THE IMPACT OF THE P2P PARADIGM ON THE NEW MEDIA INDUSTRIES

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Abstract

In Europe 2006 was the year of Voice-over-IP (VoIP). Almost all telecom providers started to offer VoIP products in combination with a phone flat rate. However, the VoIP technology was mature since 1999. Why was the success of VoIP so many years delayed? Can the enormous success of Skype be a major reason? In this paper we try to answer which influence the peer-to-peer paradigm as technology has on established business models of the new media industries. As new media industries we understand the media and telecom industries as well as Internet Service Providers (ISPs), because these industries start to merge by offering the same products and services to their customers. In three case studies we look at the telecom industry, at the media industry, and at ISPs. For each case study we first identify a reliable set of base figures. This is an important but non-trivial task, as often figures published by companies include abstractions which influence the figures in favor of the company. Having achieved reliable base figures we model the impact of the peer-to-peer paradigm on a specific industry and try to forecast the major trends of the next one to three years.

Keywords: Peer-to-peer paradigm, peer-to-peer business models, peer-to-peer case studies.

Introduction

Today up to 80% of the Internet traffic stems from peer-to-peer (p2p) applications (Hasslinger 2005). Although, a big part may still be caused by illegal file sharing applications, legal alternatives arise and become successful. The most famous one is Skype, but there are also other companies like Mercora (Mercora 2006), Kontiki (Kontiki 2002b), and Octoshape (Octoshape 2007) offering commercial p2p application, technology and services. This development is a sign that p2p technology becomes widely used and accepted. Thus, we have to ask: what are the reasons for this development? And what are the advantages of the p2p paradigm in comparison to the traditional client/server paradigm?

Peer-to-peer technology allows content providers to reduce their cost by exploiting "unused" resources at the edges of the Internet, mainly home and office PCs. From the user's point of view p2p applications also bring benefits, especially self configuration abilities and ease of use like an automatic NAT traversal. Being highly distributed p2p-based applications avoid bottlenecks and naturally scale with the number of participants. Unlike client/server-based applications they perform well during request peeks (see e.g. (Bharambe et al. 2006)) and hence offer a large potential for cost savings by avoiding unnecessary investments in server farms and offering better system perception to the users.

Knowing all these advantages what impact does the usage of p2p paradigm have on the industry? Skype is very well known and seems to influence the telephony market which has changed dramatically since Skype's launch. Further, the impact of other p2p applications is also important. In this paper we want to shed some light on the effects the usage of p2p paradigm has on the New Media Industry – telephony, media distribution, and Internet service providers. In three case studies we model the impact the p2p paradigm has on these industry and draw conclusions for their future evolution.

Case Studies

Skype's Influence on the Telecommunication Industry

Michael Powell (Ex-Chair of the Federal Communications Commission):
„I knew it was over when I downloaded Skype. […]
The world will change now inevitably." **(Charny 2004)**

Skype (Skype 2003) was founded in 2003 by the same persons that created KaZaA (Networks 2002), the famous p2p file sharing application. Skype is a p2p based Voice-over-IP (VoIP) application (Skype 2007a). Skype offers free Skype-to-Skype calls. Calls into the Public Switched Telephone Network (PSTN) have similar rates like call-by-call providers offer (Skype 2007b). In 2005 Skype received a lot of attention when it was bought by eBay (eBay 2005).

Skype is extremely important for p2p as it is the first successful business model that employs the p2p technology and its success does not stem from the illegal exchange of copyright protected content. Still, it also is a disruptive business model in its field, as it offers free Skype-to-Skype phone calls. VoIP was clearly not invented by Skype. The first companies offering free VoIP-to-VoIP calls were operative in 2002 (see e.g. (Vonage 2006b)). However, not until the year 2006, which was called the year of VoIP in Europe, VoIP could succeed as new telephony technology. Many telephony operators started to offer telephony flat rates based on VoIP technology. The question that arises is, if the success of Skype might be responsible for the sudden shift in the basic business models and underlying technology of the European telephony operators. They shifted from phone calls based on PSTN-lines where customers where charged on a per minute basis to VoIP-based flat rates. Before modeling the impact of Skype on the telephone market we will first have a look how successful Skype was since its start in 2003 and what might be the reasons for that success.

Figure 1 and Figure 2 show a comparison of the customer increase of Skype against the US-based VoIP-provider Vonage (Vonage 2006a). In a shorter time span Skype could gain more than double the customers than Vonage, although Vonage has a substantial marketing budget to gain customers (see Figure 3). In 2005 Skype still did not have marketing expenses,

because users were persuaded to join Skype by word of mouth (Gaskin 2005). Today, Skype is having a marketing department with headquarter in London (see (Wolff 2006)).

If distribution just by word of mouth is so successful, Skype must provide a benefit to users, that competing products do not provide. In comparison to VoIP providers using SIP (Force 2006) the advantage of Skype is, that it circumvents firewalls and NATs. Users simply download the Skype client and can start to chat or talk with their "buddies". Unlike, a new Vonage customer has to configure her/his router or firewall to forward the RTP stream to the correct IP-enabled device (see Figure 4). Not all customers were experienced enough with their computer equipment to do that.

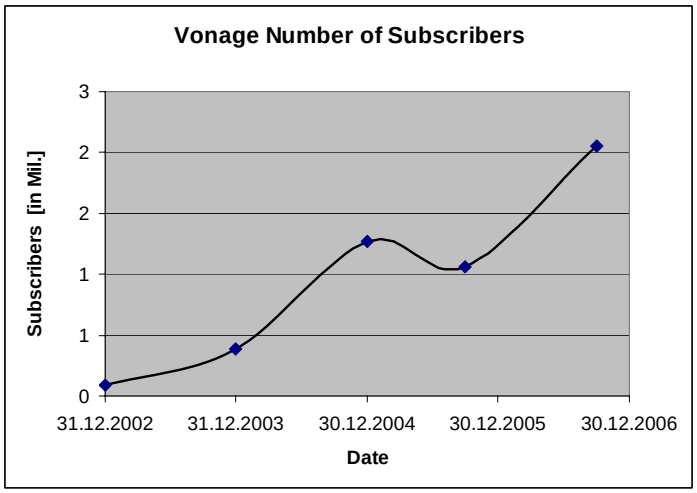


Figure 1: Number Of Line Subscriptions Of Vonage (Vonage 2006b)

