *Indifferent Saver* scenario. CDNs may also be a feasible option, because several large ISPs are already building their own CDN servers and this trend is likely to continue.

In the *Quality Buyer* scenario, the winning actors tend to be small scale content providers and thus buying content delivery services from CDNs and cloud providers is a feasible solution in terms of cost savings and received service. In addition, because the payment-based content providers do not have the ability to control the network operation role, in-network caching solutions (such as ICN) is the least beneficial caching architecture in this scenario.

Because of economies of scale and significant network effects, the advertising content providers in the *Demanding Saver* scenario prefer to build their own caching systems. However, because ICN requires the involvement of the underlying network, the most feasible caching architectures for advertising content providers are the CDN and the cloud. In addition, because CDNs and clouds are not standardised solutions, the advertising content providers may gain certain competitive advantages from deploying their own solutions.

Finally, the P2P architecture is not preferred in any of the scenarios. This is because the P2P solutions are very fragmented and the winning actors lose both revenue and control over the content delivery process if P2P is used.

7. Conclusion

This paper presents possible scenarios of heavy commercial Internet content delivery in the next 10 years. Many key uncertainties about the future are identified mainly related to the control of content and network as well as the content access and caching systems. The content provider's revenue model and the access ISP's bundling singled out as the two most critical uncertainties, upon which four future scenarios were constructed: *Comfort Buyer*, *Indifferent Saver*, *Quality Buyer* and *Demanding Saver*.

Each scenario identifies the corresponding winning business role and the related winning actors that get control over the Internet content delivery market and can decide which caching architecture to use. The alternative winning actors are a) (small) local access ISPs, b) (large) global access ISPs, c) (small) payment-based content providers and the banking system, and d) (large) advertising content providers.

Based on the winning actors of each scenario, an overview of the possible dominating caching architectures can be reached. In-network caching, whether Information-centric networking or web proxy caching, are strong candidates for the *Comfort Buyer* and *Indifferent Saver* scenarios. On the other hand, content delivery networks (CDNs) – either pure play CDNs or content provider built CDNs – and clouds are possible outcomes in the *Quality Buyer* and *Demanding Saver* scenarios.

This paper focuses on the qualitative analysis of scenarios. Utilising for instance the system dynamics method to model interdependencies between the trends and uncertainties could provide a path from qualitative to quantitative analysis.

Acknowledgement

The authors thank all the participants of the brainstorming sessions for all the valuable inputs. This work has been funded by the European Commission, under grant FP7-ICT-2009-5-257448-SAIL.

References

- Ahlgren, B. et al., 2011. A Survey of Information-Centric Networking (Draft). In *Proceedings of Dagstuhl Seminar on Information-Centric Networking*. Dagstuhl, Germany.
- AT&T, 2012. *Enterprise – Content Delivery*. [online] [Accessed on 15 Jun 2012] at: <http://www.business.att.com/enterprise/Portfolio/content-delivery/>.
- Castro, M., Costa, M. & Rowstron, R., 2004. Performance and dependability of structured peer-to-peer overlays. In *Proceedings of 2004 International Conference on Dependable Systems and Networks*.
- Casey, T., Smura, T. & Sorri, A., 2010. Value Network Configurations in wireless local area access. In *Proceedings of the 9th Conference on Telecommunications Internet and Media Techno Economics (CTTE)*. IEEE, pp. 1–9.
- Cisco, 2011. *Cisco visual networking index: forecast and methodology, 2010-2015*. [online] (Updated 1 Jun 2011) [Accessed on 08 Feb 2012] at: http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-481360.pdf.
- Dutta, R. et al., 2007. The SILO architecture for services integration, control, and optimization for the future internet. In *Proceedings of IEEE International Conference on Communications, 2007 (ICC'07)*. IEEE, pp. 1899–1904.
- Edgecast, 2012. *Licensed CDN*. [online] [Accessed on 15 May 2012] at: <http://www.edgecast.com/solutions/licensed-cdn/>.
- Elisa, 2012a. *Elisa Viihde – IPTV Service*. [online] [Accessed 15 Jun 2012] at: <http://www.elisa.com/en/viihde/>.
- Elisa, 2012b. *On Elisa*. [online] [Accessed 15 Jun 2012] at: <http://www.elisa.com/on-elisa/>.
- Enqvist, H. & Casey, T., 2010. Mobile Communications Industry Scenarios and Strategic Implications for Network Equipment Vendors. In *Proceedings of the 21st European Regional ITS Conference*. Copenhagen, Denmark: International Telecommunications Society (ITS).
- FICORA, 2010. *1 Mbps broadband (universal service): Internet is part of necessary universal services*. [Updated on 2 Dec 2010] [online] [Accessed on 14 Jun 2012] at: <http://www.viestintavirasto.fi/en/index/internet/laajakaista/yleispalvelu.html>.
- GGC, 2012. *Google Global Cache Beta*. [online] [Accessed on 14 Jun 2012] at: <http://ggcadmin.google.com/ggc>.
- Gutierrez, P.A. & Carapinha, J., 2011. Cloud Networking: Implications of Agile virtualization on Provider Relationships. In *Workshop on Challenges and Solutions for Network Virtualization, Communication in Distributed Systems 2011 (WowKiVS'11)*. Kiel, Germany.
- Hagiu, A. & Yoffie, D.B., 2009. What's Your Google Strategy? *Harvard Business Review*, 87. 2009
- Jacobson, V. et al., 2012. Networking named content. *Communications of the ACM*, 55(1), pp.117-124.
- Netflix, 2012. *Company Overview*. [online] [Accessed on 15 Jun 2012] at: <https://signup.netflix.com/MediaCenter/Overview>.

