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Technology White Papers

Net Neutrality and Multimedia Services

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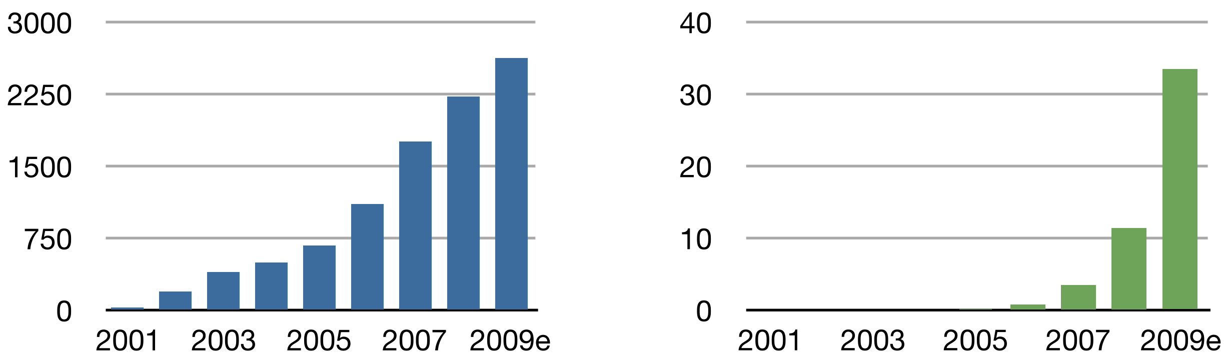
Multimedia Streaming - Why Network Operators Are Asking for More Money

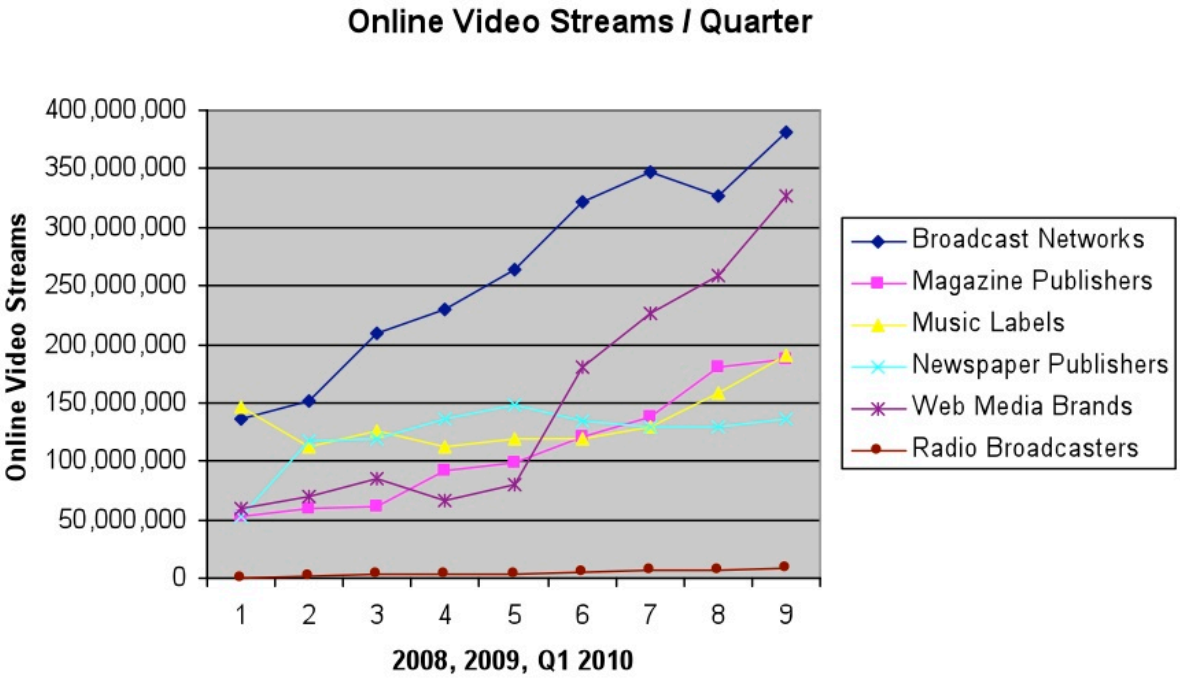
Internet Traffic Development

The Bundesnetzagentur, the regulatory authority of Germany, has published figures for the volume of traffic on broadband connections in Germany. This is shown in the two figures below for fixed, and mobile traffic. The development clearly shows that the traffic is increasing fast. The increase in mobile data traffic is exponential, and the increase in fixed broadband is at least linear.



