Looking Under the Hood of the Internet

Evolving the Internet's underlying structure to meet future demands

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If you are an average Internet user, you've almost certainly watched an online video or been on a video-conference when, suddenly, despite your high-speed broadband connection, the video stopped or the image quality dramatically worsened. Similarly, as an online shopper, you will also have experienced a long delay when waiting for an ecommerce webpage to upload. It is at these times that you realize that the Internet does not guarantee any level of service quality.

Over the last decades, the nature of the traffic for which the Internet and its ecosystem was initially developed has fundamentally changed. Next-generation content and applications are being designed all the time, but there are some hidden bottlenecks preventing these from achieving their full value creation potential. At the heart of the different layers that enable the Internet experience lies the Internet Protocol (IP) interconnection ecosystem. The further evolution of this often overlooked area will have a substantial impact on the effectiveness of innovation and investment in our developing Internet-based society and economy. However, it is by no means clear how this evolution will take place. How can quality be better managed and regulated, and what are the business model options?

Over the last decades, the nature of the traffic for which the Internet and its ecosystem was initially developed has fundamentally changed. Next-generation content and applications are being designed all the time, but there are some hidden bottlenecks preventing these from achieving their full value creation potential. The Internet has effectively become a new media platform as its usage has shifted to richer types of content, particularly streaming video. As a media platform, the quality of delivery has become an important business issue that needs to be solved so that it can deliver its potential added value – for end users as well as for businesses. In this article the authors lay out different ways how this issue might be tackled.

Demands for quality from the Internet are changing radically

In 2014, the Internet reached over 2.7 billion individuals and has become mission-critical for most Content & Application Providers (CAP). Over the last decades, the growing consumption of media content and applications has led to a revolution in the nature of

Picture by Sebastian Kaulitzki / dreamstime

Internet traffic. It has effectively become a new media platform as its usage has shifted to richer types of content, particularly streaming video. In this scenario, users and companies expect to use the Internet to transport vast amounts of data, and hence their key quality criteria relate to bandwidth and latency (response time in simplified terms).

As a media platform, the quality of delivery has become an important business issue. Indeed, even minor quality issues directly impact the willingness of end users and advertisers to pay for online services. For example, the conversion rate (i.e. the proportion of visitors who actually buy) on a popular ecommerce website can drop by a factor of 10 if the average load time for a webpage increases from 1 to 4 seconds[1].

Additionally, the Internet has become a ubiquitous and essential medium for business communications, with a de facto expectation of availability anytime anywhere, and on any device. At the same time, the Internet is becoming vital for Machine to Machine (M2M) communications. As a case in point, many transactions take place today over the Internet, such as payments, a car dealership placing an order with the manufacturer, or data being sent from a distant meteorology station in order to predict a hurricane or when best to harvest crops. These M2M transactions require different levels of quality from the 'traditional' Internet, such as security, completion, and determinism.

Currently no one player has end-to-end control of quality

The Internet as we experience it encompasses many layers, and the global Internet is at the very bottom of a complex stack – the Internet stack. End users experience the Internet through a vast set of connected devices, operating systems, applications and online content, but are often not aware of the complex underlying interconnected structure of physical, data link, network and transport layers that make it all possible.

When an end user wants to access a particular video, website or other application which is not hosted on their own PC, smartphone or tablet device, they connect to a CAP server via one or more interconnected networks. IP interconnection manages the interfaces between these various networks, applications and devices, and is indispensable to the delivery of the online service.

The Internet, and particularly IP interconnection, is based on 4 principles which define its innovation potential:

1. The Internet Protocol follows a simple logic of a best effort service to all traffic sent. Internet routers (the devices that route the traffic across the network to their final destination) are programmed to do "their best" to deliver IP packets (information) to the requested destination, i.e. to find the best available route at a given instant to send the packets to the "next best hop". The Internet Protocol offers no guarantees that packets will not be lost, delayed, corrupted or duplicated. With this best effort mechanism, all users are served but without any guarantee on when things will be delivered.

2. The Internet is robust and self-healing: It redirects packets towards an alternative route whenever congestion arises or a (temporary or definitive) resource loss is revealed. It is like re-routing road traffic based on current congestion or road closures.

3. The Internet Protocol is application agnostic, because it does not discriminate on the nature of the traffic, its value, or any other criteria.

