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Convergence, IP Telephony and Telecom Regulation:

Challenges & Opportunities for Network Development, with particular reference to India

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Convergence, IP Telephony and Telecom Regulation:
Challenges & Opportunities for Network Development, with particular reference to India

William Melody, Ewan Sutherland & Reza Tadayoni[1]

1. Introduction

The primary forces driving the transformation of national, regional and global economies are dramatic changes in technologies, policies and markets. The combination of,

1) the development and increasingly pervasive applications of information and communication technologies and services (ICTS) on the one hand, and
2) the worldwide movement to market liberalization and restructured regulation on the other,

are opening new opportunities for participation in the ICTS sector and the application of communication-based services throughout the economy.

The conversion of telecommunication (telecom) networks and all forms of communication and information content to *digital standards* has created an electronic network infrastructure that facilitates the convergence of formerly discrete telecom services on a single telecom network. More recently, extended applications of *Internet Protocol (IP)* have permitted the convergence of services on the Internet to include, not only data, pictures, music and video, but also voice communication, including public voice services. Voice over IP (VoIP) is the latest major step in a convergence process that has been underway for three decades. It means that now all types of services can be provided in an integrated manner over the Internet using IP. The Internet services in turn are provided over the digital network facilities of telecom operators.

The convergence of telecom services using IP also completes a technical unbundling process that allows for a clear separation of facility network capacity from the services supplied over those facilities. In the historic model of telephone service supply, specific services and facilities were integrated by technical design as both were supplied by telephone monopolies. IP has permitted a clear separation between network facilities and services, first for data, then pictures, audio, video and private voice communication, and now for public voice communication as well. This is illustrated in Figure 1. In Figure 1, Layer 1 represents the Network Infrastructure Facilities (cables, wires,microwave towers,

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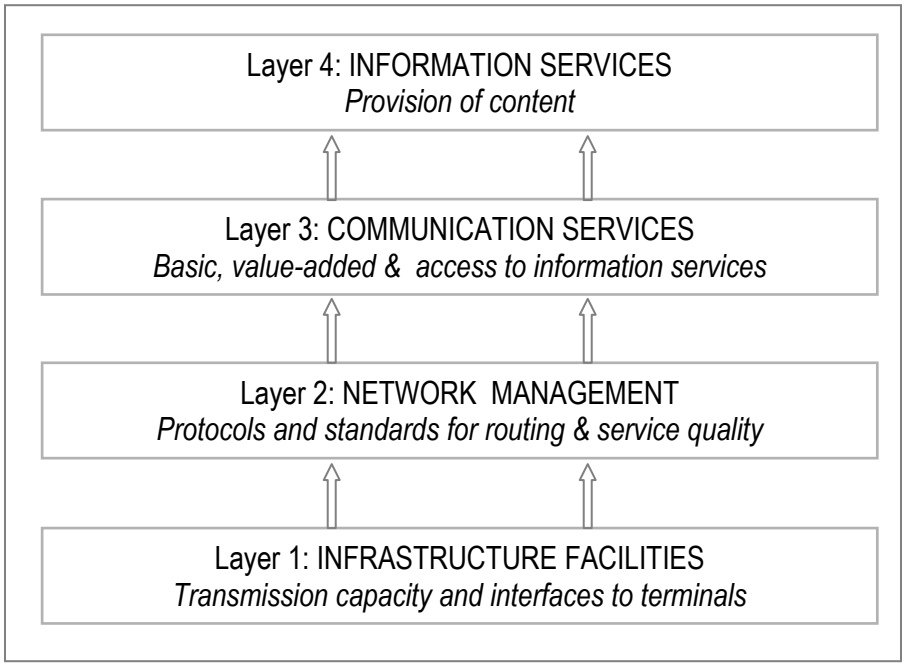
mobile cells, satellites, etc.) that provide the raw capacity that enables telecom connections. Layer 2 represents Network Management, the standards and protocols that permit the routing and determine the technical quality of network services. IP has permitted the gradual unbundling of network services from infrastructure facilities. Layer 3 represents the provision of Communication Services using IP. Until VoIP was introduced, Layer 3 was typically referred to as "Value-added" services, because it did not include basic public voice communication, only additional services. With VoIP it includes all types of communication services. Layer 4 represents the Information Services that are accessible on a network using IP.

With IP applied to all services, the structure of the overall market for communication services is radically changed from the former vertically integrated structure where most services and facilities were licensed and provided together, to a horizontally structured market consisting of distinct submarkets for network infrastructure capacity, network management, communication services and information services. This reduces the barriers to entry to this market and its submarkets significantly and provides new opportunities for increased participation by new players, entering submarkets at any level, and providing a wide variety of different service packages. It requires incumbent operators to reassess their business models and their strategies in the new market structure as they must face increasing competition at different layers in the new horizontal market structure. But at the same time they are presented with new opportunities to develop new services in the new market environment.

Figure 1

From Vertical to Horizontal Markets



A more precise characterization of this more recent development in convergence using IP would be "Everything" over IP (EoIP). All forms of electronic communication now can be provided in an integrated fashion over a single network using IP. Although IP was developed for, and initially applied on the Internet, the largest users of IP are the incumbent telephone operators around the world. They are in the process of converting their entire telecom systems to IP because of the enormous cost reductions to be achieved, and the potential for providing new converged services in the future information economy, including e-commerce, e-government and other e-application services. At the same time, the extended application of IP by Internet Service Providers (ISP) to include public voice services has opened a major new service opportunity for them, and introduced a significant new element of participation and competition in the supply of both public voice services and new converged services.

The introduction of VoIP services has raised a number of issues of adjustment to the new environment by telephone operators and service providers, by policymakers and regulators, and by users. Any major technological improvement that dramatically reduces unit costs and expands service capabilities offers the potential of enormous benefits in terms of network and market expansion, cost and price reductions, and new services development. But it also brings the threat of significant losses to those benefiting from traditional ways of doing things, and a requirement that the inherited structure of policies and regulations be reassessed and modified to meet the new challenges and opportunities unfolding.[2]

VoIP raises far greater concerns than data, pictures, music or video over IP because public voice services provide the largest source of revenue to established telephone operators. The established structure of telephone service prices in most countries depends heavily on higher prices for calls of longer distances, and especially international calls. VoIP provided by ISPs over the Internet illustrates "the death of distance" for voice phone calls. This threatens the established revenue base for many traditional telephone operators, who must now seek to establish new business models and pricing structures for their services.[3]

Important issues are also raised for national (and in some cases regional and international) ICT policymakers and regulators. They must reassess the extent to which, in the new environment, their established structures of policy and regulation,

1) provide *artificial barriers* to the achievement of the VoIP and EoIP benefits for users, network development, the economy and society;

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[2] In his major study of economic history Joseph Schumpeter described the process of major technological change as "creative destruction". See, Schumpeter, J.A. (1975) *Capitalism, Socialism and Democracy* (New York: Harper), [orig. pub. 1942], pp. 82-85. What is destroyed is the old ways of producing and marketing goods and services. Those that adapt to the new environment contribute to the creation. Those that don't are left behind and some go out of business. Unfortunately, far too often the established operators do not, or cannot adapt. AT&T may be a recent example in the telecom sector.

[3] The Economist magazine carried a major review of telecom developments a decade ago entitled "The Death of Distance", The Economist, 30 September, 1995. It is finally arriving, although most established operators, policymakers and regulators seem unprepared.

