INFORMATION NOTE

Internet Protocol (IP) Telephony

1. Background

1.1 On 4 October 2004, the Office of the Telecommunications Authority issued a consultation paper entitled "Regulation of Internet Protocol (IP) Telephony". In the consultation paper, the Telecommunications Authority sets out his preliminary views on various regulatory issues of IP Telephony [1], and invites the telecommunications industry and interested parties to comment on these issues. The purpose of this information note is to provide Members of the Panel on Information Technology and Broadcasting of the Legislative Council with background information on IP Telephony with respect to its underlying technology, means of transmission, possible benefits and drawbacks, and regulatory implications.

2. Technology of Internet Protocol Telephony

2.1 IP Telephony is a generic term defined as the conveyance of voice, fax and related services over packet-switched networks using IP technology. It is also commonly referred to as "Voice over Internet Protocol" or "VoIP". IP Telephony or VoIP can be transmitted over the Internet, a privately managed IP-based network or a combination of both. "Internet Telephony" refers to the specific type of IP Telephony transmitted over the Internet.

Circuit versus packet-switching

2.2 Traditional telephony carries voice traffic over the Public Switched Telephone Network (PSTN) using circuit-switching technology. For IP Telephony, voice data are transmitted over packet-switched networks using IP technology.

[1] These issues include policy and licensing, numbering arrangement, interconnection and charge settlement, as well as consumer interests such as access to emergency services, backup power supply and quality of service requirements.

Circuit-switching

2.3 In the traditional circuit-switched PSTN, a physical path or circuit is established between the calling and the called party and this path is held open for the duration of the call. In other words, the path is dedicated to the conversation and cannot be used by third parties while the conversation takes place. This dedicated path remains open until the parties terminate the call, thus freeing up the path for use in another conversation.

2.4 The advantage of the circuit-switching technology is the extremely high voice quality made possible by the exclusive use of the circuit by the calling and the called party. However, the major disadvantage is that this type of switching may represent an inefficient use of network capacity. The network cannot be available for other uses even when there are pauses and silences in the conversation and no information is being conveyed.

Packet-switching

2.5 IP technology breaks up a "call" or voice traffic into small packets. A packet is a block of user data containing both content and controlled information, including the intended receiver's address to direct the network to deliver the packet to the correct destination. Each packet of a call is sent over the network through different routes by routers[2] and reassembled in the right order at the destination.

2.6 In IP Telephony, there are no dedicated paths, and multiple conversations can be sent over the same network at the same time[3]. In addition, IP Telephony does not require the setting up of a continuous circuit irrespective of whether there are lulls in the conversation. It only transmits information when a user speaks. When there are pauses between words, or gaps in a conversation, nothing is sent and no bandwidth is used. This allows the network to be available for transferring other packets. As such, packet-switching makes more efficient use of the network capacity.

[2] Routers are computers which read the destination address attached to each packet and then forward the packet to the correct location via the most efficient route.

[3] IP Telephony removes the pauses and quiet parts of speech before transmission. This process, coupled with data compression techniques, allows the delivery of telephone calls with a lower bandwidth. As such, packet-switching allows several telephone calls to occupy the same amount of space taken up by only one telephone call in a circuit-switched network. See Tyson and Valdes (2004).

Requirement for broadband connection

2.7 High-speed Internet access or broadband connection is a key enabler of the provision of IP Telephony services. Apart from supporting multimedia applications, the high bandwidth[4] provided by broadband connection facilitates high-quality voice transmission which is particularly important for IP Telephony[5]. Such high bandwidth must be available not only for the download, but also for the upload, since voice usually involves two-way communications.

Internet versus privately managed IP-based networks

2.8 The networks involved in the provision of IP Telephony services can be the Internet, a privately managed IP-based network or a combination of both.

The Internet

2.9 When the Internet is used for the conveyance of telecommunications traffic, all data packets are treated as no different from other types of traffic[6]. The network provides no service guarantees and only promises to make the "best effort" to deliver individual packets. In the case of network congestion, data packets can experience delay or be dropped entirely until traffic is reduced.