Annual Broadband (left) and Mobile (right) Data Volume in Germany (Million Gigabytes)
Data: Bundesnetzagentur

Where does this accelerating increase in traffic come from? A recent report by Brightcove and TubeMogul seems to reveal one of the reasons, if not the main reason: video streaming. When comparing the video stream numbers for 2008 and 2009 (see figure below), they seem to go well with the overall trend that is shown in the broadband volume figures for Germany.



Number of Video Streams Observed Q1/2008-Q1/2010
Source: Brightcove/TubeMogul Report

It seems thus likely that a good part of the traffic growth is fueled by increasing on-line video usage. Video service providers and consumers are certainly pushing for higher video qualities (e.g. YouTube HD). This will further accelerate the traffic per video usage, and at the same time the number of usages will also continue to grow.

Peering

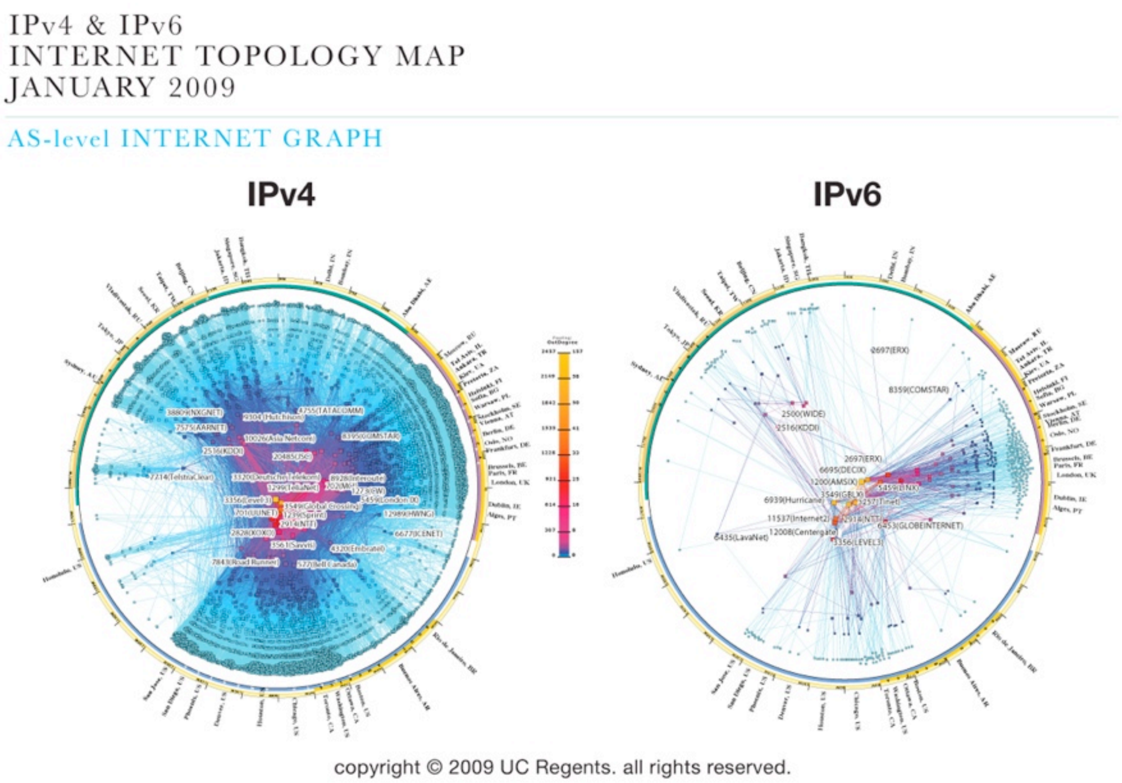
To provide world-wide IP service, connectivity is needed at many levels. From the subscriber line, through the metro backbone, provincial and national concentration points, up to providers covering whole regions. To accommodate the enormous demands on the infrastructure when acting as a regional provider, the investments are more than considerable. The statistics for the broadband traffic in Germany report an estimated 2,632 Million Gigabytes of data transferred throughout 2009. If this volume were hypothetically to be spread out evenly across the whole year, a provider aggregating the traffic for Germany alone, would need to be able to handle a steady flow of roughly 668 Gigabits per second. And that continuously for 24 hours, for 365 days. Of course the traffic in reality is never spread out evenly, and the peak data rates are considerably higher than the above hypothetical average. Other industrial countries will probably produce comparable volumes of IP traffic.

