International Telecommunication Union

The Future Internet

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The Internet has grown from a small experiment into a collaborative network with more than one billion users. The rise of mobile access poses additional infrastructure challenges including addressing and routing, which might require a review of the architecture. This Report surveys the current debate over the Internet architecture, and identifies key emerging trends and features of the Internet, in an attempt to provide pointers for future standards work for consideration by the ITU-T membership and the broader standards community.

Telecommunication Standardization Policy Division
ITU Telecommunication Standardization Sector

International Telecommunication Union

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- Identifying candidate technologies for standardization work within ITU.
- Assessing their implications for ITU Membership, especially developing countries.

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This report was prepared by Arthur Levin, Ewan Sutherland and Young-Han Choe.

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The Future Internet

1 Introduction

Despite many changes and transformations since its inception, the Internet has proved to be flexible as new applications and services arose:

> It was conceived in the era of time-sharing, but has survived into the era of personal computers, client-server and peer-to-peer computing, and the network computer. It was designed before LANs existed, but has accommodated that new network technology, as well as the more recent ATM and frame switched services. It was envisioned as supporting a range of functions from file sharing and remote login to resource sharing and collaboration, and has spawned electronic mail and more recently the World Wide Web. But most important, it started as the creation of a small band of dedicated researchers, and has grown to be a commercial success with billions of dollars of annual investment.[1]

From a simple means of communicating among computers, the Internet, coupled with the uptake of broadband, has emerged as a fundamental part of modern society in most countries. New applications emerge everyday and some have become cultural icons, such as YouTube and Facebook. Its hierarchy has been extended from international, national and campus networks to include networks for businesses, homes, cars, and individuals. The Internet has gone mobile, as devices on cellular networks have been enabled for the Internet Protocol (IP), already used by several millions of individuals and potentially several billions. Sensors have been added to some networks, extending the system to objects fitted with RFID tags, creating the potential for the Internet of Things (IOT).[2] On top of these networks and devices lies a vast array of applications for e-commerce, e-government, e-education and e-health, together comprising the Internet of Services (IOS). In order to reduce greenhouse gas (GHG) emissions, Internet services are also being developed to monitor energy use and to increase energy efficiency.[3]

To meet the demands of new applications, services and users and to serve as a vital part of national and global infrastructure, the Internet is continually evolving. At the same time, some observers have questioned whether the underlying architecture is sufficiently robust to evolve and adapt to these new demands, and instead contend that a “clean slate” approach is needed to develop a ‘new’ Internet of the future. Supporters of the clean slate approach often cite security concerns as one of the key reasons to develop a new architecture.

To assess this debate and its impact on future standards work, this Report begins by examining the design and architecture of the Internet, and contrasts the different views calling for evolutionary and radical changes to the Internet. It then examines key trends in the Internet, how these might develop and their impact on the future architecture and design of the Internet. The possible effects of the various trends are then mapped onto the processes for standardization to identify some future areas of work. The Report ends by drawing some conclusions.

2 Framing the Debate

The “design” of the Internet has been the subject of debate for years. There have been periodic calls to purge the accumulation of fixes and patches and to adopt the so-called “clean slate” approach. These call for radical change come both from designers seeking to join the Internet founding fathers, and also from some of the founding fathers themselves.

The existing Internet architecture dates back to the 1970s and was designed to create simplified network and implementation protocols, guided by concepts such as Layering and packet switching. Among the design goals of the existing Internet architecture are:

- Connection of existing networks,
- Survivability,
- Support of multiple types of services,
- Accommodation of a variety of physical networks,
- To allow distributed management,
- Cost-effectiveness,
- To allow for host attachment with a low level of effort, and
- To allow for resource accountability.

To achieve these goals, the following design principles were used:

- Layering,
- Packet switching,
- Network of collaborating networks, and
- Intelligent end-systems

The evolutionary view is that the Internet should continue as it has over the past decade with targeted patches to fix problems as they emerge.[4] In order to meet the challenges of disruptive technologies, one suggested solution is the use of overlay networks which can provide performance and reliability without competing with existing infrastructure.[5]

Underlying this position is the view that the Net is now fully commercial and that the inertia of existing investments made by operators and by individuals requires an evolutionary approach. Moreover, the firms investing billions of dollars will ensure that, one way or another, it survives and continues to grow and prosper. Some also point out that the original architecture has already shown the capability to adapt to new services and applications that were not imagined when the Internet began.

Some supporters of the evolutionary view posit that the most commonly-cited problems, such as security and spam, are not a problem of architecture. In a recent presentation at the 2008 IGF in Hyderabad, Bob Kahn, one of the original creators of the Internet, proposed new standards for Digital Object Architecture (DOA), to enable better information flow across the Internet. He contends that the DOA approach would address the problems, but keep the basic architecture intact.