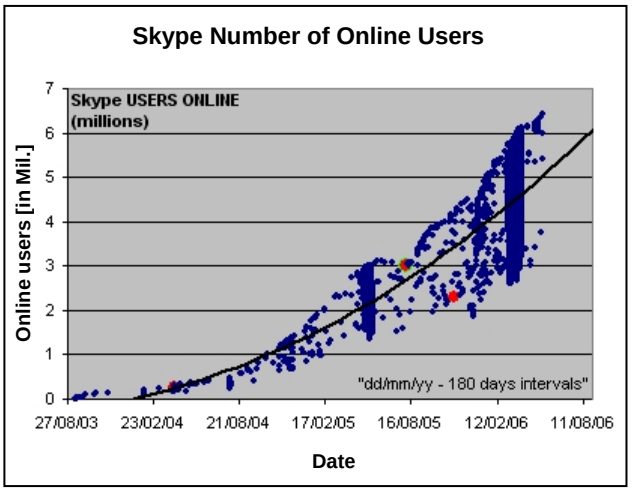


Figure 2: Number Of Online Users In Skype (Mercier 2007)

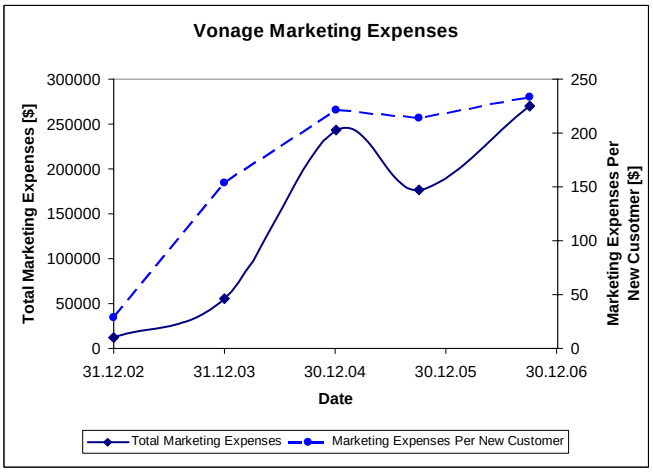


Figure 3: Vonage Marketing Expenses (Vonage 2006c)

Table 1: Vonage Investments in Hard- and Software (Vonage 2006c)

Assets	2004 (in US-Dollar)	2005 (in US-Dollar)
Network infrastructure and computer hardware	17,800,000	58,917,000
Software	2,543,000	4,667,000
Note: The company had in the corresponding years the following number of customers:: 390,566 (2004) und 1,269,038 (2005)		

For phone calls into the PSTN net both VoIP providers and Skype have an advantage over Call-by-Call providers. They are using rented PSTN lines only for the last part of the way; that is from the VoIP/PSTN-Gateway to the call receiver. As the gateways are typically positioned at strategic locations this allows offering very low priced phone connections. Call-by-Call

providers typically also have to rent the long distance lines, for example transatlantic connections. Here VoIP providers and Skype use the Internet; the used bandwidth is paid by the end user, probably using an Internet flat rate.

Another important advantage of Skype over VoIP providers using SIP is shown in Figure 5. Skype's only centralized part of infrastructure is the login server. Call setup is done by the p2p overlay network. This overlay network is composed of the users' computers running the Skype client. Therefore, with every new Skype user the resources available for the Skype infrastructure grow in a natural way, too. On the other hand Vonage has to extend its server infrastructure frequently when the customer base grows, because call setup requires the central SIP gateways (see Figure 4). For phone calls into the PSTN both companies need VoIP/PSTN-gateways. Here, there is no difference in the required infrastructure.

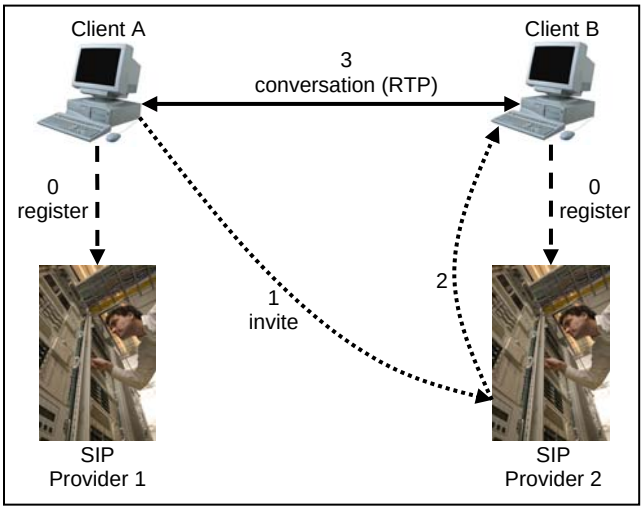


Figure 4: SIP Infrastructure

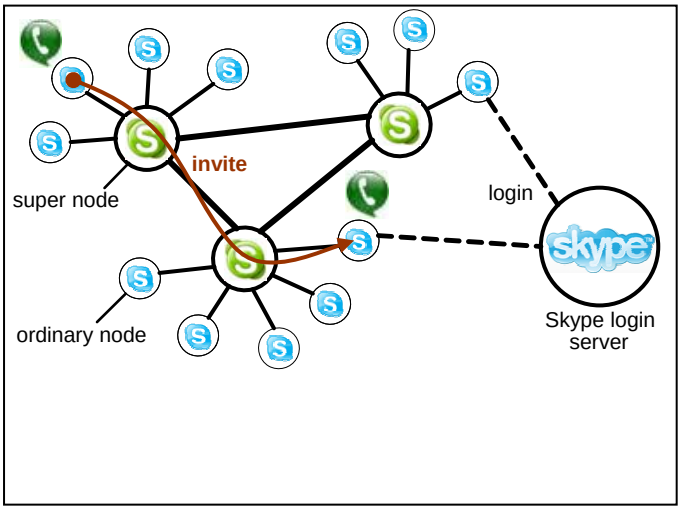


Figure 5: Skype Overlay Network Architecture

Setting

Understanding the technology based competitive advantages of Skype (build-in NAT-traversal, naturally extending network resources, cost advantages) still there is no clear understanding which impact Skype had on the telephony sector during the last years. Skype claims that 7% of all international phone calls are today Skype calls (Skype 2006). That would be a very distinct market share and would force its competitors to act, especially with the fast growing user base of Skype (see Figure 2). Also, from 2003 to 2005 the telephony companies AT&T und MCI faced a yearly decline in revenues for international phone calls of 20% to 30% (PriMetrica 2005b). To which part is Skype responsible for this development?

