Chapter 3

ICT Infrastructure

This chapter addresses the infrastructure of the information society – access, quality, investment and tariffs.

Introduction

In the late 1980s, the OECD started work on defining performance indicators for the telecommunication industry, with the aim of enabling international comparison and informing policy. The report *Performance Indicators for Public Telecommunications Operators* (OECD, 1990) summarised the initial set of indicators used by the OECD to compare the development of telecommunication services in member countries. The report also included a summary of the initial OECD methodology for comparing telecommunication tariffs. This methodology formed the basis for analysing the telecommunication sector in the biennial *Communications Outlook* (OECD, 1991 onwards).

The International Telecommunication Union's (ITU) *Definitions of World Telecommunication/ICT Indicators* (ITU, 2007 and 2010) identifies and defines key telecommunication/ICT indicators for analysing the sector (*e.g.* number of fixed telephone lines, mobile cellular subscriptions, fixed Internet subscriptions, etc).[1] Its goal is to assist the standardisation of statistics in order to improve analysis and comparisons within and across countries and telecommunication operators. Given that the telecommunication/ICT sector continues to change rapidly, the indicators to measure the telecommunication/ICT sector need to be adapted regularly. The impressive growth and changes in the mobile and Internet sectors over the last few years, for example, have called for the revision of existing definitions. These changes are discussed and the indicators considered and adopted at the ITU's World Telecommunication/ICT Indicators Meeting (WTIM), which is organised regularly. Following the 7th WTIM in 2009, an Expert Group on Telecommunication/ICT Indicators (EGTI) was created to revise the ITU telecommunication/ICT indicators and their definitions. At a meeting of the EGTI in March 2010, revisions were finalised for more than 160 indicators. One of the main objectives was to harmonise the definitions of fixed and wireless broadband with the OECD and the EU. The revised indicators were included in the ITU data collection in 2010. The mandate of the EGTI was extended at the 8th WTIM in 2010 and the group will continue to discuss and define new indicators, such as quality of service and mobile broadband tariffs. A revised version of the ITU *Definitions* will be published by ITU in 2011 in the *Handbook for the Collection of Administrative Data on Telecommunication/ICT* (ITU, 2011).

ITU's definition of public telecommunication infrastructure originally excluded broadcasting. Given the interest in platforms other than circuit switched telecommunication networks, which can now provide "like-services", the ITU later appended definitions for broadcasting (*e.g.* multi-channel television connections, homes passed by cable, direct-to-home satellite antennas and so forth).

At the time that ITU started its data collection, the public telecommunication sector excluded private networks that either did not automatically connect to the public network or that had limitations on membership. Prior to widespread liberalisation, networks such as the Internet that operated in parallel with or overlaid telecommunication infrastructures, were not considered part of the public telecommunication sector. They

were used by "closed user groups", such as academia, and were not accessible by the public. When the Internet was commercialised and became a mainstream part of the public telecommunication market, the ITU started to collect data to capture this development. Today the Internet market is captured in the ITU's *Definitions* and annual data collection through several indicators, including fixed Internet subscriptions, fixed and wireless broadband subscriptions and international Internet bandwidth.

The OECD's main publications in this area are the *Communications Outlook*, the *Information Technology Outlook* and the *Science Technology and Industry Scoreboard*. OECD publications can be purchased or freely read on line. Reports in the area of Communication Policy can also be freely downloaded from the OECD website.[2] ITU publishes its data in a number of formats, including in electronic format, and particularly through its World Telecommunication/ICT Indicators Database, and in various publications. Leading ITU publications in this area include the *World Telecommunication/ICT Development Report*, the *Measuring the Information Society Report,* the *Yearbook of Statistics*, as well as a number of regional reports.[3]

Public switched telecommunication networks (PSTN)

In most countries, ministries dealing with telecommunications or telecommunication regulatory authorities collect a basic set of indicators, which allows them to monitor market development, inform policy and ensure efficient regulation of the communications sector. For the most part, these indicators are tied to a service (*e.g.* telephony) provided over a specific infrastructure (*e.g.* PSTN). Increasingly, it has become evident that the diffusion of the Internet and the increased penetration of broadband services necessitate a more comprehensive list of indicators.

ITU's *Definitions* defines a range of traffic measures for the PSTN. The measurements used across countries are generally one or more of: minutes, units of time. PSTN traffic may also be recorded in relation to whether it is local, domestic long distance or international. These categories are increasingly less applicable to the way that telecommunication prices are structured, in that tariffs are becoming less sensitive to distance and time. An improvement in traffic indicators has been to include and distinguish fixed and mobile originating calls, including those that are on- and off-net Internet calls. This has been particularly important in view of the accelerating usage of mobile telephony, especially in developing economies.