Privately managed IP-based networks

2.10 A privately managed IP-based network[7] allows IP Telephony service operators to "flag" voice packets as the highest priority, thereby allowing voice packets to be "the first in the queue" to move through a congested route when alternative routes are not available. Through data-packet classification, delay is reduced and quality improves.

---

4 Bandwidth is the transmission capacity of a communication medium, which is measured in terms of bits per second (bps). In general, the higher the bandwidth reaches, the greater is the information-carrying capacity of a medium.

5 In general, voice digitization techniques require 64 kbps to function properly. See Goralski and Kolon (2000).

6 IP-based network can be used for the transmission of all types of telecommunications traffic including voice, data, video, audio and e-mail.

7 A privately managed IP-based network can be a circuit leased from a broadband network operator with its transmission capacity reserved for the exclusive use of the leasee concerned.

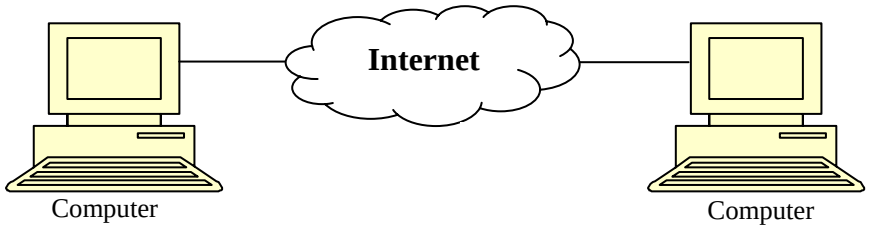
3. Means of transmission

3.1 IP Telephony calls can be set up from a personal computer (PC) to another PC, between a PC and a telephone, and also from one telephone to another telephone.

Personal Computer-to-Personal Computer

3.2 PC-to-PC telephony services are the original form of IP Telephony. Both the calling and the called party are required to connect their PCs to the Internet simultaneously before any connection can be set up, and they use compatible software and hardware (e.g. multimedia computers).

Figure 1 – PC-to-PC



Personal Computer-to-Phone or Phone-to-Personal Computer

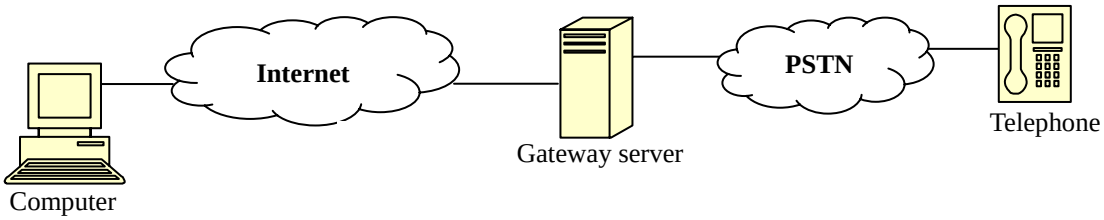
3.3 In PC-to-Phone or Phone-to-PC IP Telephony services, one end of the users is a subscriber to traditional PSTN telephony services while the other end is a subscriber to IP Telephony services with his/her computer connected to the Internet.

Personal Computer-to-Phone

3.4 The PC-to-Phone IP Telephony services enable a PC user to call a telephone. Voice data from the PC user are transmitted as digitized packets through the Internet to a gateway server[8], at which the digitized packets are converted into voice signals. The gateway server then dials the called party's telephone number, and when a connection is made, the server will send the speech of the PC user and transmit the called party's speech in the other direction.

[8] A gateway server performs coding and decoding of analogue voice signals, and compresses and converts IP digitized packets.