2) create *unjustified biases* favouring or retarding one segment of the industry over the others in the process of transition to the new environment;
3) adequately address new *public service* and *public interest* opportunities and requirements in the new environment; and
4) adequately *facilitate* the application of the new technological and services possibilities for extending *network and services development* to unserved and under-served regions and people,

Although the issues of structural adjustment raised by VoIP are requiring the serious attention of policymakers and regulators in all countries, the issues for developing countries are more difficult and particularly acute. Most developing countries started the telecom reform process much later than most developed countries, and have not yet fully completed the transition to an effective structure of liberalized market participation and independent regulation. Virtually all developing countries face a daunting task of not just upgrading the national network for broadband access to Internet services, but also the more difficult task of extending the national telecom network by several orders of magnitude to unserved rural areas and the majority of the population that has poor or no access to telecom services. Policymakers and regulators in developing countries must confront the greatest challenges in adapting to the new VoIP environment. But this new environment offers outstanding potential for overcoming inherited problems and taking advantage of the participation of many players, old and new, to extend telecom infrastructure and services networks by an order of magnitude to unserved and under-served areas.

This paper builds on a Workshop on ***Convergence, VoIP and Regulation*** sponsored by *info*Dev and the Telecommunication Regulatory Authority of India (TRAI) in Delhi, 11 March 2005 for regulators, policymakers and industry players in India. Using this workshop and the case study of India examined at the workshop as a valuable reference point for analysis, the paper develops the key issues associated with VoIP, IP telephony and EoIP that are confronting developing country policymakers, regulators, operators, service suppliers and users. It is intended as a useful reference document primarily to assist developing country policymakers, regulators and other participants in the telecom reform process. The primary challenge is to fashion appropriate policies and regulations that will facilitate the transition and growth of national telecom infrastructures into electronic information infrastructures that will support the development of e-economies and information societies.

Section 2 of the paper outlines the technology foundation of IP and its implications for regulation, leading to a summary in section 2.4 of the specific regulatory issues raised by the implementation of IP technology. Section 3 identifies recent telecom market and services developments arising from IP convergence, noting particularly how users are adapting their demands to the new opportunities. It notes the increasing range and diversity of communication and information sharing made possible by IP and identifies some important policy and regulatory issues being raised by them. Section 4 examines the implications of IP-based converged services on policy and regulation in developing countries, using India as a case study. It identifies the central elements of a convergence

regulatory paradigm, and key areas where regulators and policymakers will need to develop careful strategies for reform if they are to achieve the major benefits that IP-based convergence services can offer. In this context, it identifies areas where India will need to focus increased attention in completing its telecom reform process and creating the network foundation for the future Indian economy and society. Annex's I – III provide a layman's guide to the technical features of VoIP.

2. Convergence: IP Technology and its Regulatory Implications

Since the early 1980s, one of the major objectives of the telecom sector has been the establishment of one network infrastructure, with the ability to integrate all available and future services, today denoted as infrastructure convergence. This was mainly based on the recognition of inefficiency regarding operation and management of dedicated network technologies for different applications/services; like PSTN for voice telephony, FDDI/frame relay/X25, etc. for data services and specific broadband networks for video telephony. In this process the idea of ISDN (Integrated Services Digital Networks) and Broadband ISDN (B-ISDN) was born and in the late 1980s, B-ISDN based on ATM was seen as a revolution in the telecom sector as well as academia.

The IT sector was aware of this development and their agenda was to be part of this integrated communication infrastructure of the future, their suggestion was the IP protocol and the Internet. The IT industry didn't want the telecom industry to single-handed decide on the technology and structure of future networks. The telecom network architectures were seen to be inflexible and ineffective when it came to service development, innovation and competition. The claim was that the B-ISDN project was based on the incumbent telecoms' huge interest in continuing to control the value proposition, opposite to the Internet, which is based on an open platform[4].

From a technological point of view the Internet Protocol (IP) is a key driver of this development. However the convergence process also takes, place at content, service, market and regulatory levels. The aim of this section is to examine the technical features underlying VoIP service in a convergence perspective and to identify the regulatory implications of this technology.

In the following, first the two major developments, which have been preconditions for VoIP are described; the Internet itself, and the development of broadband infrastructures. Later the VoIP technology is described and the regulatory implications are identified.

2.1 Internet Protocol (IP) and the Internet

[4] A detailed discussion of the problems connected to this architecture is given in: Denton, T.M.: 'Netheads vs. Bellheads - Research into Emerging Policy Issues in the Development and Deployment of Internet Protocols', http://www.tmdenton.com/netheads.htm , 1999.

The emergence of the Internet, which is based on the IP protocol, is considered as one of the most radical innovations in the communication field in the recent years. IP technology is designed in a way that enables a radically different environment for service development, innovation and competition, both when it comes to infrastructure platforms and service development platforms. In the following some of the important characteristics of IP platforms are outlined:

- ✓ IP technology is based on a distributed network architecture, where routing and intelligence are distributed in the network.
- ✓ In the IP networks, signaling and data transmission are integrated in the same network.
- ✓ The service provision is disintegrated from infrastructure operation and the terminals attached at the edges of the network can create and offer services.
- ✓ The service development platforms have mainly been open.

These characteristics of the technology create good conditions for development and competition where several actors can be involved in service creation and provision. The general Internet is the major IP network in the world but it is far from the only IP network. In recent years, several private IP networks have been established and utilized for both corporate and residential services, and the future of communication platforms, namely the Next Generation Internet architecture is based mainly on IP technology.

The private IP networks mainly have the same characteristics as the general Internet, however with a vital difference which is the possibility of establishing certain levels of quality of service (QoS) within these networks. This enables the providers of private IP networks to offer high quality services to their costumers. QoS in the IP based networks is implemented by allocation and reservation of capacity for different services following predefined prioritization schemes. The main deployment of QoS is, nevertheless, connected to the introduction and development of IP version 6 (the advanced or next generation IP), which enables end-to-end QoS provision.

2.1.1 IP mobility and portability/nomadic use

Generally we can distinguish between two types of mobility:

- Terminal mobility: A mobile terminal can move around the network without disrupting the service;
- Personal mobility: A user can move to different terminals and networks and still be connected;

Terminal mobility requires a wireless connection, while person mobility can be implemented without necessarily having wireless connections. What is available now on the Internet could be called person mobility or portability; one can move to different places connect to the Internet and check e-mails, etc. Through their advanced services, mobile operators are attempting to provide terminal mobility.

Mobility can be implemented at different levels:

- At link layer

- At application layer
- At IP layer

When it comes to e-mail application the mobility (nomadic use) is implemented at the application level. This type of mobility is highly relevant for the VoIP. The VoIP service can be offered like e-mail, i.e., such that the only precondition for service accessibility is availability of an IP connection. Here it is extremely complex to determine the location of the caller, which creates regulatory problems for emergency calls, discussed below.

2.2 Development of broadband

Broadband is a precondition for the success of high quality VoIP services and real complementarity and competitiveness with regular telephony. The development of information and communication technologies in recent decades has been primarily dominated by three main paradigms:
1) Development and deployment of efficient technologies for data communication; here the Internet Protocol (IP) has proven its dominance;
2) The integration of different services in one and the same network, driven by the fact that operation and maintenance of different dedicated networks for different services is not optimal based on techno-economic assessment; and
3) Emergence of different mobile and wireless networks, driven by the need for mobility, flexibility and short time to market.

Broadband was developed initially within the first paradigm and was an answer to the demand at the consumer side for high speed connections, primarily for improved quality access to the Internet. The development tendency, which we are witnessing now and which is likely to continue in the future is that the broadband development expands in scope and more and more is a part of the two other paradigms. Broadband infrastructures offer, Internet access, other known services like regular telephony and TV/video distribution, as well as possibilities for new services like the intelligent/smart home services. Developments in mobile and wireless networks are also to a high degree influenced by broadband development, both when it comes to the mobile 2G and 3G and the development within the wireless technologies like WiFi and WiMAX.