4. The lack of central intelligence makes the Internet an easy to scale network: Capacity can be added progressively as traffic reaches thresholds at each individual node of the global interconnected network.

[1]The Future of the Internet – Innovation and Investment in IP interconnection, Arthur D. Little 2014", also according to Aberdeen Group, Joshua Bixby, Company reports of Amazon, Bing, Shopzilla

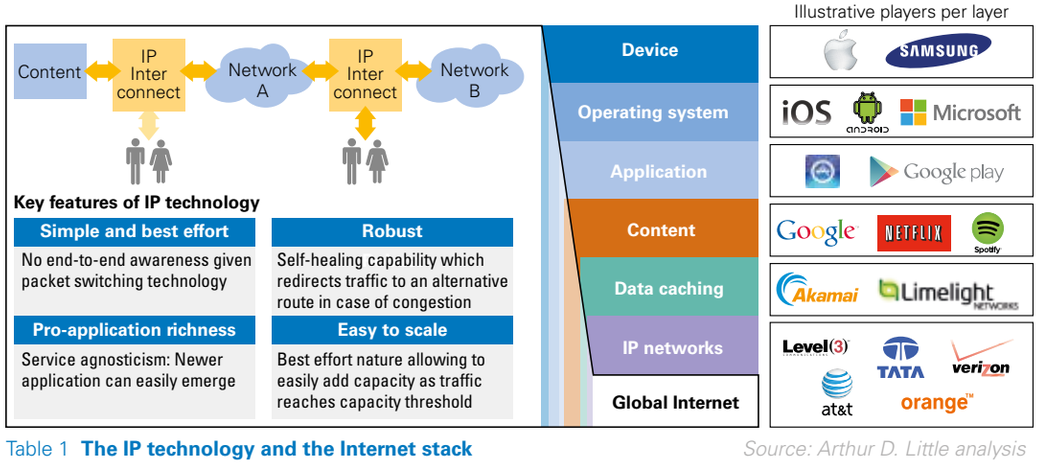

Table 1 **The IP technology and the Internet stack** *Source: Arthur D. Little analysis*

A major consequence of the way that the current Internet ecosystem has developed is that no single player has end-to-end control over it. Consequently quality, as experienced by the end user, is the sum of all efforts/investment by the various IP interconnection players in their part of the Internet-chain.

Data traffic means money, but business models are complex

The Internet does not exist for free. Data traffic determines money flows between involved parties in a complex way. Ultimately, there are only two sources of money in the ecosystem: end users and advertisers.

End users buy connectivity services from Internet Service Providers (ISPs) in order to be granted access to the services and content provided or sold by CAPs. Traditionally, fixed and/or mobile telecom/cable operators, acting as local access providers (or terminating ISPs), guarantee end users access to the global Internet by paying a transit provider and/or investing in peering capacity (i.e. interconnecting with their "neighbors" and thereby avoiding to pay for transit).

At the other end, CAPs also need to connect to the Internet by paying an access and/or transit fee to the local-access network operators or to global ISPs specializing in Internet transit services. CAPs may alternatively opt to buy content delivery services (hosting content on server farms closer to the end user) from commercial, independent providers, or even invest in and roll out their own Content Delivery Networks (CDNs). Examples of these include Netflix's Open Connect, Google Global Caches, and Amazon's CloudFront. Apple is reportedly also building its own CDN to manage its growing iCloud service usage, as well as hosting and delivering streamed and downloaded content from the iTunes and App Stores.

CAPs generate revenues from distributing content to end users over the Internet, also called Over-The-Top (OTT). They therefore set up different types of business models, such as:

- Eyeball monetization, i.e. having advertisers pay to reach end users
- Direct end user subscriptions or pay-per-use for content or services (e.g. subscriptions to video services or information sites)
- Intermediation of transactions between online merchants and final customers through an online marketplace (e.g. eBay, Amazon, iTunes)
- Any mix of the above.

Whatever the route data takes to reach the end user, a contribution is always paid to finance the various pieces of infrastructure used. In the case of peering, such contributions usually take the form of co-investment rather than a financial transaction.