Model

Today, there are many telephone flat rates for national calls offered. Therefore, in this case study we model the influence of Skype on the international telephony market. Figure 6 shows an estimation of the development of the telephone market for international calls[1]. Skype claims that it served 7.1 billion minutes in Q2/2006 and that this is 7% of the world wide telephone market for international calls. Table 2 shows a summary of Skype's statements about its market share. However, we

[1] Own illustration, following PriMetrica, I. "TeleGeography Research Shows International VoIP Traffic Grew 80% in 2002," 2003, http://www.telegeography.com/press/releases/2003-12-10.php, last access: 25.08.2006, PriMetrica, I. "TeleGeography 2006 Executive Summary," PriMetrica, Inc..

discovered that these numbers are sugarcoated. As base figure for calculating Skype's market share in 2006 Skype did not use the total amount of international but used the total amount of the circuit switched calls of the 20 countries with the highest amount of international call minutes. Further, Skype used the numbers from (PriMetrica 2005a), which contains the figures for 2004 and not for 2006.

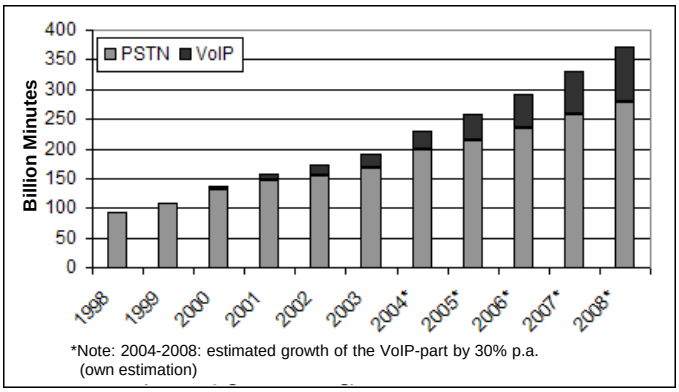


Figure 6: Development Of International Calls Split Into PSTN And Voip Parts, (PriMetrica 2003), (PriMetrica 2005a)

Table 2: Percentage Of Skype Of World Wide International Phone Calls

Year	International Share of Phone Calls		Skype Phone Minutes	Ratio of International Calls at Skype
	(in %)	(in Bil. Min)	(total in Bil. Min.)	(in %)
2005	4%	6.48	17.3	37%
2006	7%	11.34	27.8**	40%

* Reference base of Skype is 162 billion minutes after (PriMetrica, 2005a)

** Q1-2/2006 after official Skype statememt [REF]; Q3-4/2006 estimated

Accordingly, we remodeled the market share of Skype for international calls again using the model showed in Figure 7. The 20 countries with the highest amount of international calls are only responsible for 80% of all international phone minutes (PriMetrica 2005a). The resulting amount is still missing the international VoIP traffic, which was 17% of the circuit switched international call minutes in 2004 (PriMetrica 2005a). The result is then extrapolated for 2006 using the international growth prediction from (PriMetrica 2005a) (see Figure 6). Table 3 summarizes the result for the modeling. For 2005 we calculated a market share for Skype of 2.5%. For 2006 the model resulted in a market share of 3.9%, instead of 7% as stated by Skype.

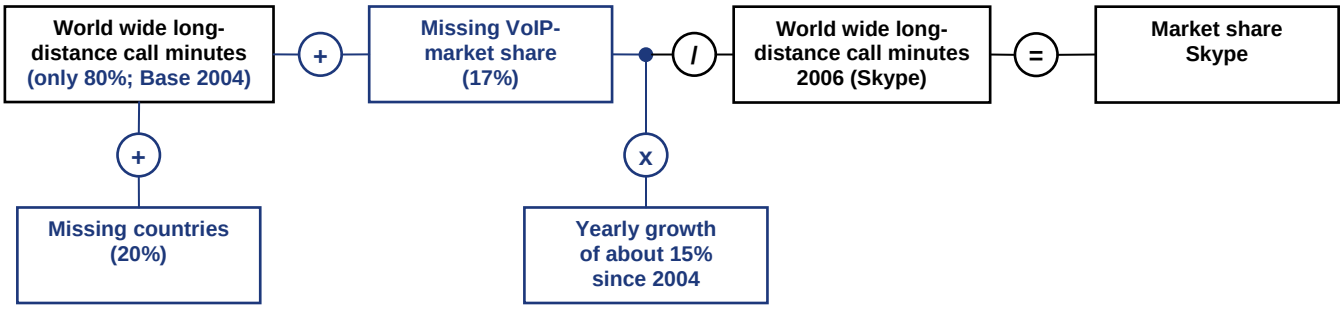


Figure 7: Model To Estimate Skype's Market Share For International Calls In 2006

With 3.9% Skype has still a significant market share for international calls. However to further determine the influence of Skype on the international phone market we will further evaluate the situation. In Table 4 we calculate the theoretical monetary amount of the phone calls Skype users did in 2005 and 2006. For 2006 we estimate a theoretical value of the international calls with of almost 3 billion dollars. Table 5 shows the actual revenues of Skype (retrieved from (eBay 2006)).

The important observation from this is, that Skype converted a 2.9 billion Dollar market value into a 155 million dollar value. Of the market value not even 6% of value remained. Thus, Skype is clearly a disruptive technology.

It could be argued that with Skype many additional calls were done that would users have never done if they had to pay for it. However, even if we assume only half of the Skype calls to have been done also on normal phone lines, still only 11% of the theoretical market value remained.