Figure 2 – PC-to-Phone



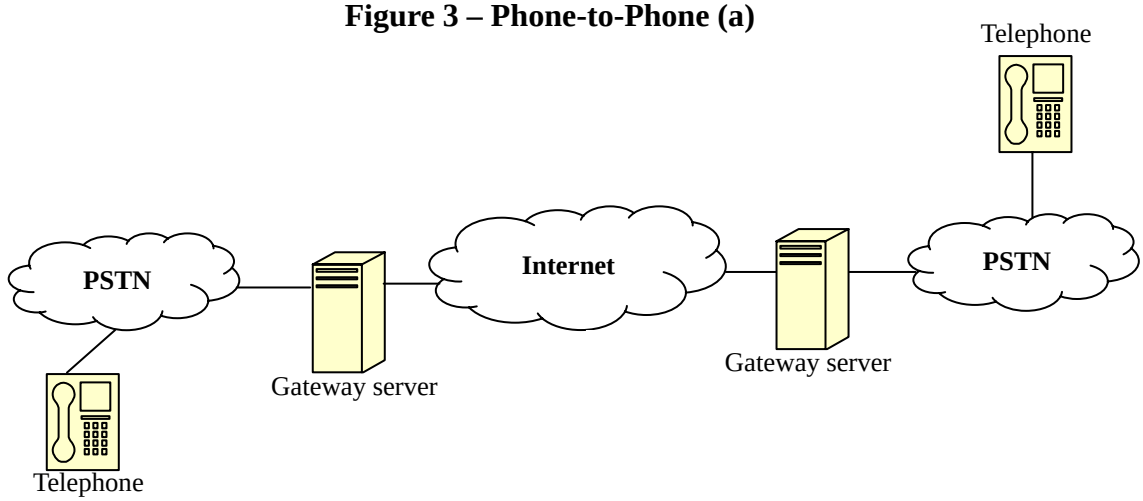
Phone-to-Personal Computer

3.5 In Phone-to-PC IP Telephony services, a call goes over PSTN to a gateway server, which digitizes the voice signals and compresses them into IP packets. The digitized packets are sent over the Internet to the PC user at the receiving end. However, there is a need to assign a telephone number to the PC for mapping with its IP address as it is impossible for a PSTN phone to call the PC using its IP address[9].

Phone-to-Phone

3.6 Phone-to-phone IP Telephony services eliminate the need for a PC and allow users to make and receive calls using ordinary telephones. A call originated on PSTN goes to the nearest originating gateway server, at which the voice signals are encoded into digitized packets. Each packet contains a destination address directing it to route through the Internet to a terminating gateway server, which is located as close as possible to the destination telephone. The terminating gateway server converts the digitized packets into voice signals and forwards the call through PSTN to the called party.

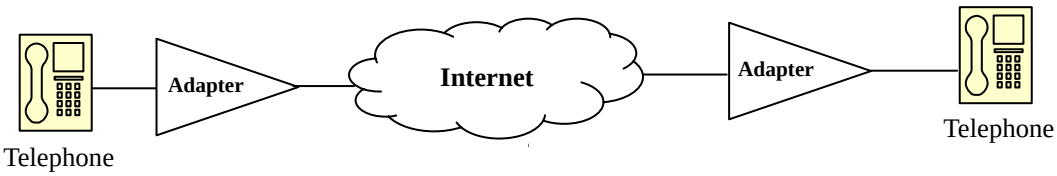
Figure 3 – Phone-to-Phone (a)



[9] IP address is a unique number which identifies a computer sending or receiving information in packets across the Internet.

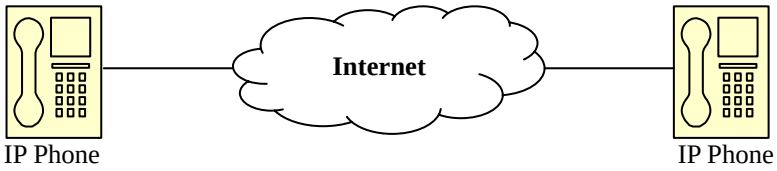
3.7 Phone-to-phone IP Telephony services commonly use an adapter to enable a telephone to connect directly to the Internet. The adapter takes the analogue voice signals from the telephone and converts them into digital data ready for transmission over the Internet.