Orange, 2011a. *Group*. [online] [Accessed on 15 Jun 2012] at: http://orange.com/en_EN/group/.

Orange, 2011b. *Press release: Orange France updates its triple play range, introducing Livebox star and Livebox zen*. 8 Apr 2011. [online] [Accessed on 14 Jun 2012] at: http://www.orange.com/en_EN/press/press_releases/cp110408en.jsp.

PayPal, 2012. *About us*. [online] [Accessed on 15 Jun 2012] at: <https://www.paypal.com/fi/cgi-bin/webscr?cmd=p/gen/about-outside>.

SAIL, 2012. *Sail-project*. [online] [Accessed on 14 Jun 2012] at <http://www.sail-project.eu/>.

Sanoma, 2012. *Press Release: Helsingin Sanomat is the first Finnish media company to provide a combo deal for an iPad and newspaper*. 23 Apr 2012 [online] [Accessed on 19 Jun 2012] at: <http://www.sanoma.com/about-us/sanoma-news/news/helsingin-sanomat-is-the-first-finnish-media-company-to-provide-a-combo-deal-for-an-ipad-and-newspaper>.

Schoemaker, P.J., 1995. Scenario Planning : A Tool for Strategic Thinking. *Sloan Management Review*, 36(2), pp.25-40.

Schoemaker, P. and Mavaddat, V., 2000. Scenario Planning for Disruptive Technologies, in Day, G.S. and Schoemaker P.J.H. (eds.): *Wharton on Managing Emerging Technologies*, New York: John Wiley & Sons, pp. 206-241.

Schollmeier, R., 2002. A definition of peer-to-peer networking for the classification of peer-to-peer architectures and applications. In *Proceedings of the First International Conference on Peer-to-Peer Computing*, pp.101-102.

Sony, 2012. *Music unlimited*. [online] [Accessed on 24 May 2012] at: <https://music.sonyentertainmentnetwork.com/>.

Spotify, 2012. *What is spotify*. [online] [Accessed on 24 May 2012] at: <http://www.spotify.com/fi/about/what/>.

Telefonica, 2012a. *About Telefonica*. [online] [Accessed on 15 Jun 2012] at: http://www.telefonica.com/en/about_telefonica/html/home/home.shtml.

Telefonica, 2012b. *Telefonica Content Delivery Network*. [online] [Accessed on 15 Jun 2012] at: <http://www.telefonica.com/cdn/en/index.shtml>.

UN, 2006. Press Release, ORG/1469 – United Nations Member States. 3 Jul 2006. [online] [Accessed on 15 Jun 2012] at: <http://www.un.org/News/Press/docs/2006/org1469.doc.htm>.

Vakali, A. & Pallis, G., 2003. Content delivery networks: Status and trends. *Internet Computing, IEEE*, 7(6), pp.68–74.

Vaquero, L.M. et al., 2008. A break in the clouds: towards a cloud definition. *ACM SIGCOMM Computer Communication Review*, 39(1), pp.50–55.

Vodafone, 2012. *About us*. [online] [Accessed on 15 Jun 2012] at: http://www.vodafone.com/content/index/about/about_us.html.

Voddler, 2012. *About voddler*. [online] [Accessed on 24 May 2012] at: <http://voddlertalk.voddler.com/om/>.

Wischik, D., Handley, M. & Braun, M.B., 2008. The resource pooling principle. *ACM SIGCOMM Computer Communication Review*, 38(5), pp.47–52.

YouTube, 2012. *About YouTube*. [online] [Accessed on 15 Jun 2012] at: http://www.youtube.com/t/about_youtube.

XFINITY, 2012. *Comcast Triple Play*. [online] [Accessed on 14 Jun 2012] at: <http://www.comcast.com/Corporate/Learn/Bundles/bundles.html>.