Table 3: Corrected Skype Share Of World Wide International Calls

Year	Percentage of International Calls (in %)
2005	4% ↘ 2.5%
2006	7% ↘ 3.9%

Table 4: Monetary Value Of International Calls Via Skype

Year	World Wide Call Minutes (in Bill. Min.)	World Wide Revenues from Calls (in Bill. $)	Average Price Per Minute* (in $/Min)	Skype Call Minutes (in Bill. Min)	Monetary Value of Skype Call Minutes** (in Bill. $)
2005	258.4	69.7	0.27	6.48	1.75
2006	291.9	74.6	0.26	11.34	2.90

* Price per Minute = Revenues / Total Call Minutes
** Monetary Value = Skype Minutes x Price per Minute

Table 5: Skype Revenues Of International Calls

	Skype Net Revenues (eBay, 2006)				
	Q1/2006	Q2/2006	Q3/2006	Q4/2006*	Sum
Revenues in thousand $	35,160.00	44,158.00	50,021.00	54,000.00	
Percentage International	87%	86%	84%	83%	
International revenues in thousand $	30,589.20	37,975.88	42,017.64	44,820.00	155,402.7

* Own estimation

Conclusions

Classical telephony providers are under strong pressure, as their revenues decline since years heavily. A reason is the trend towards IP-based telephony, which can be offered to end users as a flat-rate based add-on to their Internet connection. Therefore, telephony providers have to find new business models to create new revenues. Revenues are very important for these companies as they have to be able to pay a large staff that grew when telephony was only PSTN-based. In order to create additional revenues traditional telephony providers, which are in most cases also Internet Service Providers, integrate horizontally into new business areas, e.g. IP-TV. However, also the traditional cable TV companies are integrating horizontally and offering now Triple Play with telephony and IP-TV. The current growth of the Call-by-Call market is down to 0% from formally 30%. As customers pay already national VoIP-based phone calls based on a flat fee, VoIP-to-VoIP calls are free even for international calls and the distribution VoIP-based telephone connections increase dramatically, it can be estimated that the formally 700 billion voice phone market will face a dramatically decline in the next few years. Skye reduces the market value of its calls by estimated 90%. Due to the technology shift towards VoIP we forecast the same development for the complete telephony market – only 10 – 20 % of the current market value will remain. Although the numbers of impact today presented by Skype are overstated, Skype will play an important role in the future telephone market. It is the most convenient product with the best usability of all VoIP products due to automatically NAT-traversal. Unlike your VoIP phone at home, Skype can be used with any Internet connection without the need for configuration. Therefore, it is and will be the most attractive telephony solution for mobile users.

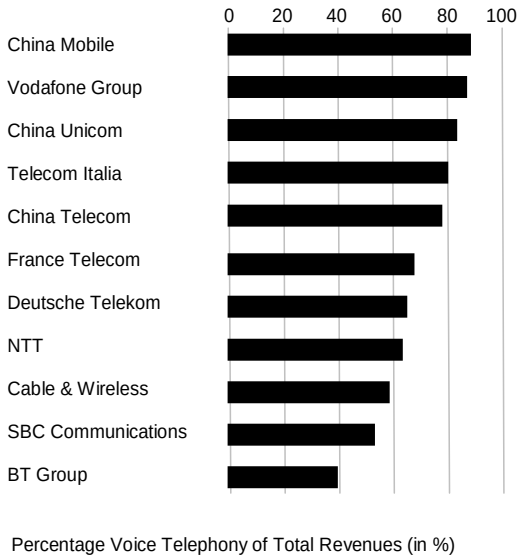


Figure 8: Percentage Voice Telephony Of Total Revenues (Economist 2005)

Evolution of the Media Industry

David Wood (Head of New Technology in the Technical Department, European Broadcasting Unit) about streaming the Eurovision Song Contest into the Internet using "edge caching": *"Probably cheaper to give every user a free CD!"* (Wood 2006)

The p2p paradigm became famous by different file sharing applications, like Napster (Shirky 2001), Gnutella (Clip2 2000), KaZaA (Networks 2002), eDonkey2000 (MetaMachine 2003), etc. The basic idea is to deliver content directly from one end user who obtained a requested piece of content before, to the requesting end users. Since a few years these ideas are now also being used in commercial products. Figure 9 gives an overview on the companies active in this area. In this Section we will present the case study of Kontiki (Kontiki 2002a) resp. the BBC integrated Media Player (BBC 2005b) for P2P based distribution of stored content and the use case of Octoshape (Octoshape 2007) for P2P-based live-streaming of events, namely the Eurovision Song Contest (Union). For both cases we will model the cost efficiency of the p2p-based solution against a potential client/server based content distribution.

Setting for P2P-based Distribution of Stored Content

From November 2005 to February 2006 the BBC conducted a field study where they tested the concept of the so called BBC integrated Media Player (BBC iMP) (BBC 2005b). In that field trial 5000 users representative for the UK's population could download selected parts of BBC's radio and TV program of the last seven days. In total more than 190 TV-shows and 310 hours of radio program were available, in addition to regional programs and some movies. Some programs were already available in HD-TV resolution. The time limit of the download was enforced by the Windows Media Digital Rights Management system. The programs where distributed using a p2p-based distribution platform of a company called Kontiki (BBC 2005a). The BBC decided against streaming because the ADSL-links BBC's customer would use for the p2p-based distribution would not be sufficient for high quality video streaming.