Figure 4 – Phone-to-Phone (b)



3.8 With the advent of related technology, IP phone has emerged as a commercial product recently. IP phone is an integrated device which can be directly connected to the Internet without the requirement for additional software or hardware such as an adapter.

Figure 5 – IP Phone-to-IP Phone



4. Possible benefits of Internet Protocol Telephony

4.1 IP Telephony makes available the following services and features:

Multimedia services

4.2 IP is a convergent transport technology capable of integrating voice, data and video into one network environment. As such, IP Telephony provides consumers not only with additional choices on voice services, but also with a wide range of innovative multimedia content, applications and services using IP-based technologies.

Mobility

4.3 Consumers are rendered mobile by IP Telephony since the services can be accessible from anywhere with an Internet connection. This is particularly the case as there is no geographic boundary in the provision of IP Telephony services. A subscriber to an IP Telephony service does not necessarily have to be a resident of the country/city in which the service platform is established.

4.4 For example, an overseas subscriber to an IP Telephony service provided in Hong Kong can access the service through broadband connection provided by a network operator in any place outside Hong Kong and possibly use a Hong Kong telephone number. He/she can make and receive calls under the same Hong Kong telephone number wherever his/her telephone is connected to the Internet. The overseas subscriber can also save International Direct Dialling (IDD) call charges, since he/she, though locating elsewhere, is treated as a local user when making calls to Hong Kong.

Efficient networking

4.5 Many companies maintain two separate networks – one for the conveyance of voice traffic and the other for data transmission. An IP environment enables these companies to integrate the two networks into one, resulting in economies of scale.

5. Possible drawbacks of Internet Protocol Telephony

5.1 There are some services and features which IP Telephony may not offer at the current stage. These include:

Backup power supply

5.2 In some jurisdictions, the voice services provided by the traditional telephony system are usually supported by backup power supply outside the customer premises, e.g. from local exchanges[10]. This is to ensure the provision of uninterrupted telephone service even when there is an interruption or failure of electricity on the customer premises. However, IP Telephony services require the use of a PC, a phone adapter or an IP phone, which needs local power supply from the customer premises. Therefore, users of IP Telephony services may be subject to the potential interruption of telephony service in case of a power outage on their premises.

[10] In Hong Kong, the Telecommunications Authority has set out the requirement for backup power supply from telephone exchanges for fixed telephone line services during failure of public electricity supply.

Quality of services

5.3 Unlike traditional telephony services, IP Telephony calls are delivered over the Internet where the communication is conveyed by means of packets and is re-constructed later. In such an environment, the level of service quality could be affected by a couple of factors, namely:

Architectural differences between telephone and IP networks

5.4 Telephone networks have been engineered to provide extremely reliable, high-quality voice transmission, making real-time, two-way conversations possible between the calling and the called party[11]. As mentioned in paragraph 2.3, the circuit-switched PSTN usually dedicates a communication path for the duration of a call.

5.5 In contrast, an IP network operates on a best-effort basis with the digitized packets taking different routes to get to the destination. It is possible that some packets arrive either too late or too soon at the destination. In addition, the network may drop some packets of data to manage congestion caused by traffic overload and/or bandwidth limitation. The occurrence of these events may lead to periods of silences and hiccups in the conversation, and in turn worsen the quality of services of IP Telephony services.

Separation of service provision from network operation

5.6 It is possible to have different operators providing broadband connection services and IP Telephony services. In other words, a customer may access IP Telephony services from one service provider via broadband connection provided by another operator. Therefore, an IP Telephony service provider may not be able to control the overall quality and reliability of the voice services, if he/she is not involved in the arrangement of broadband connection between the customer and the network operator.

Access to emergency services

5.7 IP Telephony services can be used in a "nomadic" way, i.e. from any location with an Internet connection. In addition, some customers are assigned local telephone numbers which they can use outside the country/city where their IP Telephony service providers are located. As such, it may be difficult to identify the location of the caller who uses IP Telephony services to access the emergency services. Yet such information, which is currently provided by conventional telephone services, is important for the police or other emergency service agencies to attend to the emergency quickly in case the caller cannot identify his/her location.