The Internet

A note on infrastructure technologies

Most analysts expect a transition from circuit switched networks to IP networks (*i.e.* those that use the Internet Protocol). Sometimes these are referred to as "next generation networks". These networks are expected to – and increasingly can – provide any service that might once have needed a specialised or dedicated infrastructure. Telecommunication carriers, for example, which once specialised in telephony, are beginning to provide television services over DSL connections. At the same time, an increasing number of cable television networks are providing Internet telephony. In fact, any platform that can provide broadband access to the Internet enables the user, with the appropriate terminal equipment and software, to access Internet telephony services. As a result of these developments, services are no longer tied to specific platforms. A household

without a fixed telephone line may still have a telephony service provided by a different platform.

The Internet, of course, uses some elements of the infrastructures created for PSTNs *e.g.* dial-up services use local loops. In that sense, the Internet and other private networks that overlaid public networks were recorded during historical data collection.

Notwithstanding this, a range of new access technologies has emerged that use upgraded elements of infrastructures built for circuit switched and alternative networks. In the case of telecommunication networks, the primary development has been the deployment of digital subscriber lines (DSL). Cable modem access is enabled by networks that have been upgraded from their original purpose of providing cable television. A range of terrestrial fixed wireless and mobile cellular platforms can also provide broadband access. In respect of cellular service, UMTS (Universal Mobile Telecommunications System) represented an evolution in terms of services and data speeds from "second generation" mobile networks to "third generation" (3G) mobile technologies. A fourth generation of mobile wireless technologies is currently being deployed and is sometimes designated as 4G if it represents a substantial increase in the capabilities of 3G (OECD, 2010). At the same time, a range of fixed wireless access platforms can provide broadband access within a local area (*e.g.* WiFi) or over a wider area (*e.g.* Wimax and Mesh Wireless Networks).

A distinction between cellular and fixed wireless is that some fixed systems require an antenna fixed on a building to receive service. Cellular networks provide a greater ability for users to roam between cells than do fixed wireless networks (though fixed wireless networks can provide mobility within their coverage areas). Two-way broadband access via satellite requires a user to have a receiver capable of downstream and upstream communication. One-way satellite broadband accesses, and broadband access provided via digital television, require an alternative uplink technology (generally via an analogue or ISDN telephone line). Broadband access via power lines is another emerging platform. Finally, combinations of these networks can be used to provide broadband access. For example a satellite or power line might be used to provide a connection to a location, with local access provided with WiFi. In terms of definition, this group of access technologies is generally referred to as broadband (or high speed Internet access). A major emerging issue is that of capturing voice traffic over IP (VoIP) based platforms. The accelerating pace of VoIP has posed challenges for traffic measurement.

Broadband measurement

There is no standard definition of the threshold speed for broadband. Recommendation I.113 of the ITU Standardization Sector (ITU-T) defines broadband as a transmission capacity that is faster than primary rate ISDN, at 1.5 or 2.0 Mbps (ITU, 2004). In the United States, the Federal Communications Commission (FCC) established one of the first thresholds for reporting on the deployment of advanced telecommunications. The FCC originally set the speed for broadband access at 200 kbps in one or both directions. In 2010, the FCC redefined the minimum requirements of broadband, for the purposes of data collection, to 4 Mbps downstream and 1 Mbps upstream.

When the OECD first began to collect data on the take-up of DSL and cable modem access, there was no DSL or cable modem service advertised at less than 256 kbps for downstream connectivity. As this threshold was higher than basic ISDN (*i.e.* 128 kbps) it seemed a convenient benchmark by which to exclude ISDN, which was counted elsewhere,

and record the new services that had become widely known under the collective term of broadband access. For the purpose of statistical collections, ITU's fixed broadband indicator is called "Total fixed (wired) broadband Internet subscriptions" and refers to subscriptions to high-speed access to the public Internet (a TCP/IP connection), at downstream speeds equal to, or greater than 256 kbps.

In June 2002, the European Commission's Communications Committee (COCOM) established a working definition for the collection of broadband data in the European Union area. The threshold speed for both incumbent telecommunication carriers and new entrants was set by COCOM at 144 kbps. The objective was also to exclude basic ISDN lines (that is, 128 kbps).

The issue of setting a baseline speed for broadband, in so far as measurement for OECD countries is concerned, is a transient one. In 2003, Telecom New Zealand and France Telecom's baseline speeds were both 128 kbps. At the close of 2004 they were increased to 256 kbps and 512 kbps respectively. In 2003, the highest speed offered by France Telecom to residential users was 1 Mbps. At the close of 2004 an 18 Mbps service was introduced for a similar price. In the United Kingdom, the cable operator NTL raised its baseline speed from 128 kbps to 10 Mbps between 2003 and 2005.