Developments in the wireless networks are especially important as they can be seen as competitive as well as complementary to fixed broadband. The possibility for leapfrogging to mobile access to Internet services is a potential major opportunity for less developed regions. Here development of a fixed public service telephone network (PSTN) is no longer a precondition for public voice services. Any IP networks, including networks based on WiFi and WiMAX, can be used to offer Voice service.

2.3 VoIP technology

2.3.1 POTS versus VoIP

The POTS (Plain Old Telephony Services) network is a dedicated network, which is optimized for voice communication. Because of the deployed technology and the way POTS services have historically been organized, a centralized structure has been implemented to offer POTS. Two separate networks are deployed in parallel in order to establish a network connection and to transmit services between point A and B, the so called transport and signaling/control layers. Consequently, service creation and provision require access to both the control/signaling layer and the transport layer of the network, which in turn requires access to the whole telecom infrastructure. Even though interconnection to the POTS networks is possible, there are still large entry barriers for newcomers to offer services in the POTS networks. The precondition for service provision in POTS is access to all infrastructure and services development platforms, which requires huge investments.

For a long time, POTS was seen as a natural monopoly. In the new regulatory paradigm, it is generally accepted that the networks must be opened up for competition through unbundling and interconnection regulation. However, within the traditional telecom paradigm, competition will at best exist between a few actors in an oligopolistic market. The central reason for this has its roots in the technological architecture of infrastructure and service development platforms.

Using VoIP has gradually changed this situation and through the convergence process has opened up new conditions for service development. Using VoIP technology and the general Internet as backbone, new providers can offer competitive prices, particularly for long distance and for international calls. The transmission of the service over long distances within Internet is much cheaper than keeping the service within POTS with its distance-related cost structure and interconnection pricing schemes. The entry barriers for these service providers are lower and the number of them is increasing, contributing to the overall competition in the public voice market.

2.3.2 VoIP scenarios

VoIP can be offered in the IP access as well as core networks. In the core networks, the VoIP is used as a circuit emulation technology to transport PCM channels in the backbone network. In the following, three different scenarios of the implementation of VoIP are described with regard to market entry barriers:

- ✓ *Pure Internet based (computer to computer)*: In this implementation scenario, the entry barriers are very low. The only requirement is to have compatible VoIP software on two computers to be able to talk to each other. These types of services are the oldest ones and their quality has been improved due to improvements in the VoIP algorithms and due to the increase in capacity of the Internet and improved access technologies. There are several providers of these services, which are in competition with each other and with the traditional telecom operators.

- ✓ *Internet based with the possibility for PSTN interconnection*: In this case, the entry barriers differ depending on the extent and scope of the networks. One of the main parameters in this implementation scenario is the structure of the networks and the number and location of PSTN gateways. To be able to compete with traditional PSTN it is necessary to route the voice traffic as far as possible within the Internet backbone and to put the PSTN gateways as close to the end-users as possible, or to place the gateways in locations with the best tariff structure. In several of the current implementations, only one gateway is used and the gateway is located in a country where the best international tariffs can be negotiated.

- ✓ *VoIP in private IP networks*: This includes VoIP services in the corporate networks and lately in city networks and other networks established by user groups like housing associations, etc. This requires the establishment and maintenance of dedicated services with dedicated terminals. The users in these networks need, furthermore, to communicate with the PSTN networks and, therefore, at least one PSTN gateway is necessary. Depending on the extent of the networks, the VoIP service providers are totally or partly in direct competition with traditional telecom.

The first scenario is generally not accepted as equivalent to regular telephony, while the two other scenarios can be considered as roughly equivalent to regular telephony (e.g. the EU term is: Public Available Telephony Services). There are, however, major characteristics connected to these services, which present challenges to the market players in making these services true equivalents to regular telephony services. Another important aspect is the regulatory implications of specific parameters connected to VoIP services, which has been a subject for detailed debates in the US and Europe (at EU and national levels). In the following subsection these technological parameters are identified and their regulatory implications are examined

2.4 Technological parameters with regulatory implications

2.4.1 IP infrastructure development

The availability of IP infrastructures is a precondition for the provision of VoIP services. The development of IP infrastructures is both a market and a regulatory challenge. The design of an efficient regulatory regime can help development of IP infrastructures and their extension to less served areas. Efficient regulatory design will enable access to legacy PSTN and cable TV networks for the provision of IP connectivity. When it comes to rural and less served areas the new wireless technologies play an important role, where a combination of wireless infrastructures and VoIP service can enable a more efficient development of all communications services, including basic voice services.

2.4.2 QoS

With POTS, there are detailed recommendations on QoS from the ITU. In managed VoIP services it is possible to provide measurable QoS. But this is more difficult in best effort

services However, in both cases regulatory measures may be necessary. Another important issue is the facility based operators willingness to offer access to QoS provision to non-facility based operators. For example, a major debate in Europe and other regions is the lack of QoS provision in the wholesale Bit stream access products offered by the PSTN incumbents.

2.4.3 Numbering

For a long time to come the VoIP services will co-exist with the POTS. The success of VoIP will depend on its access to the national E.164 number plans. Any regulatory obstacles in accessing numbers can impede or slow VoIP development. One model is to assign a new number series for VoIP services. But this will create confusion at the consumer side on the character of these new numbers, e.g., on the cost of calling to these new numbers. Another negative aspect of this model is that it goes against technology neutrality in the regulation of VoIP services. The ideal model would be to assign numbers similar to the current PSTN numbers and to require number portability, so people are not forced to change their phone numbers when they want to change to a competitive offering VoIP services.

2.4.4 Emergency call and positioning

The possibility to perform emergency calls and to route the call to the nearest authority , (fire department, police, hospitals, etc.) has been defined as a core element of Public Available Telephony Services in Europe[5]. Similar requirements are part of regulation in other countries. Also location information becomes more and more a requirement posed both for fixed and mobile telephony. In VoIP it is possible to maintain the positioning and routing information for emergency calls. However this requires use of VoIP services from fixed locations. But, one of the promising characteristics of VoIP services is nomadic use. In nomadic use, at the current level of technological development , the position information cannot be connected to the emergency call. This is a challenge both to the market players and to the regulatory framework.

2.4.5 Power supply: In-line powering of terminals

Basic telephony service continues to work in case of electricity power failure. The current VoIP services/terminals are dependent on a functioning power supply. It is foreseeable that putting strong emphasis on in-line powering of terminals could put an enormous burden on the VoIP operators and slow development. A possible solution here with regard to emergency services could be to put the disaster/emergency requirements on mobile networks as well.

[5] For more detailed outline of teh European discussin se, e.g., ‘Communication staff working document on the treatment of Voice over Internet Protocol (VoIP) under the EU regulatory framework, Brussels, June, 2004

2.4.6 Interconnection to legacy networks

Interconnection to the legacy PSTN networks is essential for the success of VoIP services. This interconnection is implemented by using gateways and contractual agreements between VoIP providers and PSTN operators. Fair and non-discriminatory conditions for interconnection is a precondition for successful development of VoIP.

2.4.7 Interoperability & Standardization

Different standards are used to establish VoIP services; SIP, H323, …. It is important to establish interoperability between these standards. The interoperability may be implemented at the technology or market levels. Also new numbering schemes like global Dialing System and ENUM may require standardization and interoperability. If the market players cannot find solutions for interoperability, regulatory measures may be necessary.