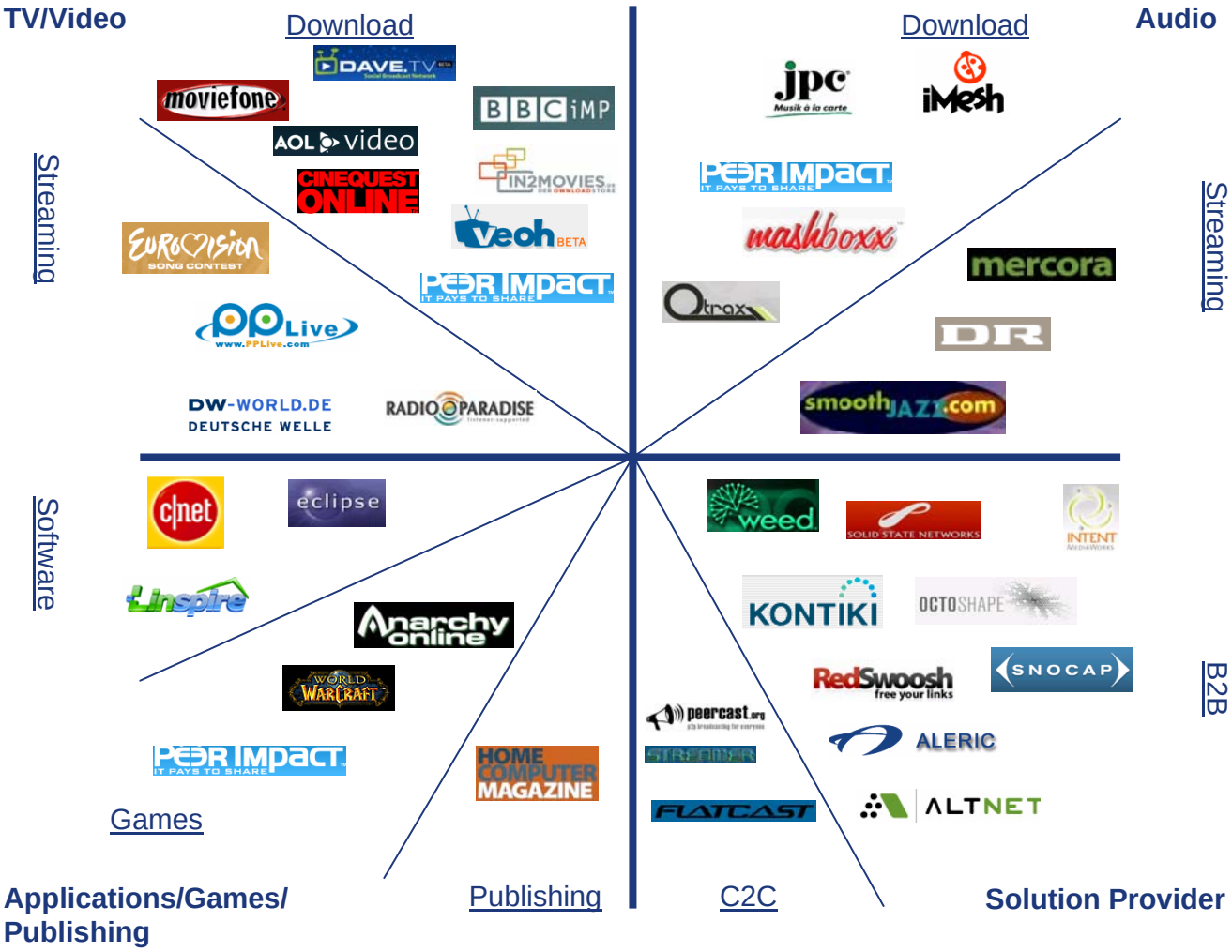


Figure 9: Overview Over The P2P-Based Content Distribution Market

Kontiki (Kontiki 2002b) uses an hybrid approach for distributing the content and the key required to watch or listen to the content, as shown in Figure 10. The user downloads an encrypted copy of the requested program. Either the program is delivered by the BBC seed server, if no other user is currently sharing the program. Otherwise, the program is downloaded from other users sharing the program. Kontiki supports also the parallel download from multiple sources. In order to watch or listen to the content the user requires downloading the decryption key from a central DRM server. Accordingly, users could only use the content when they were connected to the Internet and the DRM server was reachable (BBC 2005a).

Model for P2P-based Distribution of Stored Content

In the following we will model the traffic generated during the three month field trial and extrapolate it to a use case where the BBC offers the iMP to the whole UK. We will then compare the costs resulting from the traffic requirement of a p2p-based distribution of stored content to a traditional client/server-based solution.

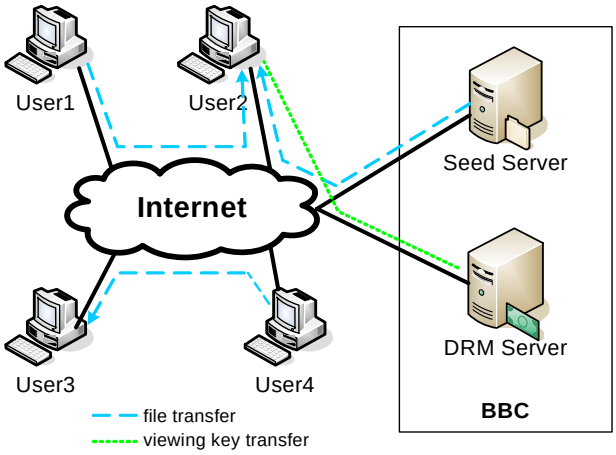


Figure 10: Kontiki Technology Concept

Table 6: Estimated File Sizes Of TV Programs By Program Type

Type	Codec	Video Resolution	Bit rate	File Size of a TV Program (30 min)
Audio	WMA	-	128kbit	-
TV	WMV	720*576	1.5Mbit	330MB
HD-TV	WMV-HD	1280*720	8Mbit	1800MB

Note: The stated values regarding the bit rates and file size of a TV program are estimation and shall serve as example.

Table 7: Comparison Of The Complete BBC Media Archive With The Imp Test Archive

	Complete BBC Archiv (in h)	iMP-Test Archiv (in h)	Ratio (in %)
TV	600.000	95	0.02
Radio	300.000	310	0.10

During the BBC iMP field trial the 5,000 users downloaded 150,000 TV-programs; this is on average 13 TV-programs per month. Further, this corresponds to approximately 6% of the traditional TV consumption of BBC programs of a typical household (BBC 2006). Assuming the average file sizes of Table 6, we estimate that at least 12 TB of data transfer occurred during the field trial per month. Assuming an average traffic upload price of 0.28€ per GB, using a central server farm the field trial would have generated traffic costs of 3,440€ per month. However, since the BBC applied the p2p-based technology of Kontiki, the actual traffic costs generated by the seed server must have been lower.

Before modeling which traffic saving can be realized by applying a p2p-based content distribution technology, we will first extrapolate the BBC iMP field trial to a normal IP-TV solution for the whole UK. Within the UK there are approximately 19 million households. As the selection of the 5000 test users of the field trial was a representative share of the UKs population, we can assume that the results of the field trial could be extrapolated to the UK.

What do these figures mean for dimensioning the required client/server system? If 1% of UK's households would use IP-TV a traffic volume of 456 TB per month would be created. A minimum of 140 servers would be required to deliver the data; each of them would have a 10kbps connection to the Internet. Further we assume a uniform distributed delivery. For the typical day time when TV consumption is the highest this system would be under dimensioned. If the example is extended to a scenario where all UK households would used IP-TV a server farm of 140,000 servers would be required. Table 8 shows the results.

As mentioned before, during the field trial the BBC iMP was only used for 6% of the normal TV consumption. Assuming the UK would completely change to an IP-TV platform with Video-on-Demand (VoD) capabilities, the presented results would have to be multiplied by a factor of 20. If the BBC would open their video archive and offer its contents per VoD, the so called "Long Tail" effect (E. Brynjolfsson 2006) would further enhance the TV consumption. The "Long Tail" effect describes the fact that media content is consumed over a long time span. Therefore, when users have the opportunity to consume independently of a TV schedule they tend to consume more media of niches than they would if bound to the TV schedule. For a comparison of the complete BBC media archive with the limited iMP test archive see Table 7.