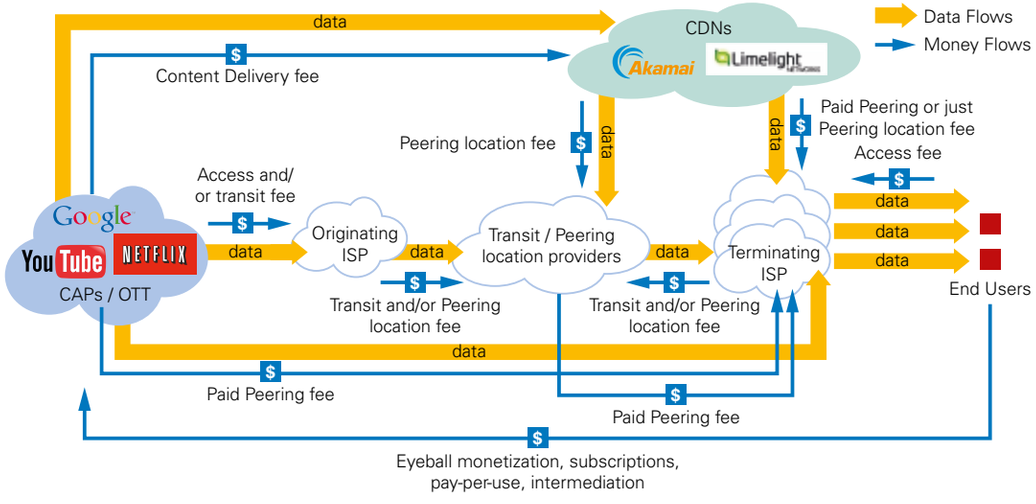

Table 2 **Data and money flows in the Internet ecosystem** *Source: Arthur D. Little analysis*

Overall, the Internet ecosystem results in a complex mix of interlacing business models that are built upon the global availability of connectivity:

- ISPs provide and sell connectivity, for access at local or international level. Their access business model is currently driven by a capacity measure, i.e. Gigabits per second (Gbps).

- Content Delivery Network operators sell caching and web acceleration services. Their business model is mainly driven by volumes (and sometimes by server throughput capacity or egress capacity), i.e. Gigabytes (GB) or Terabytes (TB).

- CAPs sell services and/or content. CAPs can apply any mix of the above-mentioned business models driven by any proxy of traffic volumes – i.e. web clicks, page/video views, unique visitors, downloads, transactions, paid events or subscriptions.

So far, the Internet ecosystem has adapted well to changes in traffic

The Internet has demonstrated an organic ability to evolve and adapt. Over time, and in order to cope with increased traffic and success, new technologies and business models have improved overall interconnection efficiency, leading to a cost reduction of around 30% per annum since 2008.

However, the majority of Internet traffic is becoming progressively concentrated with a limited number of large CAPs and a few wholesale carriers. In 2013, 35 networks carried 50% of all Internet traffic in North America, down from 150 in 2009. This concentration is a major evolution in the interconnection value chain, and has the potential to influence the negotiating power of connectivity stakeholders and affect the current equilibrium in the Internet ecosystem.

In the last few years, the largest CAPs and ISPs have been setting the pace and determining the nature of interconnection innovation through vertical integration. CAPs seek end user proximity and are increasingly investing in proprietary Content Delivery Networks or relying on third-party CDNs. On top of capacity, ISPs invest in network-based content delivery platforms ("deep caching") for internal purposes and as a service to third-party Content & Application Providers.