2.4.8 Security and consumer protection

In regular telephony services the security and consumer protection standards have been defined and are generally found adequate. With regard to VoIP services there is no one-to-one relation between the service and the physical infrastructure. VoIP is just another IP service conveyed in the IP networks and anyone with access to the network can tap the signal and actively damage the integrity of the message and the signal. To assure privacy the VoIP provider can implement end-to-end encryption, which is not 100% secure but can establish security levels comparable to those of regular telephony. The encryption will on the other hand prevent the authorities from lawfully tapping the VoIP signal. Different models for a solution to this can be found. But the most future safe solution will connect this type of security issue to IP connections generally, and VoIP will then be a treated as a sub-set of the general solution.

2.4.9 Managed versus best effort VoIP provisions

This is connected to the QoS discussion. The important thing is the transparency with regard to the quality of services provided. A best effort service provider has no means to guaranty QoS at the network level. It can offer easy nomadic use or favorable pricing and by that differentiate its services and attract consumers. However, it is important for the consumers to have knowledge about the different QoS provided.

2.4.10 VoIP Peering

Today, the most widely deployed business model is that of a VoIP service provider that offers free telephony services to its own subscribers and charges the customers for interconnection to the PSTN. A connection between subscribers of two different VoIP operators generally goes through PSTN. However several peering initiatives between VoIP operators have been introduced, effectively bypassing the PSTN operator. The

same issue is relevant for professional users, where VoIP service is established within the cooperative network and any connection to sub contractors etc. goes through PSTN. In addition, peering agreements between cooperate networks can be an efficient and cost saving solution.

3. IP Convergence: Market and Services Developments

The process of convergence of communication functions and services using IP has been underway since even before the Internet was recognized as a public "network of networks". During 2004, major implications of IP convergence for services and markets were marked in several areas. The rapid growth of VoIP was just one that must be seen in context with several others. The rollout of "triple play" service offerings (telephony, TV and web & e-mail access) by major operators in some countries as new broadband service packages was an equally significant step demonstrating that services are getting closer to taking advantage of the technological potential of IP. The rapid growth in search engine operations, business applications and online shopping in some countries demonstrate the increasing adoption of converged services to improve the efficiency and productivity of user activity.

With the unbundling of services from infrastructure facilities, the control and innovation in applications continues to shift from the telecom operator at the center of the network into servers and terminals at the network ends. These developments are providing the stimulus to demand for services that justifies investment in increased rollout of broadband capability. Although one might question the relevance to developing countries of this evolution in lucrative markets in developed countries*, it is already apparent that converged services packages may offer many people in developing countries a better value proposition and lower priced access to basic voice communication service than the traditional model of fixed network extensions for traditional telephone service*. Moreover, it provides new opportunities for extending network access in many rural areas in an economically sustainable manner. But this does require new approaches for infrastructure expansion and new business models for service provision.

Although mobile market growth is slowing in developed countries as markets begin to saturate, in most developing countries market saturation has a long way to go and growth rates are high. In 2004 China had the most mobile users in the world (almost 20%), and India had the highest subscriber growth rate (almost 80%). Services convergence on mobile networks is a few steps behind fixed network convergence, slowed significantly by the infamous 3G auctions in Europe, but is moving in the same direction, now led by South Korea and Japan. The process of unbundling services from mobile network infrastructure facilities has begun with Scandinavia leading the way facilitating MVNOs leasing network capacity from mobile license holders and actively looking for new forms of content. Applications of WiFi and Wi Max are not only reducing network access costs, particularly in rural areas, but also providing a bridge for converging fixed and mobile networks and services. Although prepaid mobile has been an enormous success in permitting an extension of basic voice service to the poor in rural areas in many

countries, an economically sustainable transition path to converged services is not yet seen.

3.1 Rapid erosion of market and service distinctions

As the developments outlined above suggest, the implications of IP convergence for services and markets are just beginning to unfold. Recent VoIP developments provide one illustration. The range of services and the diversity of traffic being carried using IP are constantly increasing. What were once distinct networks carrying distinct services, each with its own protocol, are now uniformly carried over IP networks. While there are still distinct networks, often required by license conditions and regulations imposed before IP became significant in telecom network development, the applications and services are increasingly available on multiple networks. The selection of that network usually depends on where customers are when they access an application or service, the nature of their use and decisions they have made about service providers.

There is by now a well-established pattern of innovation associated with applications and services on IP networks, characterised by new features, new functionality and new sources of revenue. Where truly mass markets exist, or can be developed, unit costs are being driven down, rapidly expanding markets as devices and services become more affordable. The distinctions between applications and services are becoming increasingly unclear in the market, calling into question the relevance of older distinctions in licenses and regulations between services and applications and among traditional classifications of service. For example, public voice communication provided by incumbent telecom operators using IP is a service, but when provided by an ISP as part of an Internet access service, it is just one of several applications. Some applications/services are merely downloaded; some are peer-to-peer arrangements; others require access to a central service. Fewer now require access to a dedicated network. Examples include instant messaging and VoIP software, such as Skype using peer-to-peer connections.[6] There is a tendency for many users to migrate to the networks with the lowest unit costs, the most users and the richest functionality.

Convergence can be delivered in a device, where a service is accessed using several modes and interfaces, running on a range of wired and wireless networks. Some consumer electronic devices already have an IP capability. For example, games consoles with Wi-Fi and Ethernet interfaces allow participation in games with other players and sound cards. These provide the components for voice conversations with friends and fellow players unrelated to any gaming. An increasing range off Personal Digital Assistants (PDAs) and music devices can also access services over IP using a radio interface or fixed docking station.

The traditional technical distinctions between networks and services also are being rapidly eroded in many markets where substitutability increasingly occurs between fixed, cellular and limited mobility. While it is clear that in many well populated areas the core network will be optical fibre cables, the rest of the network will be a mixture of fibre,

[6] http://www.skype.com/

copper and radio (both terrestrial and satellite), depending on the population density, the topography, the richness of the services and the business models for marketing them. However, the clear trend is toward everything being carried over IP (EoIP). In Japan and Korea the framework for this planned development is the "ubiquitous network society", in which users will have access to a range of services over wired and wireless, fixed and mobile networks.[7]

3.2 Changing service characteristics in dynamic markets

The standard public telephone service has been changing and will continue to change, with voice telephony being provided at different levels of quality - both reduced and increased - from the quality of service standards for the PSTN. For many users cellular mobile service already has done that, as its quality of service differs significantly from that of the PSTN. In some cases cheaper or "free" VoIP services may be a lower voice quality of service than the PSTN, often comparable with GSM and CDMA. The service may only be available if the individual is logged on to a server. However, there is also increased functionality, notably access to the service from distant locations and information about the profile and availability of other users of the system, such as "buddy lists". Users increasingly are able to make choices and trade-offs among price, different dimensions of quality and functionality.

In the current dynamic technological and market environment, there is no firm or stable definition of VoIP or IP telephony. The ITU has consciously avoided the issue. There is no definition that is sufficiently precise to be adopted in legislation. Indeed, it is hard for operators to provide a sufficiently precise description to meet the requirements of accurate advertising. Moreover it is not helpful to develop a definition, given the increasing diversity of offers and continuing innovation and packaging of services.

Telephone numbers can now be detached from the physical apparatus of the local loop, as it is possible to obtain "secondary numbers". Someone from Milano but living in Brussels can obtain a number in their home city so that family and friends living in Italy can call very cheaply. Others may want a number in Milano for reasons of business, prestige or fashion. Subscribers to such services have to provide their own access to the Internet or PSTN, then log onto the server in order to make or to receive calls. Such access can be achieved in many locations around the world, sometimes in violation of local regulations.

Global conferencing systems now allow individuals to dial into local nodes and the conference is held on an IP platform. Large volumes of calls are carried by IP telephony to remote locations for customer response call centres and business process outsourcing, increasingly to developing countries in locations where the infrastructure, services capabilities and regulations permit it.