Obviously, in order to build an IP-TV platform a client/server-based technology in combination with an IPv4-based delivery does not fulfill the requirements. Either the network has to support IP-Multicast or a different form of distribution apart from client/server must be chosen.

Table 8: Resulting Traffic And Costs In The BBC Imp Scenario

	iMP Test	Percentage of Usage of the iMP corresponding to the Number of Households (Total Number of UK Households is 19 Million.)				
		1%	5%	30%	50%	100%
Number of Users	5,000	190,000	950,000	5,700.000	9,500,000	19,000.000
Traffic* (in TB/month.)	12	456	2,280	13,680	22,800	45,600
Costs** (in €/month.)	3,441	130,744	653,722	3,922,330	6,537,216	13,074,432

* The resulting traffic is generated by 13 downloads of TV programs on average per month. One program has an average length of 30 minutes and corresponds to a file size of 330MB.

** We assume that in a client/server system the traffic costs per GB are 0.28€. (Hosting-offer of www.strato.de for dedicated Server (HighEnd-Server SR3)).

In order to compare the efficiency of a client/server-based content distribution with a p2p-based content distribution, we simulated how much traffic is generated by a seed server if a p2p-based technology is applied on top of a IPv4-based network. Using the BitTorrent simulator from (Research 2005) we have simulated a scenario where a 100 MB file is distributed to 1000 users. The result shows, that a seed server with a 6 Mbps uplink is distributing about 10% of all file chunks. Accordingly, using a p2p-based content distribution traffic costs can be reduced by 90% in comparison to a client/server-based distribution. Further results on how BitTorrent works and how efficiently the uplink bandwidth of a seed server is used can be found in (Bharambe et al. 2006).

Setting for P2P-based Live-Streaming

The Eurovision Song Contest (Union) is a yearly important event in Europe. It is an European music competition held since 1956. Each year more than 100 million people follow the event on TV. Since 2004 the European-Broadband Union (EBU) is also live streaming the event into the Internet. In 2004 and 2005 the EBU applied a client/server-based solution. Due to the high bandwidth requirement of live streaming the event, a so-called Edge Caching-based solution was applied (see e.g. Akamai (Akamai 2004)). For the Eurovision Song Contest in 2005 over 60,000 simultaneous streams had to be provided world-wide. This created costs of about 65,000 Euros for a 3-4 hour show. This situation led David Wood, Head of Technology, EBU, to the statement, that it would have been probably cheaper to give every user a free CD (Octoshape 2006b).

Due to these high costs in 2006 the EBU decided to apply a p2p-based live streaming solution from the Danish company Octoshape (Octoshape 2007), (Octoshape 2006b). Using Octoshape the Eurovision Song Contents was streamed live to 74.821 users. The users could choose between three quality levels of 700 kbps, 450 kbps, and 200 kbps. The highest number of simultaneous streams was 14,976. The average duration of a stream was 1.5 minutes.
Ocotshape claims that using their technology a cost advantage of 97% can be realized in comparison with client/server-based live streaming (Rauhe 2005).

Model for P2P-based Live-Streaming

In the following model we will calculate the actual cost savings for the European Song Contest case study.

When modeling p2p live streaming we assume that each client is also uploading parts of the received media stream to other participants. A model where 1000 users receive a 450 kbps media stream and redistribute it is presented in Table 9. Different node types are taken into account with different probabilities for participating in the p2p streaming. These probabilities are

taken from (Stefan Saroiu 2002); however, we did not consider the 5,000 kbps upload links, as these are typically company links and are well protected by firewall, why it is very unlikely that they are available for p2p streaming.

Table 10 summarizes the results of the model from Table 9 for several sizes of the p2p streaming scenario for different stream qualities. For the highest quality stream that Octoshape is able to realize still traffic savings of 53% in comparison to a client/server-based streaming.

Table 9: Model To Determine The Redistribution Factor Of P2P Live Streaming

Node Type upload capacity (in kbps)	Node Type available upload capacity (in kbps)	Probability of node existence	Providing (as ratio of the received stream)	Users (total 1,000 users)	Streams provided user-to-user	Streams provided by seed server
128	100	24%	0,2	240	48	128
384	300	47%	0,6	470	282	384
1000	750	29%	1,6	290	464	1000
Total					794	206

Table 10: Model Results For Different Stream Qualities

Users	Stream quality (in kbps)	Streams provided by seed server	Savings
1000	450	206	79%
5000	450	1030	79%
10000	450	2060	79%
100000	450	20600	79%
1000	700	475	53%
5000	700	2372	53%
10000	700	4744	53%
100000	700	47430	53%

Conclusions

Content distribution is definitely one of the main application fields where p2p-based approaches are predominant to client/server approaches. This is due to the swarming effect that can be exploited. The case studies show, that a p2p-based content distribution platform can save up to 90% traffic costs in comparison to a client/server-based platform. Additionally, the centralized infrastructure needed for seeding the content is much smaller with a p2p-approach, i.e. investments and administration costs are lower. That these cost saving are essential especially for media content with large file sizes shows Figure 11. Here the average revenues in Euro per GByte file size are shown.

A technological requirement for realizing these cost advantages with a p2p-based content distribution platform is a well working NAT-traversal for the p2p-clients. As most users will not do port forwarding for their home routers (and cannot do for example for the office desktops) this is clearly the key issue to be solved for creating a swarming effect, which is the foundation for realizing the cost advantages.

Fact is the bandwidth requirements for media services are increasing fast. E.g. radio stations are offering an increasing download portfolio to their users on their web pages, e.g. in the form of Podcasts. However, due to the strong interest of the

users in these offerings, the bandwidth requirements increase faster than the price of bandwidth is declining[2]. The BBC iMP case study also shows that there are only two options for doing video-on-demand (VoD) or IP-TV for a whole country, assuming that the infrastructure does not support IP multicast. Either replicas of the media content have to be stored to a large set of regional distribution centers. Such centers are expensive, as the whole VoD media archive and parts of the TV-program are mirrored there (see Figure 12). This requires large investments in infrastructure. Additionally the high energy consumption also leads to high operating costs. The second alternative is a distinctively cheaper p2p system. Here, caching strategies at the users' devices can avoid at least parts of the regional infrastructure. However, it is unclear how such a p2p-based media platform influences the overall traffic generated on the network. This topic is to be discussed in the last case study of this paper.