Policy makers have an interest in the take-up of various broadband speeds because some services can be better utilised at higher speeds. However, once a DSL, cable modem or other broadband connection is in place it can be upgraded to a higher speed. Accordingly, it seems unproductive to exclude a connection at one speed that might be increased as competition in the market increases. An alternative for the near future would be to set a speed over which services that require high speed can perform at a reasonable level.

Since 2010, OECD and ITU broadband statistics are categorised as Fixed (wired) broadband subscriptions and Wireless broadband subscriptions. Fixed (wired) broadband subscriptions include: DSL, Cable mobem, Fibre to the home/building subscriptions and other fixed (wired) broadband subscriptions such as power lines. Wireless broadband subscriptions include: Satellite subscriptions, Terrestrial fixed wireless subscriptions, Terrestrial mobile wireless subscriptions (the sum of active mobile broadband and dedicated mobile data subscriptions). The ITU Expert Group (EGTI) decided to introduce a new indicator "*Fixed (wired) broadband by speed*" which distinguishes broadband connections according to five different ranges of speed (ITU, 2010). ITU started to collect broadband speed indicators in 2010.

Internet network statistics

The Internet, by its very nature, enables data to be collected about itself through online surveys of computers and servers connected to it and interactive exchanges between applications. Examples include surveys of Internet hosts, secure servers and permanent connections.[4] Programs such as anti-virus software and firewalls can also remit information to a central point where these data are aggregated to provide information on security of networks.[5]

An increasing area of information in the realm of Internet statistics lies in the collection of domain names registered. These in turn provide an insight into the growing ubiquity and diffusion in Internet usage both in the developing and developed world. These categories primarily relate to the use of identifiers such as domain names,

Autonomous System Numbers (ASNs) and IP addresses. ICANN and most organisations with responsibility for country code domain names make statistics available on registration.[6] Regional Internet Registries that include RIPE (Europe), ARIN (North America), LACNIC (Latin America and Caribbean), APNIC (Asia-Pacific) and AFRINIC (Africa) also generate statistics on their activities.[7] The Internet Society also maintains a site with links to various sites containing information related to the Internet.[8]

Internet traffic exchange measures

In most countries there are no data recording the "national total" for traffic carried by networks using the Internet protocol. Australia is one of the few countries where there are official data available on Internet traffic. These data are generated from the Australian Bureau of Statistics annual Internet Activity Survey (ABS, 2010). The survey collects data on the number of megabytes downloaded by users subscribing to ISPs in Australia.

In other countries, data may be available for individual operators and a number of Internet Exchange Points (IXPs) publish statistics about traffic passing through their infrastructure.[9] Data are also sometimes available about which networks have direct traffic exchange relationships. These can either be seen in the peering tables at IXPs or via other sources.[10]

The "Weekly Routing Table Report" is an automated weekly e-mail describing the state of the Internet Routing Table as seen from APNIC's router in Japan.[11] The report is posted weekly to several mailing lists dealing with technical aspects of the Internet. It includes a number of indicators for the global Internet, such as the number of autonomous systems in the routing table, and these data broken out by regional Internet registry (RIR) region. Autonomous Systems are networks with their own distinctive routing policies that appear in the Internet routing table. In September 2010, there were more than 35 566 Autonomous Systems (ASes) in the world – up from less than 3 000 at the close of 1997.

In the United States, the Cooperative Association for Internet Data Analysis (CAIDA) is a collaborative undertaking among organisations in the commercial, government, and research sectors aimed at promoting greater co-operation in the engineering and maintenance of a robust, scalable global Internet infrastructure.[12] This includes the creation of Internet traffic metrics (in collaboration with the Internet Engineering Task Force/IP Performance Metrics group and other organisations) and work with industry, consumer, regulatory, and other representatives to assure their utility and acceptance. Another United States based institution is the Packet Clearing House (PCH). PCH is a non-profit research institute that supports operations and empirical analysis in the areas of Internet traffic exchange, routing economics, and global network development.[13] In 2007, PCH and OECD published "Good Practices in Internet Exchange Point Documentation and Measurement" (OECD, 2007). The paper sets out a methodology, produced within the Internet community, to improve measurement and documentation at Internet exchange points.