[11] See International Telecommunication Union (2002b).

6. Regulatory implications of Internet Protocol Telephony

6.1 It is noteworthy that IP Telephony may present a challenge to the traditional regulatory framework. Many telecommunications regulators have viewed voice as a telecommunications service and the Internet as a data service. Therefore, they have applied carrier-specific regulation to the former, while the latter has been largely unregulated, or subject to few regulation. However, IP Telephony obscures the difference between voice and data. It can be provided from one computer to another (i.e. a data service), but it can also be provided from one telephone to another without a computer (i.e. a telecommunications service).

6.2 As such, telecommunications regulators may have to determine whether IP Telephony is a telecommunications or data service. If IP Telephony is considered as a telecommunications service, a related issue is whether it should be given the same obligations (i.e. universal service obligation (USO) and consumer protection) and rights (i.e. interconnection rights and availability of numbering resources) commonly accorded to operators of traditional telephony services.

Universal service obligation

6.3 USO is the obligation to provide reliable telecommunications services to the public at affordable prices. USO aims at, among other things, providing telecommunications services to those who would not normally be served based on commercial principles, such as people living in high-cost service areas (e.g. rural and remote regions).

6.4 Many jurisdictions have put in place universal service funding schemes to compensate the telecommunications operator(s) for the costs incurred in fulfilling USO or universal service cost. The sharing basis of and relevant contributing parties to universal service cost vary among these jurisdictions[12].

[12] For example, in Hong Kong, the universal service cost is shared by all operators of external telecommunications services in proportion to the volume of international telecommunications traffic handled by each operator. Some jurisdictions share the universal service cost among a wider group of operators based on their net revenue.

6.5 The introduction of IP Telephony tends to affect the funding of USO in the long term. The competition from IP Telephony service operators may, to varying extent, affect the revenue of existing contributing parties to USO. For example, revenue from traditional telephony services could be reduced if there is progressive substitution of telephone lines by IP Telephony services accessible over broadband connection. In addition, the amount of external traffic delivered through conventional telephone lines could be less if more IDD traffic is migrated to IP-based networks[13]. As such, the advent of IP Telephony may render the need for telecommunications regulators to review the funding mechanisms of USO, including whether IP Telephony service providers should be obliged to contribute to USO.

Consumer protection

6.6 There is a concern that some IP Telephony services, being marketed as a close substitute for traditional telephone services, may not offer the same services to the same standard as consumers might expect. Hence, some telecommunications regulators are considering the introduction of measures to avoid consumer confusion and safeguard public interest. An example of such measures is that consumers should be adequately informed about the technical or operational limitations in IP Telephony services[14]. Another proposed measure is that IP Telephony service operators are required to meet a minimum set of conditions if they intend to market their services as a substitute for the conventional public telephone services[15].

Interconnection

6.7 The development of IP Telephony services depends, among other things, on whether users can have any-to-any connectivity. In other words, users of IP Telephony services should be able to place calls to, or receive calls from, any customers connected to other IP-based or non-IP-based networks. If any-to-any connectivity for IP Telephony is to be achieved, it is necessary to have interconnection between network operators. It is common for network operators to enter into interconnection agreements through commercial negotiations. If regulatory intervention is warranted, telecommunications regulators may need to issue detailed guidelines and decisions governing the interconnection arrangements between network operators, which include interconnection charges and technical terms and conditions.

---

[13] As discussed in paragraph 4.4, the subscribers to IP Telephony services can save IDD call charges, since they, though locating elsewhere, can be treated as local users of the country/city in which the service platform is established.

[14] The Office of Communications of the United Kingdom proposes such a measure in its consultation paper issued on 6 September 2004. See the Office of Communications (2004).

[15] As proposed by the Office of the Telecommunications Authority, these minimum conditions include directory enquiry service, quality of service, number portability and capability to make emergency calls. See Au (2004).