To share this huge load of traffic, the IP service providers have organised themselves such that each of them also carries traffic for other, up- and downstream service providers, under service agreements. At the topmost level, the data volumes and investments are so large, that it has proven impractical to measure the actual traffic and charge for the volume. The top-level providers have therefore entered so-called peering agreements. Under these agreements, the providers install hand-over points for the traffic, and make the necessary investments on their sides to provide sufficient capacity. Since the traffic can not practically measured due to the sheer volume, no money is exchanged between the top-level providers. Instead they agree to forward each others traffic. These top-level providers are often referred to as tier-1 providers. Although there is no authority which has defined the "tiers" of Internet networks, the most common definition is: “A network that can reach every other network on the Internet without purchasing IP transit or paying settlements.”

These networks are believed to be Tier 1 networks; they do not have overt settlements with any other network: Source: http://en.wikipedia.org/wiki/Tier_1_network

Name	Number of Subnetworks	Levels of Subnetworks	Policy
Qwest	209	828	North America; International
Verizon Business	701	1452	Verizon UUNET Peering policy 701, 702, 703
Sprint	1239	880	
TeliaSonera International Carrier	1299		
NTT Communications	2914		
Tinet	3257		
Level 3 Communications (L3)	3356		
Global Crossing (GBLX)	3549	499	Global Crossing Peering policy (2003)
Savvis	3561		
AT&T	7018	1382	AT&T Peering policy
Tata Communications	6453		Peering Policy

Of course it is objectively impossible for an outsider to confirm or disprove that money is being handed over in exchange for traffic. The above list is hence based on three sources: analysis of publicly available routing information, publicly available information from the network operators (see links in above table), and anecdotal evidence from industry members.

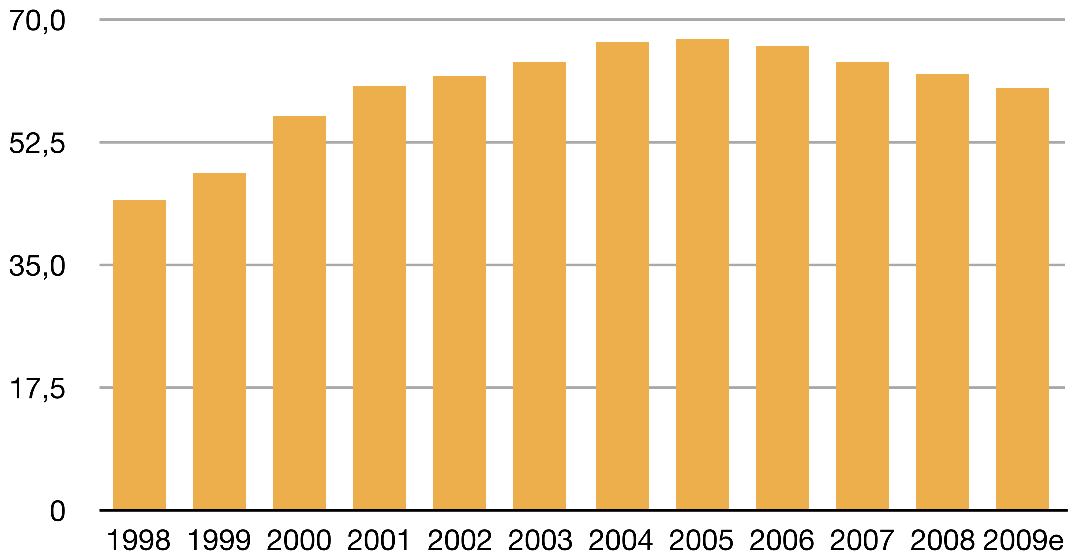


Visualistaion of Autonomous Systems (AS) and their outdegree (number of subordinate networks) on the Internet
Source: www.caida.org

In the diagram above, the Tier 1 providers appear in the centre, since they have the highest outdegree (number of subordinate networks). The data was collected by probing the entries of the top-level routing tables. In addition to the connectivity (shown as radius), the diagram is also indicative of the geographical distribution (shown as angle) of systems on the Internet.