The claim for a new clean slate was put most dramatically by MIT Professor Dave Clark, who served as the Internet's chief protocol architect during much of the 80's, in an article entitled "The Internet is Broken" that appeared in 2005:

> The Net's basic flaws cost firms billions, impede innovation, and threaten national security. It's time for a clean-slate approach.[6]

This view has been echoed by Princeton computer scientist Larry Peterson and many others.[7] The next section describes some of the work currently underway to develop a clean slate.

3 Work Underway towards a New Internet

A number of initiatives are already underway, largely at the national and academic level, to reinvent the Internet using a clean slate approach.

Among the major challenges being addressed in these efforts to develop a new design are:

- Security and privacy,
- Resistance to Distributed Denial of Service (DDoS) attacks,
- End-to-end QoS/QoE,
- Mobility,
- Reliability,
- Addressing and identity.

The structures and new paradigm research areas include:

- Flow-based routing and switching,
- Dynamic circuit switching,
- Backbone redesign,
- Point to point model redesign,
- Cross layer redesign,
- Network virtualization, and
- Design of a new security structure.

Examples from some of the current projects underway give some indication of the future Internet.

The USA has provided government funding for projects on Internet design, e.g. the US National Science Foundation (NSF) currently has invested around US$ 20 million in two projects:

- Global Environment for Network Innovations (GENI)[8]
- Future Internet Design (FIND)[9]

The GENI vision is to create a national facility to explore radical design for future global networking infrastructure, based on people and content. Another initiative is the NewArch project.[10]

The Stanford Clean Slate project is intended to "reinvent the Internet", assuming that "nothing is sacred".[11] Its scope is defined in very broad terms; not only the TCP/IP protocol stack, switches and routers, but also the services, computation and storage, plus the ways people connect to, and interact with, the Internet. It is an interdisciplinary project including engineering, computer science, management and law including several industrial partners: Cisco Systems, Deutsche Telekom Laboratories, DoCoMo Capital, NEC and Xilinx.

In Japan, the National Institute of Information and Communications Technology (NICT) launched the "Akari" programme to develop a "new generation" network architecture (NWGN) by 2015-20. The philosophy of the project is to find an ideal solution starting from a clean slate, unimpeded by existing constraints.[12] Among the new technologies being studied are Photonic Network projects.

Major initiatives in the EU include FIRE (Future Internet Research and Experimentation), FP6 and FP7 (to date 500 Million Euros in research) and EIFFEL (Evolved Internet Future for European Leadership).[13]

As most of these initiatives are in their early stages, it is too early to tell whether they will result in a feasible new architecture for the Internet that would have universal appeal.

In addition, there have been a considerable number of conferences and workshops to discuss Future Internet, such as The Future of TCP: Train-wreck or Evolution?[14] There are also series such as Hotnets[15], the EU Future Internet Assembly[16] and NetEcon.[17]

4 Meeting Future Needs- Key Trends

While cyberspace is littered with many incorrect predictions about Internet use and killer applications, several trends are currently underway that are shaping the future needs of Internet architecture and design. The growth of such features as powerful search engines, social networks (Web 2.0), online media and mobility is driving the future direction of the Internet. Some characterize these trends as transforming the network from a 'dumb pipe' to the user's intelligent partner. This section describes the ever-increasing role of the Internet as a vital part of modern society as well as a number of developing trends in Internet usage.

The commercial Internet

The intensive use of the Internet as a means of commercial dealings and transactions is a key driver of the future Internet and of changes to traffic patterns. What was once a purely academic network has been both commercialized and to some extent privatized. The academic part is now very much the minority, with commercial forces dominating the investment of hundred of millions of dollars each year. As new services are offered over the Net, and as it becomes increasingly mobile and operates at faster speeds, new demands are placed on the architecture.

The topology of the Internet has evolved rapidly, with the growth of Internet eXchanges Points (IXPs) (see Figure 1). This has allowed the exchange of IP traffic to be conducted on a more efficient basis, using a mixture of local and international exchanges.[18] However, a number of obstacles remain, especially in developing countries, including regulatory environments that support monopolies or oligopolies.[19]

Figure 1: Internet eXchange Points (IXPs)

Source: https://prefix.pch.net/applications/ixpdir/

Given bottlenecks on the Internet, service providers sought to improve the quality of experience by using caches, first proxies and then hierarchies. The next step was the introduction of Content Delivery Networks (CDNs), where a few specialists established themselves on the market by providing overlay networks and by placing servers close to the edge of the Internet in order to ensure rapid and effective delivery. [20] Initially CDNs addressed static, but later added dynamic content, streaming media and video on demand. The best known example is Akamai, which provides a content acceleration service to major information providers, ensuring their material is quickly available in key markets.[21] There are now specialist CDNs for mobile networks, such as Admob.[22]