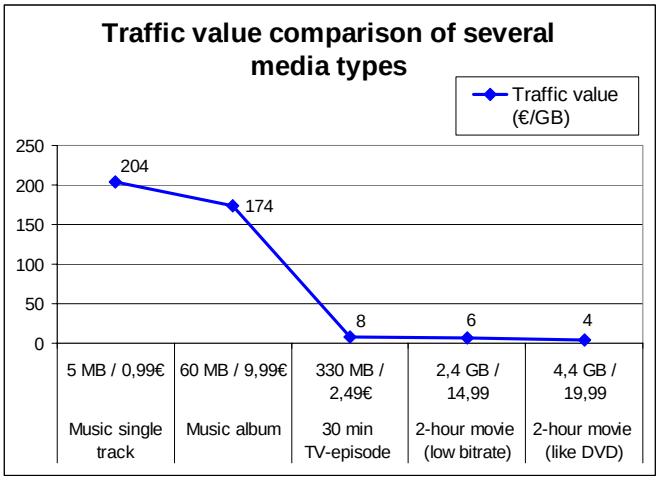


Figure 11: Traffic Value Comparison Of Media Types[3]

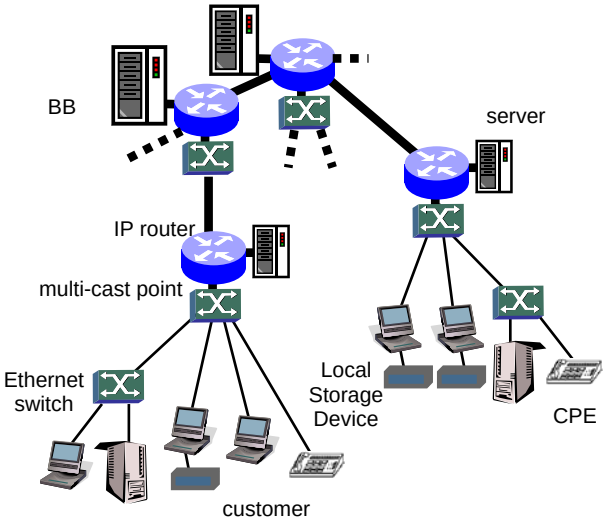


Figure 12: Video-On-Demand Architecture With Local Media Archives In Order To Achieve Scalability

The Effects of Peer-to-Peer Paradigm on Internet Service Providers

Sanjay Dhar (Product Manager/Cisco):
„On transit links […], we're seeing most P2P traffic goes offnetwork. These links are quite expensive. […] In fact these costs are the biggest overall component of your operational costs – its about 20-30% of costs." **(Marsh 2004)**

Setting

The Internet is composed by many different networks, owned and operated by Internet Service Providers (ISP). These networks are connected with so called transit links at exchange points. Two different traffic exchange agreement exist between ISPs. With peering two ISPs agree that both do not pay for traffic that is routed between them. With IP transit an ISP has to pay for the traffic that leaves its network. Each ISP is negotiating the prices individually with its neighbor ISPs (Heckmann 2004).

[2] Interview with Oliver Reuther, SWR3, Head of the Online Department
[3] Note: The prices are averages of the Online-Shops of like Apple iTunes, T-Online Musicload, Amazon Unbox for the corresponding media content.

Today, 60% to 80% of all Internet traffic is p2p traffic (Hasslinger 2005). Accordingly, also the majority of the interconnection costs for ISPs should come from p2p applications. The question we try to answer is which influence these costs have on ISPs.

In the report "True Picture of File Sharing" (Cachelogic 2004) Cachelogic, a Britisch provider of content delivery solutions, states that in 2004 West-European ISPs had p2p caused transit costs of 100 Mio €. As these figures are quite significant several questions arise: what is the future trend for p2p generated transit costs of ISPs and what can ISPs do to keep them bearable.

Model

At first we examine the assumptions of the Cachelogic report mentioned above to determine the trustworthiness of the stated figures. The calculations of this report base on the following assumptions (Cachelogic 2004) for the year 2004:

- p2p traffic is 50% of the total seen downstream traffic
- All of 33 Mio users with a broadband internet access in Western Europe use p2p applications
- An average broadband internet access has a bandwidth of 512 kbps and a contention rate of 50:1
- ISPs pay average transit prices of 50 € per Mbps per month

At least some of these assumptions seem to be quite unrealistic. For example, in 2005 only 31% of French and 34% of German users who had broadband internet access used p2p applications (EITO 2006). Instead Cachelogic assumed 100%. Furthermore, the users do not run their p2p applications 24 hours a day. For example, the users in France run p2p applications for 8.5 hours on average per day and in Germany only 3.75 hours (EITO 2006).

Additionally, not all sources of digital content (especially videos) come from outside the ISP's network. The main reason is that for most content types users build groups (e.g. national) interested in special localized versions (Eurescom study P1553 2005). Hence, it is likely that the source and the requesting peer are in the network of the same ISP and therefore do not induce transit costs for the ISP. Further, if the transit traffic goes through a peering point between ISPs it can traverse the networks without generating extra costs for the source-ISP.

So, we remodeled the p2p generated transit costs based on (EITO 2006) provided numbers as shown in Tables 11 and 12.

As we can see the figures for year 2004 differ by 88% from those of Cachelogic's study, from 100 million € down to 12 million €.

However, for the year 2010 we expect the costs to explode to 484 Mio €, even though we assumed very defensive development of internet access bandwidth. Already today, with VDSL today customers can already order Internet access with 20Mbps downstream and 5 Mbps upstream.

Conclusions

Currently, ISPs are those who suffer under the p2p applications, because they typically charge broadband traffic in a flat rate manner while the content providers apply p2p technology to move traffic from their servers into the network. This can be expected to proceed, as p2p technology is especially feasible for content providing. It can handle peeks in user requests, so called "flash crowds" (Jung et al. 2002), and provides better performance regarding the distribution time (Izal et al. 2004). Therefore, p2p technology offers benefits to both content providers and content consumers while the ISPs have to bear the costs.