The Unholy Alliance

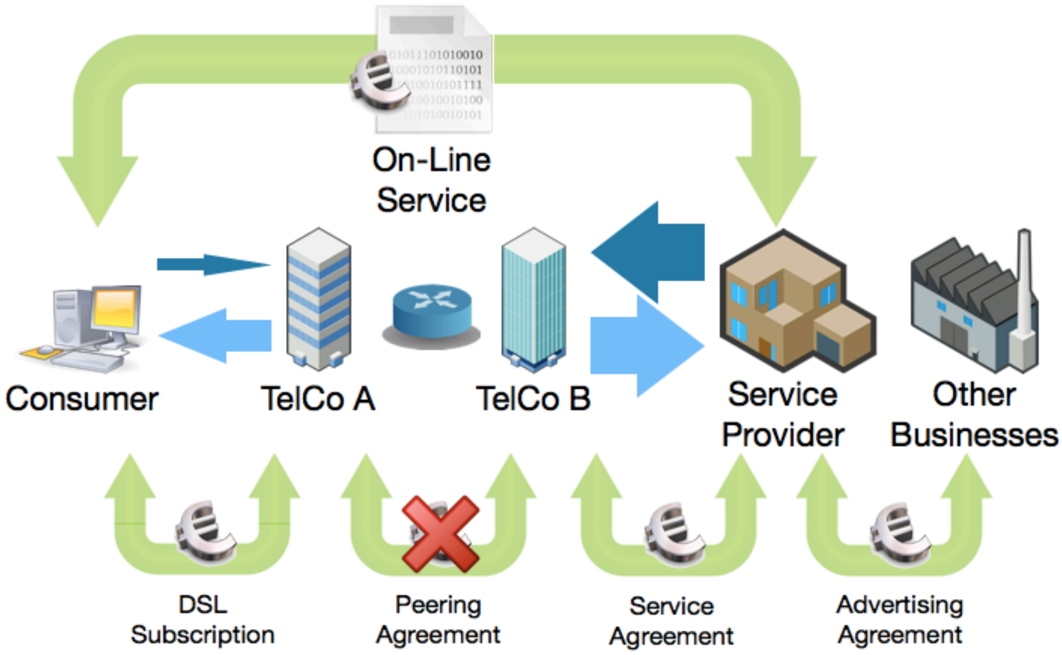
The Catch 22 for TelCos and CellCos is the combination of increasing traffic, increasing QoS/QoE requirements, and Tier 1 peering, vs. their revenues. Data collected by the Bundesnetzagentur for the German market is shown below.



Telecomms Market Volume in Germany (Billion Euros)
Data: Bundesnetzagentur

Since the peak in 2005, the Telecomms market volume in Germany has been slowly but steadily decreasing, and is estimated for 2009 at roughly the same level as back in 2003. This is in sharp contrast to the development of the traffic. In the section on Internet Traffic Development, we showed how the traffic is increasing, and how more and more video streaming is being deployed at the same time. These developments call for substantial investments by the network operators.

Now where would this money come from? As shown in the figure below, a TelCo or CellCo has revenues from consumers and businesses which are hooked up to his network, and from up- and downstream network operators in exchange for forwarded traffic. These are predominantly national customers, except for the up- and downstream network operators, which could be from neighbouring countries.



Flows of traffic and money between consumers, network operators, and on-line service providers

On the other hand, the on-line service provider receives money from advertising customers and/or consumers via service subscriptions. Since the Internet is global by nature, an on-line service provider can potentially have advertising and consumer subscription revenue streams from all countries. This will generate traffic from the on-line service provider along all the chain down to the international consumers. The network service provider that hooks up the on-line service provider is able charge more for increasing traffic. The disconnect happens, when the traffic passes through the network of a Tier 1 provider. As explained in the Peering section above, the flow of money is interrupted at that point. Hence the network operators between the Tier 1 provider and the consumer have to make investments to provide the network capacity to enable the on-line service provider's business cases. Whilst mid-level operators are able to get compensation from downstream operators, the consumer access providers can only make revenue on the consumer prices, which are fairly stable, and they are thus affected most.

As we showed at the beginning of this section, the market volume is slowly decreasing. Consumers are used to monthly flat rate plans, and the competition is for the monthly price. So the network operators are suffering from an unholy alliance of increasing investments and decreasing revenues. From their point of view they are creating business opportunities for the on-line service providers, but without possibility to capitalise on the investments.

The Current Debate

The Citizens Rights Activists

In response to statements from the network operators that they would like to charge on-line service providers for their traffic, has caused a wave of concern that, by pure financial power, the big on-line service providers would rent the whole network capacity, and that this would be the end to NGOs and other social and citizens activities on the net.

Dear Activists, This is Probably Not What You Want!