Multinational corporations have their own private voice and data networks, usually running Multiprotocol Label Switching (MPLS) over a range of infrastructure elements, including dark fibre, Gigabit Ethernet, SDH and leased lines. These are provided by a handful of global Network Service Providers (NSPs).[23] As yet, there is still limited use of Fixed-Mobile Convergence (FMC), though some cellular devices can switch to Wi-Fi, allowing access to SIP-based services, including VoIP. The MPLS networks have gateways to the public Internet and also to the CDNs that deliver their content to customers.

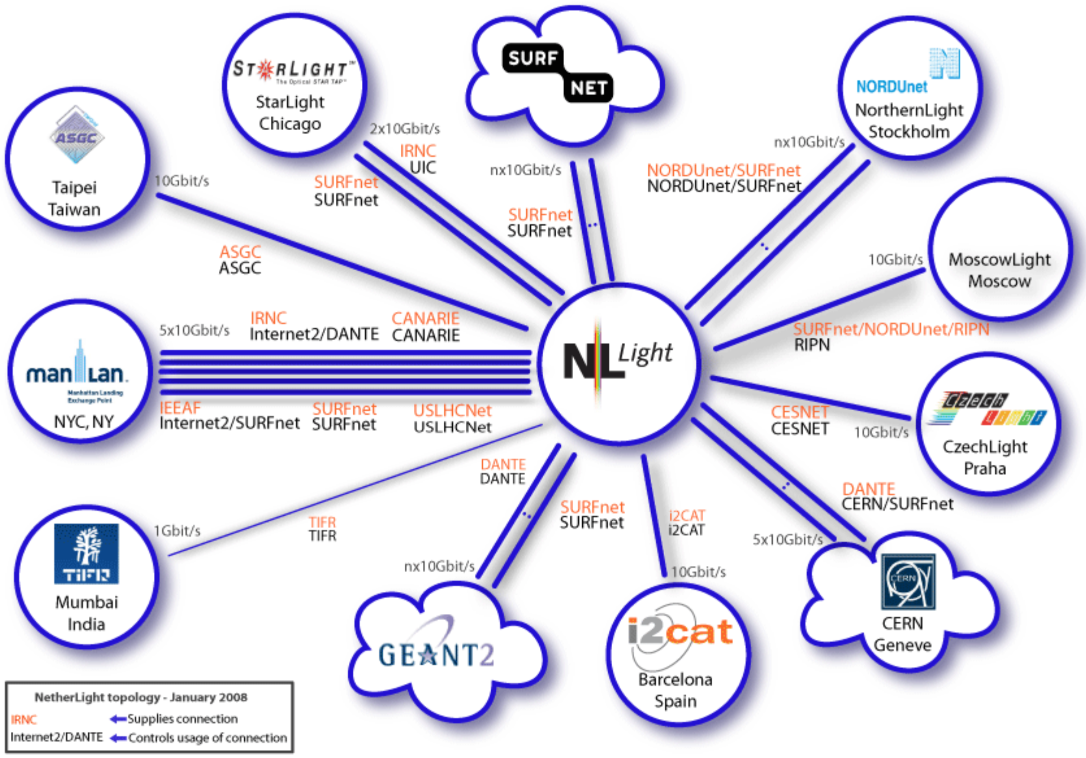
Satellite telecommunication technology (see Recommendation ITU-R S.1782) has the potential to accelerate the availability of high-speed Internet services in developing countries, including the least-developed countries, the land-locked and island countries, and economies in transition. Studies into possibilities for providing global access to the Internet at a high data-rate via satellite have been carried out, including identification of suitable fixed-satellite service (FSS) bands.

Moreover, investments are being made by Google, Liberty Global and HSBC in a company called "O3b Networks", short for the "other 3 billion" people who can't yet surf the Net, that plans to launch 16 low-cost satellites whose purpose will be to bring high-speed affordable Internet access to emerging markets across Asia, Latin America, Africa and the Middle East.[24] The service, expected to be ready to launch by late 2010, aims to take the place of the fibre networks typically used in more developed nations. The satellites will actually offer low-latency links from 1 Mbps to 10 Gbps for core trunking, instant fibre-path restoration and 3G Cellular / WiMax backhaul to areas currently without any easily accessible option.