Table 11 – Development Of Transit Relevant And P2P Related Internet Access Figures (EU25)

Year	Users with Broadband Internet Access* (Mio.)	P2P Penetration**	Users Running P2P Applications (Mio.)	Downstream Bandwidth*** (Mbps)	Upstream Bandwidth*** (Mbps)
2002	12.8	20%	2.6	0.7	0.1
2004	33.0	25%	8.3	0.7	0.1
2005	58.4	30%	17.5	2	0.2
2006	75.8	35%	26.5	2	0.2
2010	119.5	60%	71.7	25	1.5

* EU25 countries (EITO, 2006)

** 2005 the p2p penetration of the broadband internet accesses varied between 15 and 34% in West-European countries. The trend from 2006 to 2010 is estimated due to the expected higher utilization of p2p content distribution

*** Defensive estimation for 2010 as already today ISPs like Deutsche Telekom offer DSL products with 20 Mbps downstream and 5 Mbps upstream rates

BitTorrent, a currently popular p2p protocol for content distribution is very disadvantageous for ISPs (Karagiannis et al. 2005). ISPs could reduce their costs by applying the so-called ISP caching. Here, often requested p2p content is stored on ISP caches and if possible served from a cache instead of other peers. Another possibility would be a modification of p2p applications in order to make them "locality-aware". Then, the p2p applications try to load content from the peers in the same ISP network. Due to Karagiannis et al. locality-aware protocols can reduce the ISPs downlink traffic by 50% compared to the current solutions. One example of applied p2p caching is the ISP "True" from Thailand which reduced the broadband consumption of P2P applications in its network by 60%. This reduced their p2p-related costs by 40% (PeerApp 2006). An overview of possible ISP actions to face the challenge p2p traffic is shown in Table 13.

Table 12 – Development Of The ISP Costs For Transit Relevant P2p Traffic (EU25)

Year	P2P Traffic* (total in Gbps)	P2P Traffic** (transit-relevant in %)	P2P Traffic (transit-relevant in Gbps)	Transit Price for IP Traffic*** ($/Mbps per month)	ISP's Transit Costs ($/month)	ISP Transit Costs (Mio. $/year)
2002	16	40%	6	220	1,408,000	16,896,000
2004	52	30%	15	65	1,005,469	12,065,625
2005	263	25%	66	40	2,628,000	31,536,000
2006	663	20%	133	30	3,979,500	47,754,000
2010	20,166	10%	2,017	20	40,331,250	483,975,000

* = (Number of p2p users) x (upstream bandwidth) x (p2p running time) x (p2p upstream share) where

P2p running time = 6h per day, i.e. 25%, estimated based on figures of (EITO, 2006). Expected to increase to 30% (2005), 50% (2006) and 75% (2010).

Upstream share = conservatively estimated to 25% of the maximum bandwidth. The rest is used by or reserved for other applications, like Web Browsers or SIP-VoIP

** own sinking estimation because of interconnected ISP networks, increasing number of peering points und higher probability of p2p requests served from the same network for growing number of user

*** based on (Invisible Hand Networks, 2006)

Conclusion

Before Skype there was no successful application that applied the peer-to-peer (p2p) paradigm as underlying technology. Today we can find p2p success stories above all in the area of digital media distribution and IP telephony. When the p2p

paradigm became famous, many people were stating that it is disruptive technology (Oram 2001). In this paper we discussed the impact of the p2p paradigm on different industries using three case studies.
Skype (Skype 2003) shows an enormous success in the telephony industry. Skype became famous by a community effect and not by marketing efforts. A technology advantage Skype has over VoIP competitors is the built in NAT traversal capability. Skype is much easier to use behind a router than e.g. a SIP-based phone. In parallel with the success of Skype the telephony market changed. Today, for national calls VoIP-based flat rates are common in Europe. The market for international phone calls experiences a yearly decline in revenues of 20%-30% (PriMetrica 2005b) since 2003. We showed that the actual market share of Skype for international calls is 3.9% and not 7% as stated by Skype. Further we showed that Skype converted a 2.9 billion Dollar market value into a 155 million dollar value. Of the market value not even 6% of value remained. Thus, Skype is clearly a disruptive technology. Further, it can be forecasted that this effect will expand to the international calls telephony market, because VoIP-to-VoIP calls are free world wide.

Table 13 – Overview Of Possible ISPs' Reaction To Traffic Costs Induced By P2P Applications

ISP's Action	Active Influenced by ISP	Reduction of ISP's costs	Same or Better Service for ISP's customers
Ignore the development	✗	✗	✗
Blocking of p2p traffics in the own networks	✓	✓	✗
Additional investments in network infrastructure	✓	✗	✗
Charge tariff instead of flat rate for end-user or increased prices for internet access	✗	✓	✗
Filtering: Preventing p2p traffic to go out of the ISP's own network	✓	✓	✗
Rate control for p2p applications	✓	✗	✗
Least cost routing – route p2p requests to the content source inside of the ISP's own network	✓	✓	✓
Caching of popular p2p contents on ISP's servers	✓	✓	✓
Utilization of locality-aware p2p protocols	✗	✓	✓

As second case study we modeled the cost advantage of p2p-based media distribution against client/server-based media distribution. Two cases, the BBC integrated Media Player (BBC 2005b) and the Eurovision Song Contest live streaming using Ocotoshape (Octoshape 2006a) show cost reductions for traffic of up to 90%. This also implies further cost savings for infrastructure. Accordingly, using p2p-based content distribution platforms content distribution becomes much cheaper. We predict that market prices for content delivery will drop significantly during the next years.

The business case for p2p-based content delivery platforms focusing on distributing commercial content could be disrupted by the introduction of a IP multicast infrastructure across ISPs. Not affected could be p2p-based community platforms, because the interest in a single piece of user generated content is probably too low a for massiv parallel distribution. Thus, IP multicast would have no effect here.

The last case study explores the effects the strong increase of traffic stemming form p2p applications has on Internet service providers (ISPs). Cachelogic published a study in 2005 stating that ISPs face transit costs of $100 million due to p2p applications (Cachelogic 2005). This number we had to correct by 88% down to $12 million. However, we forecast a strong increase in traffic costs to $484 million in 2010, if ISPs do not change their strategy towards p2p traffic. There exist different alternatives that ISPs can apply in order to reduce the transit costs stemming from p2p application, which have been reviewed.

Summarizing, the p2p technology offers high potentials for cost savings in comparison to client/server. In markets where operational costs include a high percentage of traffic costs, the p2p paradigm can have a disruptive impact on these markets. The numbers presented in this paper speak for them selves.

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