The citizens rights movement's demand that all packets shall be treated equal will probably defeat the actual goals of the movement. Currently network operators apply traffic management os a per TCP connection basis, i.e. per port number. In practice this means that any application that uses the most TCP connections in parallel, wins over the other applications and gets most of the network's resources. From the application's point of view, it must only try to send as many packets as possible to achieve a higher throughput.

In the competition between non-commercial services versus commercial operations, the result of the who-can-send-more-packets competition is clear. Of course advertising fueled, international corporations will be able to flood the network and consume the resources.

We thus believe that the citizens rights movement should rethink their message. We believe that "fair share" or "open channel" policy would much better reflect their objectives. In the broadcast industry, regulation reserves part of the capacity (the "open channels") for non-commercial activities by the citizens. This model has worked very well, and the open channels provide a valuable platform for plurality, minority concerns, and other socially important aspects. We believe that the "open channel" model would be the best starting point for a corresponding regulation on the broadband networks.

The Solution for the Citizens Rights Activists

We believe that the solution for the citizens rights activist would be to demand a guaranteed minimum of network resources for non-commercial activities by the citizens. This minimum must be defined as a fraction of the overall resources on each link. This means that the relative service quality of the non-commercial services is always the same, no matter the connection.

The Internet Industry

For the reasons outlined as the Unholy Alliance above, network operators need to be enabled to charge for the traffic of commercial on-line service providers. We see two options: either the Tier 1 providers start charging each other for forwarding their traffic, or network operators are entitled to charge the on-line service providers for carrying their traffic.

Dear Industry, This is Probably Not What You Want!

At the moment, the network operators seem to prefer charging the on-line service providers directly. This is however sharply rejected by the on-line service providers. And for good reasons. In practice this would mean that the on-line service provider would have to enter business agreements with all network operators along the path to each of the countries where they want to offer their service. In the case of a network malfunction (e.g. deep sea cable interrupted), the traffic gets re-routed, and the on-line service provider would need to enter new business agreements with the now newly involved network operators. In practice a global on-line service provider would probably soon have to have business agreements with most network operators in the world. This raises the bar for rolling out new services to a level that would practically be prohibitive. This lack of new content and services in turn, would then render the broadband service offerings less attractive for consumers.

The Solution for the Internet Industry

We believe that the solution for the Internet industry would be that up- and downstream network operators charge each other not only for the traffic, but also for the QoS provided for the forwarded traffic. Whether or not this increase in costs will ultimately cause Tier 1 providers to stop peering and start charging, remains to be seen, but will not really matter.

This will raise costs for on-line service providers, but to a much lesser extent than the current majority position amongst the network operators. This would still allow new services to be rolled out at manageable costs, and avoid the jungle of world-wide business agreements of each on-line service providers with most of the world's network operators.

Conclusion

The Combined Solution

We have proposed solutions for both, industry and activists in the previous section. We believe that these solutions are complementary, and should be applied in conjunction:

a) **Network operators** start charging **surcharges for QoS**
   i. **from othe**r, up- and downstream **network operators**, and
   ii. **from consumers**.

b) **Regulators mandate** that **network operators guarantee** for **non-commercial services**, relative to the link capacity,
   i. a **minimum data rate**, and
   ii. a **minimum QoS**.

Steps to be Taken

Steps on the Network Operator Side

For the business agreements between up- and downstream network operators, we are convinced that the market forces will develop a solution for this.

As for introducing QoS surcharges on consumer broadband subscriptions the challenge is greater. Interoperability and comparability of offerings is key here. We thus think that consumer associations and network operators should jointly develop QoS classes for commercial services and create a series of logos for them. Then the industry needs to find a way for establishing a logo programme to ensure that consumers can assess and compare different broadband subscription offerings. **We suggest devising the following logos:**

- Speed 1, 2, 3, 4, … (sustained downstream data rate expressed in Mbit/s)
- Cloud 0.5, 1, 2, 3, 4, … (sustained upstream data rate expressed in Mbit/s)
- Game (overall low latency, “fast path”)
- Phone (managed service for VoIP and A/V chat applications)
- Radio (managed service for audio streaming)
- Video SD, HD…(managed service for SD and/or HD video streaming)

Inevitably broadband subscriptions that comply with one or more of these logos will be more expensive than today’s. We suggest that the industry undergo a **voluntary self obligation** to limit the surcharge for the future top package to be no more than **40%** more expensive than today’s top package.

Steps on the Regulatory Side

For the business agreements between up- and downstream network operators, and the QoS surcharges for consumers and on-line service providers, we are convinced that the existing regulatory, anti-trust, and anti-monopoly tools and legislation will be effective and sufficient. This implies that **data networks** are recognised and treated **as a public utility**.