Numbering

6.8 The allocation of telephone numbers is essential for users to have any-to-any connectivity for IP Telephony services. Without telephone numbers, subscribers to IP Telephony services of service-based operators cannot receive incoming calls. As such, telecommunications regulators may have to consider whether to assign telephone numbers to subscribers to IP Telephony services. If telephone numbers are necessary, a related issue should be whether the IP Telephony service operators should share existing numbering blocks with the traditional telephone services or they should be allocated with dedicated numbering blocks[16]. The allocation of dedicated numbering blocks to IP Telephony services can ease the pressure on the numbering resources. However, there is a drawback that users would need to change telephone numbers when migrating to a new IP Telephony service.

6.9 Number portability should be another policy issue for telecommunications regulators to consider if IP Telephony users are assigned with telephone numbers. Number portability allows users to retain existing telephone numbers when changing to other network operators. The objective is to foster consumer choice and effective competition by enabling users to switch between network operators without the costs and inconvenience of changing telephone numbers. If number portability is already available for the fixed line and mobile services, telecommunications regulators may need to decide whether such an arrangement should also be made for users of IP Telephony services.

Prepared by Michael YU
2 November 2004
Tel: 2869 9695

[16] In some countries, special numbering blocks have been allocated to IP Telephony services. For example, Japan has been allocating telephone numbers under a prefix "050" to IP Telephony users. In the United Kingdom, IP Telephony users are assigned a special non-geographic numbering block beginning with a new code "056". See the Office of the Telecommunications Authority (2004b).

References

1. Au, M.H. (2004) Regulation Evolving with Market and Technology. In: *15th Biennial Conference of the International Telecommunications Society.* 4-7 September, Berlin. Available from: http://www.ofta.gov.hk/speech-presentation/dg_20040907.pdf [Accessed 2 November 2004].

2. Between a rock and a hard place. (2003) *The Economist*. 9 October.

3. British Educational Communications and Technology Agency. (2004) *What is Voice over IP?* Available from: http://www.becta.org.uk/subsections/foi/documents/technology_and_education_research/voice_over_ip.doc [Accessed 2 November 2004].

4. ComputerPREP, Inc. (2001) *Voice over IP (VoIP) Essentials: Academic Student Guide (Evaluation Copy).* Available from: http://www.computerprep.com/proddesc/SAMPLE_CHAPTER/ACL01CNVOIPPR210.PDF [Accessed 2 November 2004].

5. Darlington, R. (2004) *A Guide to Voice Over Internet Protocol.* Available from: http://www.rogerdarlington.co.uk/VoIP.html [Accessed 2 November 2004].

6. Ellison, C. and Kaven, O. (2004) VoIP: Finally Worth a Look. *PC Magazine*. 3 August. Available from: http://www.pcmag.com/article2/0,1759,1630778,00.asp [Accessed 2 November 2004].

7. Farkas, B. et al. (2004) *The Titanic and the Iceberg: the PSTN Meets IP Telephony*. School of Information Management & Systems, University of California, Berkeley. Available from: http://www.sims.berkeley.edu/courses/is224/s99/GroupF/proj1.html [Accessed 2 November 2004].

8. Federal Communications Commission. (2004) *VoIP/Internet Voice*. Available from: http://www.fcc.gov/cgb/consumerfacts/voip.pdf [Accessed 2 November 2004].

9. From circuits to packets. (1997) *The Economist*. 11 September.

10. Goralski, W.J. and Kolon, M.C. (2000) *IP Telephony*. New York, McGraw-Hill.

11. Hearing voices. (2004) *The Economist.* 28 October.

12. Hold the line. (1998) *The Economist.* 10 December.

13. Hong Kong Special Administrative Region Government. (2004) *Press Release: OFTA seeks views on the regulation of IP Telephony*. Available from: http://www.info.gov.hk/gia/general/200410/04/1004167.htm [Accessed 2 November 2004].

14. If you can't beat'em, join'em. (2003) *The Economist*. 18 December.

15. International Engineering Consortium. (2004) *Voice over Internet Protocol*. Available from: http://www.iec.org/online/tutorials/int_tele [Accessed 2 November 2004].