[7] ITU Ubiquitous Network Societies Workshop, Geneva, April 2005. http://www.itu.int/osg/spu/ni/ubiquitous/

3.3 Changing market characteristics

National markets for international voice telephony have shown steep price reductions in recent years. The introduction and increase in competition has encouraged the adoption of newer and cheaper technologies, leading to more diverse offers and significantly lower prices. Consequently, international telephony has become considerably more affordable for consumers. At the same time it has caused the revenues of operators for long-distance and international telephony to decline, sometimes quite steeply.[8]

Unfortunately, many developing countries have failed to follow the examples of the leading reform countries in making international telephony more affordable and their operators more efficient. Having failed to liberalize their markets sufficiently to foster sustainable competition, the sharp price reductions seen elsewhere have not been delivered. [9]

Declining revenues may affect the viability of both established operators and of universal service funds. It may also cause financial markets to take an interest and to reduce share prices, which may delay privatisation; or it may reduce the future supply of capital for incumbent operators, unless new revenue streams are generated. This will require new competencies in management and, in some cases, new managers who are oriented more to the new services and business models than preserving the old ones.

For large corporations, the solutions to their communication needs are found most frequently in the adoption of Virtual Private Networks (VPNs) with a rapid global adoption of IP-VPNs. In order to insure against disruption these are typically split amongst a small number of global and regional suppliers, able to operate on at least a continental scale. A problem for many developing countries is the limited presence of the larger market players, their difficult relationships with incumbent national operators and the almost total absence of meaningful Service Level Agreements (SLAs). For Small and Medium Sized Enterprises (SMEs), the common pattern is one of adopting managed services, often outsourced to specialists. The availability of "secondary" numbers is creating opportunities for a presence in cities far from the physical location of business.

A number of developing countries have benefited from the new flexibility in markets as call centre and business process operations can readily be outsourced by developed country firms to developing country firms in many industries. But the scope and limitations of such activities are limited by the network coverage, capabilities and flexibility in the developing countries. Local WiFi networks are expanding rapidly in most developed and some developing countries, providing lower cost local access to multiple services over a broadband connection.

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[8] OECD on the Trends in international calling prices in OECD countries. OECD, Paris. http://www.oecd.org/dataoecd/52/9/23901905.pdf

[9] World Bank in Competition in international voice communications (Report 27671) http://wbln0018.worldbank.org/ict/resources.nsf/a693f575e01ba5f385256b500062af05/369a6c0624b1cbf985256e47005a20c4/$FILE/InternalDocumentNo1027671.pdf

For the individual user it has been a mixture of wired and wireless services, with wireless growing very quickly. In developed countries, the services are increasingly bundled, e.g., broadband Internet access with voice telephony, perhaps also with dozens or hundreds of television channels. However, there are enormous variations in the adoption within the developed countries that are still inadequately explained as the market is in an experimental period in the provision of bundled services packages. There are also secondary services, with numbers in remote locations, where individuals become their own long-distance operator. This has significant implications for developing countries in terms of the large diaspora or ex-patriate populations. Experience with mobile termination and international roaming markets has shown that mobile termination rates are a monopoly market almost everywhere, creating very serious problems for efficient market development and effective regulation.

In developed countries there is only very limited latent demand for voice telephony as the market is near saturation both geographical (universal access) and availability of a complete range of voice services. Even in the case of steep reductions in prices, the volume of calls is unlikely to compensate for lost revenues, and cannot do so with flat rate pricing models. Thus most operators will be facing a decline of voice revenues. However, elasticity of demand is potentially quite high in most developing countries, even with flat-rate pricing. Opportunities for profitable market development in developing countries, even among the poor as the prepaid mobile experience has demonstrated, may be much greater than one might expect, and in some respects greater than those in many developed countries.

3.4 Implications for regulation

The rapid rate of change in ICT technologies, markets and services being stimulated by IP convergence is creating two sets of problems for policymakers and regulators. Many established policies and regulations have become obsolete and now provide inefficient and increasingly untenable restrictions and barriers to the development and dissemination of the benefits of IP convergence. VoIP is one important area where this has become evident. Policymakers and regulators must fashion a transition path out from under the regulations that may well have served a useful purpose in the past, but which are barriers to future progress.

The second equally challenging task is to develop an appropriate policy and regulatory framework that will facilitate the realization of the full benefits of IP convergence in network and services development and the achievement of public interest goals. In many countries it will be necessary for policy changes to provide regulators with the powers, flexibility and tools to implement a transition path to a new framework of regulation that facilitates new network and services development based on IP convergence opportunities. Countries that are facilitating this transition are already seeing significant growth. Countries that are providing or permitting barriers to the pursuit of IP convergence opportunities – unfortunately far too many developing countries - are placing themselves

at an increasing disadvantage in both absolute and relative terms, not only with respect to ICT sector development, but also the productivity and growth of their economies.

The primary challenges in facilitating IP convergence relate to establishing a market environment that is open to new networks, new services and new applications. This involves encouraging rather than resisting the erosion of barriers and artificial distinctions among technologies, services and markets. It is necessary to prevent monopoly practices that restrict opportunities and to ensure that the regulatory process does not become a barrier to participation by new players who will help drive market development. To do this in a dynamic market capable of continuing innovation, regulators will need powers that give them flexibility to match regulatory standards and tools to a changing market environment, including the option to forbear from regulation where market circumstances justify.

Where countries have competition laws, they should be fully applied to the ICT sector, including the telecom industry. However, many developing and emerging economies do not have well established national competition authorities. Even in developed countries, the application of competition law to areas of high technology is neither simple nor expeditious.[10] This suggests that increased powers for telecom regulators may be a more effective solution.

Traditional regulatory issues that will remain high priorities in the convergence transition environment include:

- provision of numbering resources (in existing or new ranges)
- portability of numbers, names and addresses
- provision of reasonable wholesale service offers, and reference interconnection offers by infrastructure operators with monopoly power over access to customer groups
- price regulation over monopoly services, including network access for some users and mobile termination
- universal access and the conditions for maximizing network infrastructure and services development.

For the police and the security agencies, there is the important matter of what must replace traditional wire-tapping in an IP converged environment. This is an issue that cannot be effectively resolved by attempts to block the spread of IP convergence as it has already been diffused sufficiently throughout the global telecom/based Internet. This will require a rigorous examination of options and implications that may well lead to the establishment of agreed special standards and protocols for which national telecom regulators may be the principle implementing agencies. However, the issue must first be examined at the policy level where the appropriate policy directions to regulations will be determined.

[10] http://www.jhtl.org/publications.html

4. Toward a Convergence Regulatory Paradigm for Crafting Transition Strategies

In many respects the Indian experience with telecom reform and the issues raised with respect to VoIP parallel that of most other countries. The main developments can be presented as generic regulatory/policy issues, recognizing that each country will need to adapt its responses to IP convergence, of which VoIP is an important part, to the particular circumstances of that country. Each country will need to craft a transition strategy for implementing necessary changes, and the telecom regulator will be the principal vehicle for driving the implementation programme.

As a new technology that provides a major threat to traditional telecom network design and operation, service offerings, business models, policies and regulations, IP convergence places the established institutional structure of the sector under major strain. Although the need to adapt is recognized by all parties, there will be active resistance against losing privileged and beneficial positions in the market, not only by incumbent telecom operators, but also by others with favourable license privileges or protections. Attempts to influence the policy and regulatory transition program through political influence, monopoly power and/ or judicial delay can be expected, and steps must be taken to ameliorate these negative effects.