Regarding the above QoS labels, and the QoS guarantee for non-commercial services, we see two areas of involvement for the NRAs: since the Internet is a global marketplace,

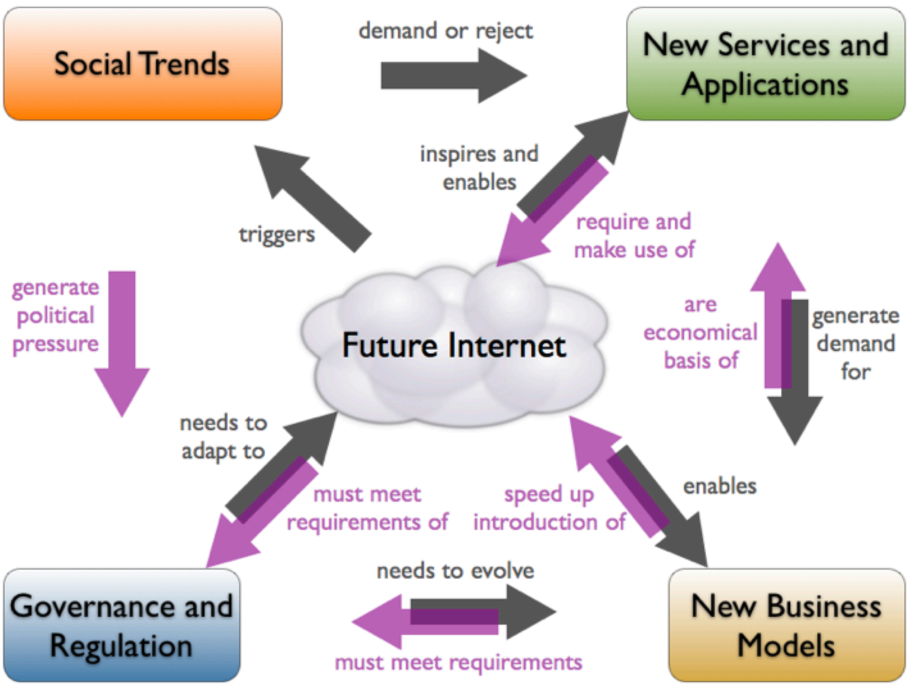
- the QoS logos, and
- the QoS guarantee for non-commercial services

need to be **harmonised at least across Europe**. This would be a job for the **regulatory authorities, in close cooperation with the consumers' associations**.

Appendix A: The Technological Base for Convergence

In the past, many attempts have been make video content available across the Web. The most prominent player here is the W3C. It started out with attempts to make the `tv` tag part of mainstream HTML in the early 2000s (which ended up as `tv` being one of the supported `@media` types of CSS2 in the CE-HTML profile), and has only recently made the `video` tag part of mainstream HTML5. So the intent to embrace multimedia content has been around for a long time. It did not become reality yet for a number of reasons. First, the infrastructure is only now beginning to become capable of handling A/V services for non-negligible audiences. Second, the streaming technologies are not yet there; RTP has been designed for video conferencing, not TV broadcast. And third, the per-country content licensing schemes applied by the content owners proved to raise the bar for rolling out A/V services on a global medium.

Recently, and in parallel to the above developments, awareness has built up in the Internet community that the Internet has de facto become a public utility like electricity, natural gas, water, roads and rail traffic. This is of course in sharp contrast to the primarily academic environment from which the development of the Internet had been steered so far. Due to its increasingly vital role for businesses and consumers, many other players started pushing for influence.



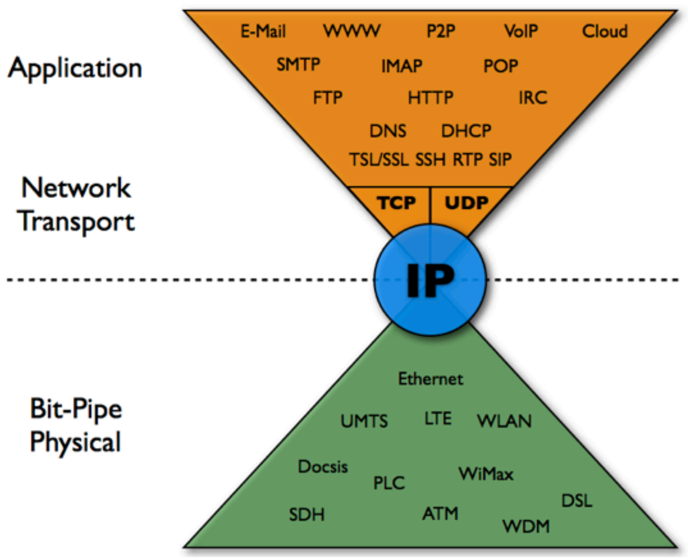
The design of the Future Internet is influenced by society, governments and industries. All actors are competing for a leading role.