Quality of services

In 1990, the OECD defined a list of indicators for monitoring quality of service in respect of the PSTN (OECD, 1990). The ITU includes three quality of service indicators in its *Definitions*, all of which refer to the PSTN. Over time, some of these indicators have become less relevant for many OECD countries. In most OECD countries, for example, there is no waiting list for a fixed telephone line and service can be provided on demand. Since the

original indicators were defined, new services have been introduced (*e.g.* broadband Internet access) or have increased in importance (*e.g.* mobile telephony). Telecommunications regulators in some countries monitor these services but there has not been any international harmonisation of methodologies and definitions. Some regulatory authorities have begun to measure the quality of broadband connections and made tools available for users to both assess their own connection and provide aggregated data. The ITU EGTI will continue to discuss new indicators, including quality of service indicators specific to broadband and mobile services.

Infrastructure investment

The OECD and ITU both collect data on investment in public telecommunication networks and use the ITU *Definitions*. The key word in this definition is "public", which refers to offering services to the public rather than ownership of the network. This indicator does not record expenditure by business on telecommunications equipment or facilities that are not used to provide services to the public. It is aimed at collecting the capital expenditures of network operators offering services to the public (*e.g.* telephony and Internet access).

Tariffs

The OECD has developed a methodology for comparing tariffs for telecommunication services in respect of fixed line telephony (residential and small business), cellular mobile services (low, medium and high user), international fixed line telephony tariffs and leased lines. (OECD, 2000) In all these cases, a basket of services is included. For example, the residential fixed line basket includes a standard line rental and 1 200 calls per annum spread over different distances and times of the day/week. Variations include adding the costs of calls to mobile networks and international calls to the basket. ITU collects tariff information on telecommunication services through its annual tariff questionnaire, which is addressed to countries (usually the regulatory authority or the Ministry in charge of telecommunications/ICT). Reported tariff data, particularly in respect of mobile and Internet services, are complemented by research. In order to facilitate international comparison, data for fixed telephone, mobile cellular and broadband Internet tariffs are used to calculate standard fixed, mobile and broadband Internet baskets. Tariffs are shown in US$, in current international dollars (USD PPP) using Purchasing Power Parity (PPP) conversion factors, and as a percentage of monthly GNI per capita. These are also used to calculate the ITU ICT Price Basket, which is a composite basket that includes all three tariff sub-baskets (fixed telephone, mobile cellular and fixed broadband Internet) (ITU, 2009). The value for the ICT Price Basket is obtained by the simple average of the price of each sub-basket (in USD) expressed as a percentage of a country's monthly GNI per capita – capped at 100 per cent. The ICT Price Basket, first launched in 2008, is published annually. It includes a minimum of 150 countries.[14]

Notes

1. Historically, the term "public telecommunication sector" referred to telecommunication infrastructure over which services were provided for the public at large. Traditionally, this included telecommunication networks (*e.g.* telephone, telex, telegraph, data) which consisted of exchanges (switches) linked by transmission circuits that connect subscribers to each other and with subscribers abroad. The term "public" referred to the access arrangement (anyone could subscribe to the network) rather than the ownership of the network.

2. They are available at: *www.oecd.org/sti/telecom*.
3. Information on ITU publications can be found at: *www.itu.int/ITU-D/ict/publications/*.
4. The longest running survey of Internet hosts, sponsored by ISC, can be found at: *https://www.isc.org/solutions/survey*. Netcraft conducts surveys of secure servers and leased line connections to the Internet. Their website is at: *http://news.netcraft.com/*.
5. See, for example, DShield which provides a platform for users of firewalls to share intrusion information at: *www.dshield.org/*, or McAfee's Virus map at: *http://us.mcafee.com/virusInfo/default.asp*.
6. Registry reports to ICANN for generic top level domains are at: *www.icann.org/tlds/monthly-reports/*.
7. ARIN's statistics are available at: www.arin.net/statistics/. APNIC statistics can be found at: *www.apnic.net/stats/*. LACNIC statistics are at: *http://lacnic.net/en/est.html*.
8. *www.isoc.org/internet/stats/*.
9. See, for example, the Amsterdam Internet Exchange at *www.ams-ix.net/technical/stats/*.
10. The Swiss Internet exchange matrix is at: *www.swissix.net/peermatrix.php*. A traceroute between any two ISPs will generally show if they have a direct traffic exchange relationship or exchange traffic via additional networks.
11. For example, the report is posted to the North American Network Operators Group (NANOG) Mailing list, the archives of which are at: *www.merit.edu/mail.archives/nanog/*. Refer also to the weekly CIDR report at *www.cidr-report.org/*.
12. *www.caida.org/*.
13. *www.pch.net/*.
14. For more information on the ICT Price Basket, see: *www.itu.int/ITU-D/ict/publications/idi/2010/index.html*.

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