This will be especially difficult in developing countries that generally do not yet have a mature and accepted structure of telecom regulation that is, 1) independent from special interest political intervention and the incumbent's monopoly power; and 2) supported by a judicial review process that respects the regulator's professional judgement on substantive issues. In many countries there will be an overwhelming temptation to determine the path of adaptation on important regulatory issues by expedient short-term political, economic or bureaucratic interests, rather than informed independent analysis of the national public interest. To the extent this happens, it will slow the process of adjustment at significant cost to economic and social development, and make the transition process more difficult and costly, restricting growth both in the sector and the wider economy.

A major task for progressive regulators will be to take a lead role in educating policymakers, communication ministries, departments, judges and politicians about the transition issues, especially the enormous benefits and opportunities provided by IP convergence as a catalyst for expanded network infrastructure and services development on a large scale. The recent *info*Dev/TRAI workshop is an illustration of the kind of ongoing participatory educational effort needed in all countries over the next few years.

IP convergence doesn't change the basic purposes and objectives of regulation. However, as has been demonstrated above, it does change the structure of telecom services and markets quite fundamentally, and therefore the most appropriate standards and tools needed for effective regulation. It also changes the information required by regulators and other participants in the regulatory process in order to analyze the issues and reach informed defensible decisions.

In all countries special attention needs to be paid to the following generic issues of transition to an IP convergence environment. Reflecting on the recent workshop with TRAI on VoIP, and India's early steps in its process of adjustment to an IP convergence environment, we comment on India's accomplishments and problem areas, with a view that this may be helpful to India in establishing its areas for priority attention in the next stage of its transition to a new convergence regulatory paradigm.

4.1 A Policy Framework for Convergence Markets and Regulation

Telecom regulators carry the primary task of implementing policy changes to adapt to a changing industry and market environment. But the scope and limitations of what they can do are determined by government policies, most often established before IP convergence was even recognised as an issue for policy or regulatory attention. Although there is much that national regulators can do within their existing policy guidelines and legislative remits, relatively few have sufficient powers to develop and implement a full program of necessary reforms. This is especially true in most developing countries.

Recognition of the benefits and opportunities of IP convergence at the policy level, and a commitment to implement necessary changes, is important in setting the policy framework for convergence. This helps ensure that issues are defined and examined holistically and comprehensively rather than as ad hoc isolated problems. For example, if VoIP is viewed simply as a diversion of voice service revenues from the incumbent operator and a decline in quality of public voice services, as some countries have done, it will only be seen as a problem with negative effects. The benefits and opportunities of VoIP within a context of IP convergence of all services providing the information infrastructure for e-commerce and future economic development, will be missed.

India has spelled out a very clear policy framework for IP convergence in its Tenth National Economic Plan, 2002- 07. The Telecommunications section begins,

> *Telecommunications is one of the prime support services needed for rapid growth and modernisation of various sectors of the economy. It has become especially important in recent years because of enormous growth of Information Technology (IT) and its significant impact on the rest of the economy. India is perceived to have a special comparative advantage in IT and in IT-enabled services. However, sustaining this advantage depends critically on high quality telecommunication infrastructure.*[11]

The Plan describes very well the implications of convergence for the sector, noting that, *Convergence of services is leading to a paradigm shift in the service composition, the structure of the industry and the way markets are organised.* (para. 43). It calls for the

[11] Government of India, Tenth National Economic Plan, 2002/07 (2001) Chapter 8.5 Communications, para. 28, 1027.

review of restrictive policies and makes specific reference to Internet telephony and WLL mobile services, and recommends a series of progressive reforms. Where these reforms have been implemented effectively, India has experienced dramatic growth and sector development. Unfortunately only limited success has been realised so far with respect to the design and implementation of necessary changes to facilitate IP convergence and VoIP development.

Perhaps a contributing factor to India's difficulties in implementing the Plan's recommendations is because telecommunication is still examined in the National Economic Plan, together with postal services, as part of the traditional definition of communications. Information technologies and services (IT) are examined as a separate chapter that is not integrated with, or linked directly to telecommunication. ICT convergence is not fully recognized in the structure of the economic plan. For example, the "digital divide" is discussed in the IT chapter, essentially as a problem of access to computers, information and knowledge, but not the telecommunication section of the Communications chapter. Yet the digital divide in India is determined primarily by a large and increasing gap between urban and rural access to telecom services necessary to deliver needed information and knowledge.

There is insufficient recognition in the Plan that the anomaly of India's world leading position in IT software and applications, and its success in attracting global call centre and BPO services, stands in stark contradiction to its mediocre world ranking in telecom network and services development. Moreover India's future economic growth in these industry sectors, as well as others, depends heavily on continuing major improvements in its telecom infrastructure and the provision of a full range of converged ICT services. For India the digital divide is primarily a telecom infrastructure and services divide, not an IT divide. The telecom divide must be overcome before the information and knowledge divides can be seriously challenged.

An important step forward in recognising and examining the implications of convergence for economic development would be for India to consider telecom and IT together as two components of an integrated ICT sector in all its economic analysis and planning. This would both strengthen the economic analysis of the telecom industry and the converged ICT sector, and increase the chances for effective development and implementation of appropriate telecom policies and regulations.

4.2 A Credible Policy/Regulatory Institutional Structure

After more than a decade of extreme difficulty in attempting to implement its first stage telecom reforms, with only marginal success, in recent years India has realised dramatic progress in several areas. Most notable has been the explosion of growth in the mobile sector where a deliberate growth strategy has paid off handsomely. The introduction of the calling party pays principle, and a combination of TRAI tariff orders (including both general tariff forbearance when effective competition was present and regulated termination prices where it wasn't) and increased competition has reduced prices to among the lowest in the world and increased penetration rapidly.

Investment in fixed network expansion has increased in recent years, but the rate of growth needs to be accelerated if India is to catch up with comparable developing countries that are growing faster. Rural development of both fixed and mobile has been disappointing as the gap between urban and rural penetration continues to increase. IP convergence on integrated fixed-mobile networks, including VoIP, will be an essential component of rural development, not only for ICT services but also for rural economic development.

A major factor in the long delay in implementing India's first stage telecom reforms, and still a serious cause of delay and uncertainty, is the lack of a credible telecom policy/regulatory structure. As with many countries, during the early phases of telecom reform, when the former government monopoly was split among operators, ministries and regulators, there was a strong bias in policy and regulation favouring the former privileges and vested interests of the incumbent operators. Governments have found themselves in a severe conflict of interest when they have attempted to be industry player, rule-maker and referee. This has been a major barrier to sector development in India that has taken more than a decade to overcome before the mobile sector was unleashed by special interventions, effective competition and facilitating regulation. Nevertheless, the available evidence and widespread perception is that India still finds itself with conflicts of interest, particularly with respect to fixed network development, and lacks a fully credible policy/regulatory structure.

The next stage of India's telecom reform for IP convergence can be implemented much more rapidly and effectively, with major benefits to the ICT sector and both urban and rural economic growth, if certain steps following international best practice are taken to create a fully credible policy/regulatory structure. These include,

1) the sale of government ownership of its state owned enterprises in the telecom sector (BSNL and MTNL)**.** Where countries have felt that government leverage was necessary to protect the national interest, a golden share with rights to intervene in the event that the national interest would be affected has been used. It might also be noted that since VSNL was divested from government, it has grown rapidly to become a leading player in the international market;
2) strengthening the independence of the regulator, including security of appointment, cause for removal, and clarity of powers to interpret and implement policy directives;
3) regulatory decisions should not require the prior approval of the DOT before implementation. Accountability should be with the court, and through new policy directives from government when needed.

Given India's experience with telecom reform, it seems safe to conclude that without attention to the credibility of its policy/regulatory institutional structure, the process of implementing IP convergence reforms will be a lengthy, difficult and costly one.