Academic networks have advanced considerably, in particular benefiting from the liberalization of the provision of infrastructure which has allowed increased access to dark fibre in Europe and North America. Not only has this permitted transmission speeds to be increased to levels of multiple Gigabits per second, it has also allowed the assignment of separate optical wavelengths for more

Box 1: Netherlight

NetherLight was created in 2002 in Amsterdam to be an open optical infrastructure and proving ground for network services supporting very high-performance applications. Initially it provided SONET/SDH cross connect and Gigabit Ethernet switching facility, but has been moving to be an optical wavelength switching facility as this technology and the control planes become more advanced.



At its heart, NetherLight has a Nortel HDXc optical cross connect that interconnects multiple 10 Gbps optical wavelengths (or lambdas). This allows the interconnection of lightpaths from different national and international network facilities, including StarLight in the USA and the Global Lambda Integrated Facility (GLIF).

The connection to CERN provides access to one of the most intensive scientific applications, the Large Hadron Collider (LHC). This is expected to generate around 15 PBytes of data each year and requires its own private 10 Gbps optical network for the transfer of data amongst its core group of researchers.

Source: http://www.surfnet.nl/nl/Thema/netherlight/Pages/Default.aspx

intensive networks (see Box 1). Thus, a single infrastructure is able to support multiple real and virtual networks, without interference or degradation of quality. It is even possible to test new network designs and protocols on one optical frequency, providing massive capacity and geographical coverage.

The addition of VoIP services to the Internet has been extremely popular. However, these are successful in large measure because of gateways to the PSTN. A significant part of the success has been achieved by overlay networks.[25]

The Mobile Internet

The explosive growth of mobile telephony means that the mobile will increasingly take the place of the PC as the access mode to the Internet. In developing countries, the mobile phone is likely to be the dominant access mode and thus the Internet will need to meet the needs of those users. The number of people who surf the Net on phones has doubled since 2006, according to Nielsen Mobile, and some predict that by 2012 there will be more mobile/wireless Internet users than wired using PCs and laptops.

At the same time, the roll-out of higher speed mobile Internet in developed countries continues apace, prompted in part by the launch of user-friendly smart phones. Increasingly, users want the full Internet experience when they access via a mobile.

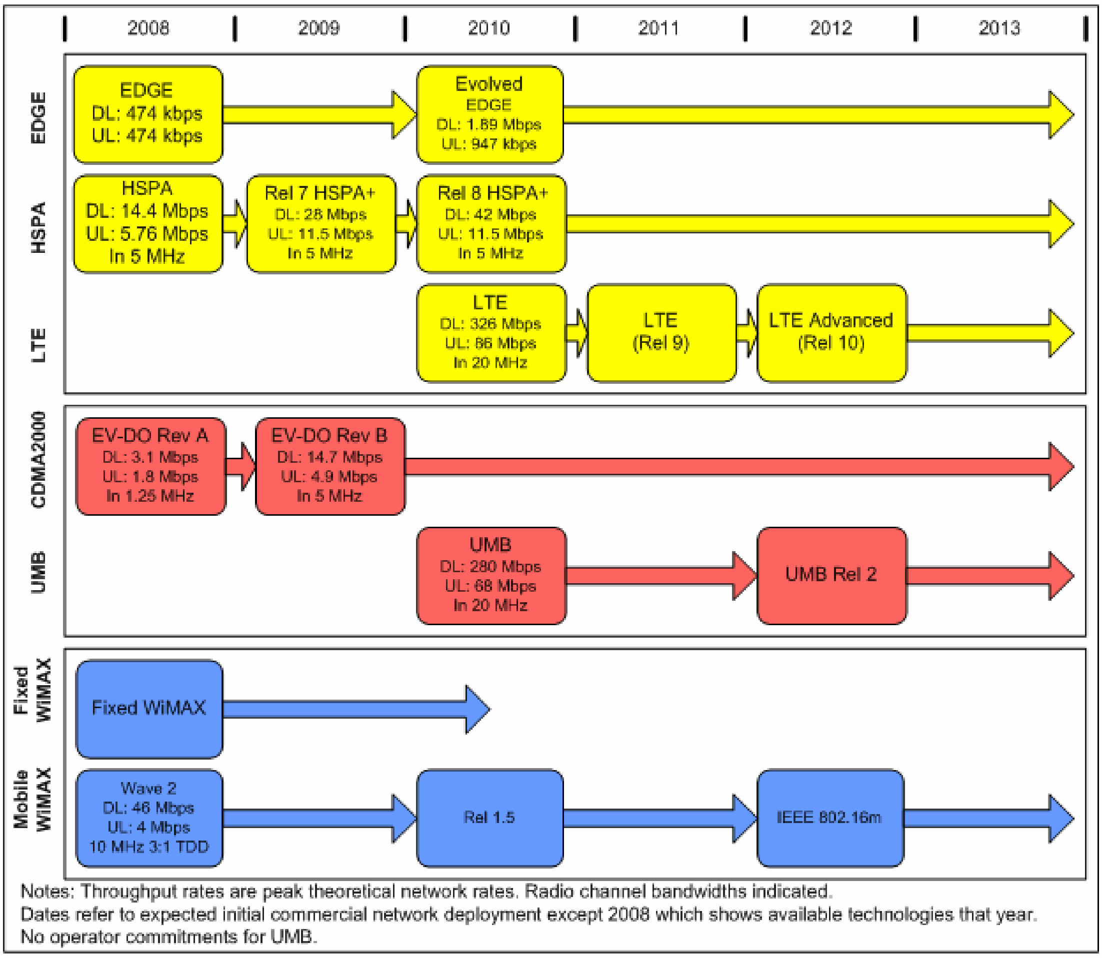
With IP included in cellular networks, the number of potential direct and indirect Internet users approaches several billions. The technologies have been rapidly advancing in the networks and handsets, from 2 to 2.5G, and from 3G to 3.5G and on to 4G, delivering much faster throughputs to devices. The evolution of these technologies is depicted in Figure 2 (image provided by courtesy of 3G Americas).