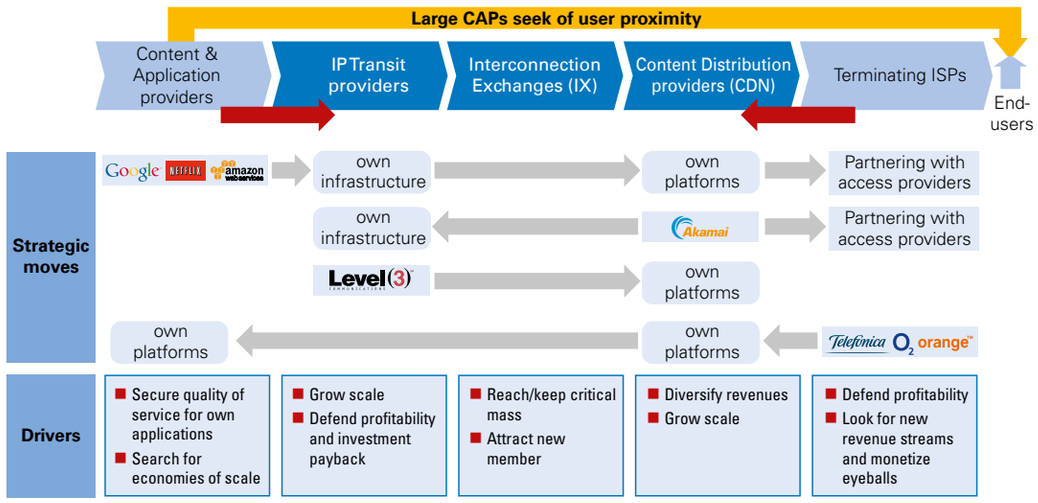

Table 3 **Trends over the IP interconnection value chain** *Source: Arthur D. Little analysis*

As a result, Content & Application Providers and Internet Service Providers increasingly interconnect directly, disintermediating pure Internet connectivity providers to some extent. Improving control on the quality of delivery over the Internet is the main motivation. This is not only true for Internet-based CAPs, but also increasingly for the video streaming strategies of traditional broadcasters. For example, average daily users on the BBC's iPlayer service have grown by 33% year on year since 2009. The balance in the interconnection value chain has subsequently changed, and traditional interconnection players have adapted to maintain their competitiveness.

Changes in the interconnection ecosystem have meant that tensions between players have intensified. However, disputes concern less than 1% of all IP interconnection agreements, and are solved without regulatory intervention in more than half of these cases. Generally end users have not been substantially or structurally affected by these disputes. The commercial interests of parties have prevailed, and mutually acceptable solutions have been found.

So far, Regulatory Authorities have generally preferred a non-interventionist approach and focused their attention on the principles of non-discrimination and transparency. They have opted for a non-stringent regulatory framework that allows the market to freely find its equilibrium and innovate in its business models. This is based on the interconnection mechanisms' place at the core of the financing of required network investments, as well as the economic balance between players within the Internet value chain and end users.

Future scenarios suggest that the current best effort model will not be adequate alone

The history of the Internet application landscape is rich in changes and disruptions. Various types of applications (FTP, Web, Peer-to-Peer) dominated Internet traffic for a while before losing ground to the next generation. This teaches us how unpredictable the evolution of the Internet application landscape can be. Nonetheless, looking at the next decade we can envisage three likely scenarios:

1. **More of the Same,** where one-way video streaming traffic provided by a limited number of CAPs remains the main online consumption model.

2. The development of the **Internet of Things (IoT)** would see mass adoption of mission-critical machine-to-machine applications such as remote health monitoring and care, driverless connected vehicles, smart grid and smart city (for more details, please refer to "Wanted: Smart market-makers for the Internet of Things", Prism 2/2011).

3. The development of the **Internet of Humans (IoH)** by which people would adopt two-way, real-time, high definition (HD) video applications as a way to strengthen and enrich remote interactions. Tools supporting advanced collaboration in the context of telemedicine, or online crowd-working demonstrate these possibilities.

A. More of the same	B. The future is IoT	C. The Internet of Humans
■ Mainly 1-way HD video ■ Limited real-time ■ Streaming of ready-to-use content ■ IoT applications remain in the Best-Effort domain	■ Mass adoption of mission-critical M2M applications, e.g. remote health monitoring & care, driverless connected vehicles, etc. ■ Industry-critical connected services, e.g. smart grid, smart traffic control, etc. ■ Secured eFinance and eAdministration	■ Mass-market adoption of 2-way real-time video streams driven by: – Online crowdworking – Ambient presence – Advanced collaboration – ...
Limited need for E2E QoE, QoS requirements are unchanged	Need for QoS covering availability, security, latency…	Need for QoS covering latency, packet loss, jitter...

Increasing need for assured end-to-end quality of experience (E2E QoE)

Table 4 **Internet Application landscape scenarios** *Source: Arthur D. Little analysis*

These three scenarios are not mutually exclusive and provide vast opportunities for innovation and value creation. It is up to the industry and policy-makers to jointly define their ambition for 2020. The application landscapes of the Internet of Things and Internet of Humans could unlock an economic value potential in the range of trillions of euros (millions of billions of euros) by 2020. However, in order to bring the Internet of Things and/or the Internet of Humans to life, advanced Internet platforms, i.e. beyond best effort, may be required for these applications.