This field of tension is shown in the figure above. In response to these many influences, a strategy has developed where architects propose a segmentation into various, virtual network connections. These virtual networks would not be directly accessible to endpoints such as businesses or consumers, but would be managed in some sort of network termination point, which is part of the access network.

This idea of revolutionary redesign has gained some momentum. In the current discussions, all elements at all levels are being reconsidered, making it a true revolution. Community support is headed by many pioneers of the current technology: Van Jacobson (conceived TCP/IP flow control), Mark Handley (IETF key figure), Larry Peterson (Princeton, GENI), and David Clark (MIT, Internet Architecture Board), to nam a few. Their conclusions are not homogenous. They do agree that a further evolution of the existing IPv4 and IPv6 technology seems less desirable, since it has already undergone so many extensions. There does however not seem to be a consensus on a direction to go. End-2-end paradigms compete with content-centric approaches, and “over-provisioned best-effort will do the job” philosophies. “Future Internet” means many things to many people, and scientific evaluation of the concepts being discussed has not even started.

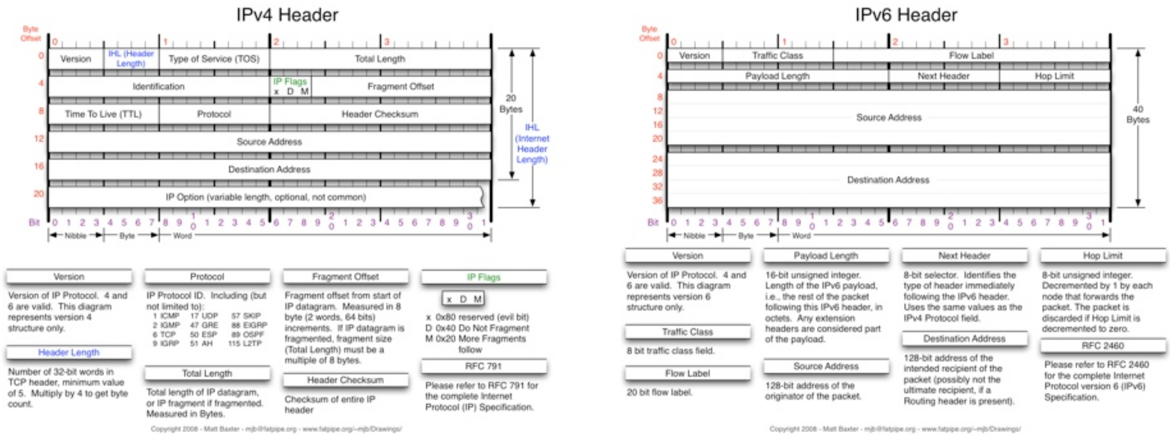
Multimedia Services - Everything on IP, and IP on Everything

Why is the media industry intrigued by IP-based platforms? Because it provides an interoperability point that shields the service and application from the physical network. This is attractive because it enables application architectures to be uniform across platforms. Development efforts for audio-visual, and interactive applications with rich content and rich metadata, are considerable. So this interoperability point advantage directly translates into money and time-to-market saved.



*IP today is **the** interoperability point.*

In the light of the Future Internet discussions in the community outlined in the previous section, even the role of IP is questioned. Of course the huge advantage of such interoperability point does not go away. So we should seriously consider whether there are any technical reasons for not continuing using IP.



The IPv4 and IPv6 headers are simple enough.

Looking at the IPv4 and IPv6 headers in the figure above, it is apparent, that they are designed for point-to-point applications, since both contain source and destination addresses. For multimedia, broadcast applications, the destination address would not be needed, since all packets are always intended for all terminals. Having said this, replacing IP with something else might in fact be an option. What would this new protocol need to look like? It would be a native multicast design, i.e. not have a destination address. Probably MPLS would be a suitable starting point. Although there has been critique of MPLS since it has lost its performance advantages due to the use of System-on-Chip (SoC) in routers, which include hardware associative memory (i.e. the routing table lookups are performed in hardware). Another starting point might be an IPv6 packet, stripped of the destination address.