Continuing advances in 3G technology under IMT-2000

The ITU-R continues its partnership efforts with external organizations in the wireless mobile broadband industry to capture and harmonize the state of the art advances being made to the 3G and 3.5G technologies (TDMA, CDMA and OFDMA systems). These systems, which had their initial deployments in the year 2000, have been enhanced to significant broadband capabilities. In their latest versions (2009) they offer significant, almost order of magnitude, improvement in end-user throughput, performance and overall user experience.

The current view of these evolved IMT-

Figure 2: Evolution of TDMA, CDMA and OFDMA systems



Source: 3G Americas, September 2008 "EDGE, HSPA, LTE: Broadband Innovation", http://www.3gamericas.org/documents/EDGE_HSPA_and_LTE_Broadband_Innovation_Rysavy_Sept_2008.pdf

2000 systems is composed of two major elements: (1) a new radio access network that is optimized for an all IP-based traffic network and (2) an evolutionary core network architecture designed to work integrally with the radio access network as a unified eco-system.

These evolved IMT-2000 systems promise significant improvement in network performance and operational efficiencies. Based on an all-IP packet based network, they enable operators to potentially reduce the number of network elements between subscribers and the internet. Higher speeds and increased support of "full mobile broadband" will allow the end users to run applications and services that are associated today with wireline broadband networks.

Developing 4G technology under IMT-Advanced

The ITU is taking a strategic global leadership in advancing mobile ICT to a new level in its work on IMT-Advanced. As explained in the December issue of the ITU News:

> To set the stage for the new wireless future, in 2003 ITU–R once again provided a further strategic vision of how the needs of the marketplace and end users could evolve. That vision is called IMT-Advanced. As importantly, ITU–R has now set in place a plan to achieve this vision. The plan and its related Recommendations and Reports define the IMT future through the ongoing development of IMT-Advanced.[26]

IMT-Advanced is a leap beyond IMT 2000, as it offers new capabilities for the physical layer of the radio interface and brings into play a greater level of radio resource management and control, advanced capabilities for spectrum channel and bandwidth aggregation, and improved performance at all levels, including quality of service aspects. IMT-Advanced represents a wireless telecommunication platform that has the flexibility to accommodate services that are yet to be imagined.

The Internet of Services

The Internet of Services (IOS) is another area that has been very successful. The best known class of services is e-commerce, with such leading firms as eBay and Amazon. The importance of searching and of the related advertising revenues enabled the growth of Google. Similarly, the development of social networking saw Facebook and its competitors grow rapidly. The addition of Location Based Services (LBS) is expected to extend social networking systems to mobile devices. The problem for network design has been the unpredictable nature of the successes (and failures) of services, making it difficult to know the nature and levels of traffic they will generate.

Innovation and Growth

In many countries, broadband Internet is now viewed as a vital part of national infrastructure and a centrepiece for economic and social development. The economy has become, to an increasing extent, the Internet economy, including the applications that are used in electronic commerce, government and social activities. The Internet now extends far above the TCP/IP protocol stack, into services and their uses.