Every day, the Internet community releases fascinating future application concepts that show how the daily interactions that make up our professional and personal lives could evolve. Box 1 shows some examples relating to ultra-high definition (UHD) real-time video communication.

Box 1 New concept applications relating to ultra-high definition real-time video communication

- **Ambient presence** would enable remote human interaction through wall-sized screens. As an example this could be used for a telemedicine service that covers diagnosis, treatment, monitoring, and patient education, and provides convenient, site-independent access to expert advice and patient information.

- **Secure home delivery** would allow remote control of access to our homes and offices by remotely operating door-locking systems, monitoring the identity of the person knocking at the door and by ensuring that delivery of the package (e.g. online purchase) or provision of a service (e.g. plumber) is completed securely.

- **Remote care** would allow patients affected by chronic diseases to interact in real-time with remote relatives, and access on-site medical equipment that provides critical information regarding their vital functions.

- **Online personal training** would enable online training, coaching or professional advice via real-time video communications.

- **Ubiquitous HD videoconferencing** would enable all working desks to access any other working desk(s) in real-time, delivering a high definition standard for improved collaboration.

- **Advanced work collaboration** would integrate HD videoconferencing with interactive boards for immersive collaboration experiences.

The common factors among these new applications are stringent requirements in terms of seamless reachability and access, Quality of Experience (QoE), availability of connectivity and reliability, as well as the security and privacy of the information involved. These requirements are a long way from the current best effort Internet services, which certainly offer open access to any application, but cannot guarantee QoE, especially when more than one network is involved.

Consequently, interconnection Quality of Service (QoS) needs to be extended to cover new parameters, such as latency reduction, availability, jitter, packet loss limitation, security, and data protection. As the Internet evolves from nice-to-have to mission-critical services, next-generation applications for sectors such as the Financial Services industry, the Electronic Payment sector, and high-security Governmental Bodies (such as the police, military and emergency services) will generate a demand for new interconnection requirements that go well beyond additional speed. Security and data protection deserve special attention as they play a critical role in the safe use of next-generation applications, especially for the Internet of Things.

The emergence of next-generation applications will thus substantially change the Internet ecosystem and push current performance requirements to new levels. This will require new network architectures, IP interconnection business models, definition of Quality of Service and Quality of Experience and Internet governance. At the same time the best effort Internet is, and will no doubt continue to be, essential in the future, and there is early evidence to indicate that it can continue to improve and co-exist with complementary end-to-end Quality of Service platforms if properly monitored.

Key players in the interconnection ecosystem are currently reflecting on how to re-invent and diversify their service portfolio. Multiple business models could provide an answer to the implementation of those Quality of Service requirements, provided there is regulatory clarity. Therefore, the industry is calling on policy-makers and regulatory bodies to have a rational debate on how to enable future Internet platforms and accelerate the value creation from next-generation applications.

Picture by Shawn Hempel / dreamstime

- Progressively reflecting additional Quality of Service levels in end user pricing for Internet services (both for connectivity and applications/content)

- Exploring B2B2C business models integrating on-demand access to high-quality Internet.

What is definite is that the Internet, because of the nature of its ecosystem and the agility of key players, will continue to adapt to deliver the new features necessary for the Internet of Humans and the Internet of Things to thrive.

It is therefore a safe bet to continue to embrace the Internet as an integral part of your business-critical systems; on the contrary, not embracing it or failing to understand sufficiently what happens "under the hood" and the risks involved as it adapts, could put businesses at a disadvantage. When building new processes or redefining business models predicated on the Internet, it will become increasingly important to understand the driving forces that will shape the evolution of the web.

Insights for the executive

The pervasiveness of the Internet through all industries and business systems is only going to increase in the near future. The emergence of next-generation applications in the world of the Internet of Things and the Internet of Humans will require an increasing focus on the end user's Quality of Experience. Beyond further improving speed, new Quality of Service features will have to be managed.

Ultimately end users and/or advertisers will only pay for the costs of improved interconnection Quality of Service if they understand the value it adds to next-generation applications/content. Consequently, new business models will have to be developed which efficiently monetize enhanced Quality of Service and unlock value creation. Examples of these may include:

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