4.3 Regulatory Resources, Competence and Processes

As the key player responsible for implementing IP convergence policies, the telecom regulatory agency (TRAI in India) must develop a strategy for implementation that is guided by the principles of best practice regulation, but attendant to the specific

circumstances (both constraints and opportunities) in the country. This requires that the regulator be proactive in establishing and implementing regulations that will facilitate convergence in a timely and effective manner. A credible policy/regulatory institutional structure, as described in 4.2 above, is important in providing the enabling powers and a positive environment for the regulator to perform this important task.

But more is required. Regulators must have sufficient resources to attract highly competent people with expertise on the frontier issues of the technologies, industries, markets and regulations both in the country and internationally. They must be able to establish regulatory processes that function effectively, providing transparency and publishing sufficient information to allow public participation, while ensuring the expeditious treatment of the specific regulatory issues under examination. This is necessary for the regulator to demonstrate its competence and credibility to all sector players and participants (including the judiciary), thereby building confidence in the regulatory process through a continuing demonstration that its regulatory decisions are based on independent, objective, accountable analyses of evidence.

Regulatory processes in India and most other countries will be placed under significant strain during the next stage of telecom reform implementing convergence policies and regulations. The incentive for the most powerful vested interests to try to "game" the regulatory process to delay progress, as occurred during the initial stage of reform in India and other countries, will be very great. Although TRAI has acquired significant expertise in the field and established a degree of transparency that is superior to that in most countries, further strengthening and improvement will be necessary to address the regulatory challenges being presented by IP convergence. A review of the resource requirements, levels of expertise needed, and regulatory processes would be a useful first step in building increased confidence in the competence and credibility of TRAI to meet the challenges ahead.

4.4 Substantive Regulatory Issues Raised by IP Convergence

IP convergence raises a number of important issues relating to the substantive standards and rules established by policy and regulation to direct and guide the telecom industry and ICT sector's development. IP convergence not only brings a significant change in the technological foundations of the sector, but it also provides for major changes in markets and the economics of the sector. Thus many of the substantive standards of policy and regulation during the first stage of telecom reform are rendered obsolete and provide major barriers to the achievement of the benefits of convergence.

Many of the substantive regulatory standards requiring re-examination and modification are within the current jurisdiction of regulators. Some will require policy changes. But all these issues are being thrust before regulators, and where policy changes are needed, the analyses of the regulators will be an important input to their development.

4.4.1 Market conception and definition

As IP convergence provides for the integrated supply of all kinds of communication services using a common protocol (Level 2 in Figure 1), at the same time it removes the boundaries and limitations traditionally associated with particular technologies and services. Increasingly, converged services can be provided over almost any telecom technology. Thus traditional forms of licensing specific technologies and/or services are rendered obsolete. They become artificial restrictions on market development. In the first phase of telecom reform there was a focus on liberalisation by licensing specific new operators to provide specific services (e.g., voice, data, value added, broadcast, mobile, international, etc.), or specific technologies (e.g., fixed network, 2G mobile, VSAT, WLL, etc.). These were based on reasonably clear distinctions among the capabilities of the technologies and the services they could provide. With IP convergence the reasons for those distinctions have disappeared, and their attempted enforcement becomes increasingly difficult and arbitrary. VoIP is now demonstrating this. It can be provided over any technology, and in combination with any other services.

This means that regulators must shift their focus from managing the defined (and restricted) roles of the individual licensed players in the market to managing the market environment. This implies a change from regulating incumbent monopolies in vertically integrated markets across infrastructure and services, to regulating imperfectly competitive markets that are horizontally structured, as exhibited by the four levels in Figure 1.

More attention now needs to be paid to access and entry conditions at each level to eliminate artificial barriers and ensure entry barriers are minimised. Direct regulatory tools such as price regulation then need to be applied only to the specific areas where monopoly power exists, e.g., monopoly control over access.

The focus of regulation needs to shift to applying standards that enhance competition and opportunities to participate in the market at any level, as components of a sector competition policy. This will require ongoing analysis of the market conditions at each level, the viability of wholesale and retail markets, and the different conditions in call origination and termination markets. In most developing countries, the structure and functioning of regulation has introduced a new element of investment risks (regulatory risk) because of the uncertainties surrounding the policy/regulatory process of entry and market participation.[12] Regulators will need to be proactive in changing the market environment to one where existing market players and new investors see the regulated telecom market environment as inviting and supporting participation and investment, with success determined by the marketplace rather than privileged market positions awarded policymakers, regulators or courts.

Although there is evidence that the convergence transition process already has begun in India, it will not be easy to implement. India has been relatively slow to recognise

[12] Mahan, A. and Melody, W. (eds) (2005) *Stimulating Investment in Network Development: Roles for Regulators.* Case studies and research from WDR Research Cycle 2.)

the value of expanded participation and competition in the sector, and some of its early attempts to manage its sector liberalisation programme were much less effective than anticipated. Resistance to further liberalisation can be expected to be very strong as long as the government remains the owner of the major players and TRAI decisions must be vetted by the Department of Communication. Thus the rate of progress will depend heavily on the strategic ability of TRAI, in a very different environment, to plan, develop and implement the necessary steps to foster increased participation and investment in network and services development.

4.4.2 Licensing

The licensing of telecom operators and service providers has been the instrument of telecom market liberalization during the first phase of reforms. The licenses defined the scope and limitations for using technologies and providing services, and typically required payments to governments for the privileges associated with the license. Although the licensing process has been a mechanism for liberalising markets to a degree, it has also been one for controlling and restricting entry, and in many cases raising large amounts of money for governments through license fees. It has provided an absolute barrier to entry for unsuccessful license bidders and other potential market participants. IP convergence has been eroding the justification for these license restrictions, both the service limitations in existing licenses and entry barriers preventing new players from entering the market.

VoIP convergence in particular has rendered most, if not all, the restrictions and privileges of narrow technology-based and services-based licenses obsolete. It requires that the purposes and practices of licensing be reassessed in the new market environment. In many countries a process of conversion from specialized to unified licenses will be necessary to remove the inherited license restrictions against achieving VoIP benefits, and to avoid intractable regulatory issues. Where licensing is still needed, class licenses may be more appropriate than specialised licenses for most purposes. In many cases simple registration by service providers may be sufficient.

India already has taken progressive steps in the direction of unified licensing, now being implemented by TRAI. However, the process is not yet complete. It is focusing primarily on rationalising the license conditions for the operators that are already licensed. It needs to complete this process, and to address the conditions for market participation by potential new players, and to minimizing the barriers to participation in network infrastructure and services provision by all players, existing and new.

4.4.3 Public resources

The effective management of public resources is essential to achieving the full benefits of IP convergence. This requires that existing regulations relating to rights of way, spectrum, numbers and domain names must be reassessed for more efficient use in a market environment with many more participants and increased levels of competition. The effectiveness of the management of public resources can make a

major difference in determining both the geographical and services coverage of IP convergence services as a foundation for economic development.

The difficulties associated with obtaining essential rights of way for the development of landline networks have been a major barrier to fixed network development in many countries. The spectrum allocation and assignment processes in some countries have been designed and implemented more to capture money for the government from restricted licensing than promote network development. Processes for planning, allocating and assigning telephone numbers, and more recently domain names, have been characterised by struggles between powerful interests that prefer to use them as mechanisms for restricting competition and user flexibility (e.g., number portability) rather than facilitating access by users and new competitors.