The 2008 OECD Ministerial Conference stressed the importance of the Internet to innovation and to the creation of jobs and economic growth.[27]

The European Union expressly addressed the use of ICTs and innovation in its Lisbon Agenda in 2000.[28] The revised Lisbon Agenda focused on jobs and growth, again emphasizing a wide range of applications of the Internet.[29] To implement this, the European Commission has policies for the wider availability of high-speed access to the Internet and by a range of research projects under the banner of the future Internet. For example, the FIRE project examines the long-term needs for Internet architecture, through a series of large-scale, interconnected test-beds.[30]

In Japan the development of ICTs is seen as a source of economic growth and productivity gains. The U-Japan policy, to create the ubiquitous network society, was launched in December 2004 by the Ministry of Internal Affairs and Communications (MIC). With this anything and anyone was to be able to access networks and freely transmit information from anywhere at anytime.[31] It was to create a number of new areas that would ensure the growth of the ICT industry, a theme taken up by leading Japanese manufacturers.[32]

Internet and TV

The industry dream of one box in the living room is moving closer to reality. As the Internet encroaches on the market share, viewing hours and advertising revenues of traditional broadcast media (already in some countries more time is viewed surfing the Net than watching broadcast television), new technologies are emerging to enhance and facilitate Internet viewing over television sets.[33] LG has recently introduced a TV set that allows wireless Internet viewing and Boxee is a small start-up that gives TV users a single interface to access all photos, video and music on their hard drive, along with television shows from sites like Hulu and YouTube. Intel is partnering with Yahoo to produce a widget channel that lets viewers email friends, trade shares or check the weather while watching television programs. Thus, it is more than likely that in 10 years Internet TV will be drastically different that what it is today.

New Web Technologies

New web technologies may change the nature of data flows and searches on the Internet. The 'semantic web' has been described by Tim Berners-Lee, inventor of the World Wide Web, and others as the 'web of the future', in which any piece of information, such as a photo or banks statement, could be linked to any other. Instead of a collection of pages, the semantic web would enable direct connectivity between much more lower-level pieces of information, giving rise to new services, and in effect is about machines talking to machines.[34] The semantic web will, however, raise new privacy and security challenges.

Proprietary Internet

It has been widely observed that the open, transparent nature of the Internet is one of the key drivers of its success and its global reach. The Network of Networks is generally accessible to all, although the price may vary and languages may be a barrier.

On the other hand, some caution of the risk that the Internet could break apart or that some parts could be closed off, due in large part to security concerns. Professor Zitrain of Harvard law School has warned that the Internet is closing:

> We face a wholesale revision of the Internet and PC environment of the past 30 years. The change is coming partly because of the need to address security problems peculiar to open technologies, and partly because businesses want more control over the experience that customers have with their products.[35]

As examples, he cites the approved sourcing of applications for the iPhone 2.0 and Web 2.0 software-as services ventures like the Facebook platform and Google Apps. Other refer to this Internet as a "gated community", where users may have to sacrifice certain freedoms and anonymity in return for better security.[36] This is already the case for many corporate and government Internet users.

Cloud

With the growth in IT expenditures as a component of business costs and operations, small and medium-sized enterprises are turning to third parties to outsource their IT needs. Cloud computing refers to the trend of outsourcing IT needs and its growing popularity as a business model will place further strains on the Internet, particularly with regard to security, reliability and cost of access. Technology Watch published a separate report on this phenomenon in March 2009.[37]

Traffic Jams (?)

The rapid growth of the Internet has placed new demands on communications networks and this growth of Internet traffic has been the subject of periodic controversy. New technologies that generate large quantities of traffic include video-sharing sites, videoconferencing, movie downloads, online gaming, remote medical imaging and online storage of documents.

Some claim that the Internet will collapse under the weight of traffic in general or of specific events, giving rise to the term ‘exaflood’. A recent study by Nemertes concludes that demand will exceed total broadband capacity at the access layer of the Net by 2012 and will require investment of some US 137 billion USD over the next 5 years to keep pace with demand.

On the other hand, some consider that the growth will be manageable, largely due to declining unit costs, even if some providers are unhappy about the costs they must carry. Andrew Odlyzko, a computer scientist at the University of Minnesota, estimated Internet traffic in 2007 to have been 3-5 EBytes worldwide, with a growth rate of 50-60% per annum, but that the actual rate of traffic growth seems to be decreasing, with traffic growth estimated at 100% in prior years. [38] TeleGeography published figures last year showing that in 2007-08, capacity grew faster than traffic.[39]

Usage Patterns

While always billed as a global network (of networks), reality is now beginning to match the hyperbole. In its initial days, the Internet was largely a communications tool for developed countries. But that picture is changing.

According to some analysts, in 2008 the number of Internet users in the Top 10 developing markets surpassed the number in developed markets for the first time.[40] In percentage terms, some of the faster growing user markets include China, Pakistan, Colombia, Iran, Egypt, Venezuela and Nigeria. This transformation is having a dramatic impact on the Internet, as a growing diversity of languages, alphabets, access devices and cultures must be accommodated.