As oft, history unfolds slowly before our eyes, and the first steps towards such new systems will most likely be new transport protocols **on to of IP**. The probably most prominent example is MPEG's DASH (dynamic adaptive streaming over HTTP). This has the advantage that it plays well with all equipment installed today, esp. consumer premises devices, and corporate firewalls. For new protocols replacing IP for multimedia broadcasts, the commercial introduction schedule should more be in the mid-term (2020). Research is however already ongoing. A selection of current research projects is presented in the table below.

Future Internet Projects (Selection)

Project	Website	Description
USA		
NewArch	www.isi.edu/newarch	Under DARPA funding, USC/ISI, MIT LCS, and ICSI collaborated 2000–2003 on a research project to reconsider the Internet architecture in the light of present realities and future requirements.
100x100	http://web.archive.org/web/20080526013400/http://www.100x100network.org/	100 MBit/s to 100 Million homes: under National Science Foundation (NSF) funding, 2000–2005
Clean-Slate Design	http://cleanslate.stanford.edu	Stanford University reserach project, funded by nine sponsors (Cisco, NTT DoCoMo USA, Deutsche Telekom, NSF, NEC, Xilinx, Ericsson, Lightspeed, MDV)
GENI	www.geni.net	Global Environment for Network Innovations: launched by the NSF in 2005; building a test-bed for new Internet architectures using virtualisation techniques; in the 3rd round of solicitation now building a prototype

Project	Website	Description
FIND	http://find.isi.edu	Future Internet Design: launched by the NSF in 2006; long term programme for exploring network architectures; organised into three phases of three years each; a couple dozen participating projects
PlanetLab	www.planet-lab.org	International cooperation of test-platforms for networking technologies, headed by Princeton University; currently deploying 1018 nodes in 487 participating sites
Europe		
4WARD	www.4ward-project.eu	two-year research project on Future Internet (2008–2009), headed by Ericsson, with participation from Alcatel-Lucent, NEC Europe, Nokia Siemens Networks, Deutsche Telekom, France Telecom, Telecom Italia, as well as numerous research institutes
EIFFEL	http://fp7-eiffel.eu	Evolved Internet Future For European Leadership: a think tank, launched in July 2006 by DG InfoSoc, to stimulate discussions on Future Internet in Europe
FIRE	www.ict-fireworks.eu	Future Internet Research and Experimentation: initiative under FP-7 for connecting existing test-beds, to form a European test-bed for exploring new service and network architectures
FISE	http://fise.smoothit.org/Main/HomePage	Future Internet Socio-Economics: expert working group under FP-7 on social and economic aspects of Future Internet
FIA	http://cordis.europa.eu/fp7/ict/ssai/future-internet-assembly_en.html	Future Internet Assembly: launched March 2008; forum, to connect the numerous FP-7 programmes on Future Internet and avoid fragmentation of efforts
FEDERICA	www.fp7-federica.eu	Federated E-infrastructure Dedicated to European Researchers in Computing networking Architectures: FP-7 project for network virtualisation on the paneuropäischen GÉANT2 reserach network; deploying 13 nodes linked by point-to-point connections
TRILOGY	www.trilogy-project.org	„Architecting the Future Internet“: BT-lead, three-year research project (2008–2010) to develop new solutions for the control architecture of the Internet; with participation from Deutsche Telekom, NEC Europe, Nokia and a couple of universities
Germany		
G-Lab	www.german-lab.de	BMBF project running till 2012; EUR 12M funded building of a test-bed for developing Future Internet concepts and technologies; with participation from universities, network operators, and suppliers (amongst others Alcatel-Lucent, Ericsson, NSN, and Qualcomm)
100GET	www.celtic-initiative.org/Projects/100GET/	Transport Networks for Future Internet, 100 GBit/s Carrier-grade Ethernet Transport Technologies (BMBF funded, and under the EUREKA initiative of CELTIC)
EASY-C	www.easy-c.de	Next Generation Mobile Networks: Beyond LTE
Japan		
AKARI	http://akari-project.nict.go.jp/eng/index2.htm	Architecture Design Project for New Generation Network: aims to implement the basic technology of a new generation network by 2015
JGN2plus	www.jgn.nict.go.jp/english	test-bed run by the National Institute of Information and Communications Technology(NICT); three-year project starting from April, 2008

Project	Website	Description
Korea		
FIF	http://fif.kr	Future Internet Forum: discussion forum hosted by the Open Standards and Internet Association (OSIA) on Future Internet research and development activities with some 500 members from universities, businesses and authorities

Appendix B: References

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