16. International Telecommunication Union. (2000a) Background issues paper. In: *IP Telephony Workshop.* 14-16 June, Geneva. Available from: http://www.itu.int/osg/spu/ni/iptel/workshop/iptel.doc [Accessed 2 November 2004].

17. International Telecommunication Union. (2000b) *ITU Internet Reports: IP Telephony*. December.

18. Intven, H. et al. (2000) *Telecommunications Regulation Handbook*. The World Bank. Available from: http://www.infodev.org/projects/314regulationhandbook/ [Accessed 2 November 2004].

19. Kwan, L. (2004) Regulation of new technologies: IP telephony and next generation networks. In: *Seminar on Next Generation Networks and Telecommunication Regulations*. 25-26 August, WuXi. Available from: http://www.ofta.gov.hk/speech-presentation/ofta-20040825.pdf [Accessed 2 November 2004].

20. Lee, G. (2004) City opens a new route to fixed lines. *South China Morning Post*. 29 October.

21. Listing again. (2002) *The Economist.* 11 April.

22. Logan, M. (2004) Ofta may ease way for Net telephony. *South China Morning Post*. 5 October.

23. McPhillips, E. (1999) *The Factors Affecting the Growth of VoIP*. Available from: http://www.hpl.hp.com/techreports/1999/HPL-IRI-1999-003.pdf [Accessed 2 November 2004].

24. OECD. (1998) *Internet Voice Telephony Developments*. Available from: http://www.oecd.org/dataoecd/12/39/2091642.pdf [Accessed 2 November 2004].

25. OECD. (2002) *Trends in IP Technology: Their Impact on the Traditional Telephony Carrier World.* Available from: http://www.oecd.org/dataoecd/24/5/2076710.pdf [Accessed 2 November 2004].

26. OECD. (2003) *Trends in International Calling Prices in OECD Countries.* Available from: http://www.oecd.org/dataoecd/52/9/23901905.pdf [Accessed 2 November 2004].

27. Office of Communications. (2004) *New Voice Services: A Consultation and Interim Guidance.* Available from: http://www.ofcom.org.uk/consultations/current/new_voice/new_voice_services.pdf?a=87101 [Accessed 2 November 2004].

28. Office of the Telecommunications Authority. (2004a) *Internet Protocol (IP) Telephony Service*. Available from: http://www.ofta.gov.hk/tips/servicetype/local/voip.htm [Accessed 2 November 2004].

29. Office of the Telecommunications Authority. (2004b) *Regulation of Internet Protocol (IP) Telephony*. Available from: http://www.ofta.gov.hk/report-paper-guide/paper/consultation/20041004.pdf [Accessed 2 November 2004].

30. Office of the Telecommunications Authority. (2004c) *Telecommunications Authority Report on Promotional Material Relating to Hong Kong Broadband Network Limited's Broadband Phone Service*. Available from: http://www.ofta.gov.hk/report-paper-guide/report/rp20040927.pdf [Accessed 2 November 2004].

31. Rosengrant, M.A. (2002) *Introduction to Telecommunications*. Ohio, Prentice Hall.

32. The power of voice. (2002) *The Economist.* 12 December.

33. The shape of phones to come. (2001) *The Economist*. 22 March.

34. Tyson, J. and Valdes, R. (2004) *How VoIP Works*. HowStuffWorks. Available from: http://computer.howstuffworks.com/ip-telephony.htm/printable [Accessed 2 November 2004].

35. Wheatley, J.J. (1999) *World Telecommunications Economics.* London, The Institution of Electrical Engineers.

36. Wikipedia. (2004) *Voice over IP.* Available from: http://en.wikipedia.org/wiki/IP_Telephony [Accessed 2 November 2004].

37. Wolter, C. (2004) VoIP: The Right Call. *PC Magazine*. 22 June. Available from: http://www.pcmag.com/article2/0%2C1759%2C1602132%2C00.asp [Accessed 2 November 2004].