5 Standards

The evolving trends in Internet use will have a deep impact on standards work.

Early standards to ensure interoperability included TCP/IP and related standards such as File Transfer Protocol (FTP) Simple Mail Transport Protocol (SMTP) and HTML, some of which are more than 30 years old. As the use of the Internet moves from text to multimedia (video, images and audio) and as new types of devices are connected (laptop, smart phones, etc.), the number of required standards also is increasing rapidly. Single access devices that provide extensive functionality (GPS mapping, Wi-FI, TV) may contain hundreds of embedded standards.

The OECD Ministerial agreed to:

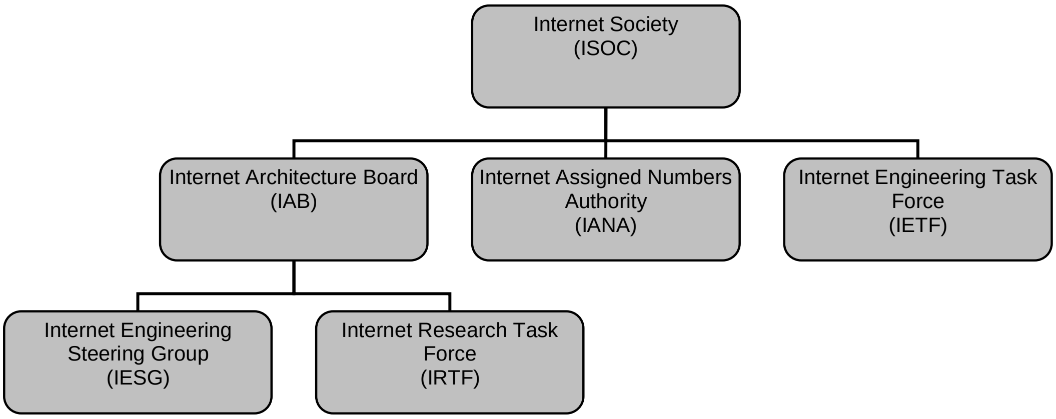
> Uphold the open, decentralized and dynamic nature of the Internet and the development of technical standards that enable its ongoing expansion and contribute to innovation, interoperability, participation and ease of access.[41]

There are a wide range of organizations involved in the formulation of standards for the future Internet and the number is increasing as the types of services and access devices grows.

The current architecture is overseen by the Internet Society (ISOC), a non-governmental organization, comprising national chapters, with membership open to both individuals and organizations.[42] ISOC has issued charters to the IETF, IAB and IANA (Figure 3).

IETF[43] is currently studying representative topics which include scalability for routing, addressing, mobility, multi-homing and routing table related issues. Problem comes from the combination of Identifier and locator. The IETF is open to any individual and comprises an international community of network designers, operators, vendors and researchers.[44] Several IETF working groups are managed by Area Directors who are members of the Internet Engineering Steering Group (IESG).[45] Oversight is by the IAB, including adjudication of appeals against the IESG.[46] IANA coordinates the assignment of unique parameter values for Internet protocols.[47] The IRTF promotes research on the evolution of the future Internet through Research Groups on protocols, applications, architecture and technology.[48]

Figure 3: Internet architecture organizations



ITU

The current work program of the ITU-T for the Study Period 2009-2012 embraces many Questions of relevance to the Internet. These activities are summarized in Annex A.

6 Conclusion

For the reasons cited in this Report, it is difficult to forecast future requirements for the Internet with any certainty. This task is made yet more difficult by the addition of millions of new users each year, many from developing countries using mobile devices for access, and of new services and applications.

In RFC 1287, Clark et al acknowledged that any change to the Internet design would take years to plan and to implement. Nearly two decades later, systematic change is even more difficult, with the prospect of modifying or replacing equipment for one billion being a significant undertaking and one that gets more difficult each day. The prospect of even unintentional disruptions to e-commerce, e-government and day-to-day social applications as the result of a transition to a new design is potentially extremely risky.

It is very difficult to define a boundary for the Internet, given the addition of overlay networks, applications and services, outside the TCP/IP stack, but still perceived as part of it. While to engineers "architecture" may be the correct analogy, for users it is seen as a system, of which TCP/IP is an invisible part of underlying infrastructure.

The existing architecture has already proved able to "deliver" or at least to permit the creation and rapid expansion of eBay, Google, YouTube, Skype and Facebook. Despite some critics, evolutionary changes to the original design have proved adequate to meet most new needs.

The next few years of the Internet are to some extent already "baked in", with the further deployment of IP over cellular networks and, in developed countries, over fiber to the home.

Yet, despite the obstacles, there is a significant constituency that argues for a clean slate approach to the Internet and work is underway on features of such a design. This Report has identified a number of new trends that would need to be addressed in any new architecture. While not directly addressed in this Report, security concerns and mounting monetary losses due to cybercrime, phishing and their ilk lend support to calls for a clean slate.

Since the evolutionary approach is ongoing, the question could be asked if there is a tipping point that would favour the clean slate advocates. One candidate to trigger the transition to a new design would be an Internet catastrophe, such as a cyberterrorist attack.[49] The rivalry in the USA between FIOS and U-verse is already an example of architectural competition, with the former deploying FTTH while the latter has deployed FTTN/VDSL.

In this admittedly uncertain landscape, it is difficult to anticipate future standards work beyond the mid-term. As a result, this Report has surveyed the debate over Internet architecture, and identified key emerging trends and features of the Internet, in an attempt to provide pointers for future standards work for consideration by the ITU-T membership and the broader standards community.

Annex A

ITU-T	*Title*	*Scope*
SG2	Service definition, numbering, routing, disaster relief, early warning and telecommunication management	• Numbering • Emergency communications • ENUM
SG3	Tariff and accounting principles, economic and policy issues	IIC
SG5	Protection against electromagnetic environment effects	EMC requirements
SG9	Television & sound transmission and integrated broadband cable networks	• Voice and video IP applications • IPTV over CATV networks
SG11	Signaling requirements, protocols and test specifications, intelligent networks and test specifications	Signalling requirements and protocols for IP-based networks, NGN, mobility, multimedia related signalling aspects
SG12	Performance, quality of service and quality of experience	QoS and QoE
SG13	Future networks, NGN, mobility management and fixed-mobile convergence	Architecture, Impact of IPv6 to an NGN (Q.7/13)
SG15	Optical transport networks and access network infrastructures	Access and core networks
SG16	Multimedia coding, systems and applications, ubiquitous applications and accessibility for persons with disabilities	Multimedia capabilities for services and applications for existing and future networks, including NGN and beyond
SG17	Security, identity management, languages and description techniques	• Identity management • Security • Formal languages and description techniques • Conformance and interoperability testing
FG CarCom	From/In/To Cars Communication	• Car-to-Car • Infrastructure-to-Car
FG FN	Future Networks	• Visions of future networks, based on new technologies • Interactions between future networks and new services • Familiarize ITU-T and standardization communities with emerging attributes of future networks • Encourage collaboration between ITU-T and FN communities
FG ICTs & CC	Climate Change	Methodology to measure impact of ICT on GHG emission reductions

Glossary

ATM	Asynchronous Transfer Mode
CDT	Center for Democracy and Technology (USA)
DoS	Denial of Service
FG	Focus Group
FIND	Future Internet Design (USA)
FTP	File Transfer Protocol
FTTH	Fibre To The Home
FTTN	Fibre To The Node
GENI	Global Environment for Network Innovations (USA)
GHG	Greenhouse Gas
GLIF	Global Lambda Integrated Facility
GNI	Global Network Initiative
IAB	Internet Architecture Board
IANA	Internet Assigned Numbers Authority
ICTs	Information and Communication Technologies
IESG	Internet Engineering Steering Group
IETF	Internet Engineering Task Force
IOS	Internet of Services
IOT	Internet of Things
IP	Internet Protocol
ISP	Internet Service Provider
ISOC	Internet Society
ITU	International Telecommunication Union
IXP	Internet eXchange Point
LAN	Local Area Network
LBS	Location Based Services
LTE	Long Term Evolution
MIC	Ministry of Internal Affairs and Communications (Japan)
MPLS	Multi-Protocol Label Switching
NAT	Network Address Translation
NICT	National Institute of Information and Communications Technology (Japan)
NRPS	Network Resource Provisioning Systems
NSF	National Science Foundation (USA)
NSP	Network Service Provider
OECD	Organization for Economic Cooperation and Development
PAN	Personal Area Network
PCH	Packet Clearing House
QoE	Quality of Experience
QoS	Quality of Service
RFC	Request for Comments
RFID	Radio Frequency Identification
SDH	Synchronous Digital Hierarchy
SLA	Service Level Agreement
SG	Study Group
SOA	Service Oriented Architecture
TCP	Transmission Control Protocol
USN	Ubiquitous Sensor Network
VDSL	Very high speed Digital Subscriber Line
VoIP	Voice over Internet Protocol
VPN	Virtual Private Network
WAN	Wide Area Network
WSN	Wireless Sensor Network
WWW	World Wide Web

Notes, sources and further reading

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