The primary lesson from this experience is that governments should make a more comprehensive examination of their policies and regulations with respect to public resources, and regulators should be more proactive in promoting the efficient use of public resources to achieve maximum network development. The powers of telecom regulators to manage these public resources vary widely across countries. But as the telecom sector's development is critically affected by the government's management of these public resources, telecom regulators can play an important role in assessing their efficiency and contributing to reforms.

India has begun to examine its policies and practices for managing some of these public resources, most notable TRAI's review of important spectrum issues. But if there is to be an effective response to the challenge of using its public resources effectively in the new IP convergence environment, the Indian government will need to undertake a comprehensive assessment, with TRAI making major contributions.

4.4.4 Public service requirements

The major changes in information and communication technologies and services that have taken place over the past quarter century and are continuing at a rapid pace have changed the nature of public communication dramatically. These changes are requiring that traditional ways of providing various communication public services are breaking down. These include emergency communications for citizens (e.g., emergency telephone numbers), security for law enforcement agencies (e.g., legal wire tapping), and personal privacy protection. Now that mobile services are prompting people to give up fixed network services, and IP is being used increasingly to provide various forms of voice service, it is apparent that a "new business model" is needed to ensure that publicly acceptable standards on these matters are developed and implemented in the new convergence environment.

Some regulatory and other public authorities have reacted as if VoIP is the single cause of the problems developing for public services. This is a fundamental mistake. VoIP is simply the latest development in the continuing series of technology and market changes that collectively require a reassessment of how emergency and

security services can best be provided in the new environment, and what standards of privacy are possible and most appropriate.

This is a major policy issue in most countries that generally goes beyond the remit of telecom regulation, although telecom regulators should play a leading role in the analysis of the problems and the development and implantation of the new policies. VoIP has highlighted attention to this issue. Blocking VoIP, or imposing onerous requirements on VoIP provided by new operators will not solve the problems. That requires a comprehensive understanding of the implications of all forms of convergence (IP, fixed-mobile, etc.) and the development of appropriate policies and regulations. The sooner this is done in all countries, the better.

In India these issues have been a matter for discussion, but a move toward the development of a comprehensive set of policies and regulations for the new environment has not yet achieved momentum.

4.4.5 Network interconnection and access

Efficient interconnection is crucial to the effective implementation of virtually all policy and regulation opening opportunities for new participants in the provision of telecom infrastructure and services, whether directly competitive to established operators or market expansions to new areas, services or users. The effectiveness of interconnection regulation has been a major factor in determining the overall effectiveness of reforms adopted during the first stage of telecom reform that introduced new licensed operators in the mobile, satellite and fixed services sub-markets. With the unbundling of services from infrastructure, network access requirements by value-added service suppliers raised related issues.

Because of the asymmetry of information and negotiating power between dominant and smaller operators and service suppliers, and the fact that interconnection and access costs are imposed by one competitor on another, market negotiations cannot be expected to yield an efficient result or foster effective competition. Thus regulation, often reluctantly, has been forced to intervene to ensure that interconnection and access costs are reasonable. In many countries, the regulatory requirements of public reference interconnection offers and cost-based prices for interconnection, imposed on monopoly operators, now provides a satisfactory framework for competitive market development. The traffic or usage units of measurement for the interconnection and access provided have been the traditional telephone network units of minutes (time duration), miles (distance) and circuits (capacity).

IP convergence is rendering these units obsolete for the future. Circuits are neither connected nor provided. Neither distance nor time are determining cost factors. Rather new measures relating more to increments of bandwidth, quality and other claims on network capacity are the more relevant units of measurement. Thus virtually all interconnection and access arrangements will need to be renegotiated in the new environment with many more players in markets that are still characterized by major asymmetries in negotiating power among the players. Interconnection and

access issues may be even more important in the transition to the future convergence environment than they were in the first stage telecom reform process. Public reference interconnection offers and proactive regulation on interconnection where monopoly power exists will be needed to drive the transition.

India has had an extremely difficult time with interconnection issues during the first phase of its telecom reform. TRAI is now better equipped to drive the interconnection and access reforms needed for the future convergence environment. But whether TRAI will be able to do it effectively may depend upon changes to enhance the credibility of the Indian policy/regulatory structure. Interconnection and access in a converged environment must be a high priority on TRAI's agenda.

4.4.6 Revenue settlements and price regulation

The inherited pricing structures in telecom, and the tools of price regulation, have been those established during the era of national monopolies. International revenue settlements have been structured to preserve national monopoly price determinations for both originating and terminating public telephone calls in the country. Business users in many countries have bypassed public network monopoly services and revenue settlement prices for many years using leased lines and private networks. Increasingly, individuals have been able to bypass this structure through a variety of arrangements in recent years. As a result the revenues realized by national incumbent operators have declined steadily.

VoIP may provide the final blow that will terminate international revenue settlement arrangements allowing countries to charge monopoly prices for international calls. International services and pricing structures will have to be developed from new business models, as suggested above for interconnection and access prices. The international services market is by now sufficiently competitive that in most circumstances, prices no longer need to be regulated as long as entry to the market is not restricted.

The common tools of price regulation for national services by the dominant operator(s) have been return on investment or price caps. Although relevant and appropriate to facilitating the initial stages of telecom reform, they are not likely to be the most appropriate in a convergence market environment. For the future the regulator will need to focus attention on identifying the specific monopoly nodes in a network characterized by more players and more competition. Here also, the first order of business for regulators in addressing monopoly elements is to reduce barriers to entry, and regulators will need the flexibility in a dynamic market environment to forbear from price regulation where competition is effective, and implement it where it is not. Only specific prices for monopoly nodes in the network at either wholesale or retail levels, and basic service prices for end users served by a monopoly will need to be regulated. This requires increased capabilities by the regulator in market and cost analysis, as well as the effects of new pricing structures.

TRAI has adapted its pricing regulation in the mobile sector extremely well, combining forbearance of price regulation where competition can be effective and imaginative regulation of termination prices to facilitate market development. It will be more difficult to achieve the same effective regulation and market development foe fixed network infrastructure and services, and for fixed-mobile convergence, but should be achievable if TRAI is provided with the freedom and flexibility to do so.

4.4.7 Universal service/access

Traditional policy and regulation in many developing countries still links universal access responsibilities with the incumbent fixed network provider, even though mobile service penetration exceeds fixed, and there may be additional local service providers in some areas. The most common subsidy mechanisms have involved financial transfers to the incumbent national operator for use in extending the fixed network to high cost areas. This model for extending network coverage is a product of the earlier monopoly structure.

Experience has shown that it has done a very poor job in stimulating network extensions with little demonstrable expansion, high administrative costs, an absence of incentives for efficiency, and restrictions on competition. Universal access methods that have brought much better results include reverse subsidy auctions where most if not all participants are not dominant incumbent operators, asymmetrical pricing structures for high costs areas, and support for local co-operatives and private operators.

In addition to its general lack of success in achieving universal access objectives, the traditional monopoly model is also rendered obsolete in an IP convergence environment. Funding support from monopoly services to subsidise universal access will decline quite rapidly in future years, and the most effective way to extending universal access is by following a diversity of approaches, primarily those initiated at the local level. Attempts to maintain the traditional monopoly model will only create a major inefficient drag on sector development.

With full convergence, the number of ways of providing universal access, and the number of participants who can contribute to it, increases substantially. Direct money transfers among carriers, or government grants to pre-selected designated operators, creates perverse incentives more likely to restrict network development. These will need to be replaced by the approaches based on the successful experiences of recent years and involved the full diversity of new players that are, and will be entering the market.

India continues to follow the traditional monopoly model of universal access subsidies through its universal service fund and access deficit charges paid to incumbent operators by the newer competitors. There has been no significant demonstrable effect on network development as India's fixed network coverage remains relatively low by international comparison, especially in rural areas. It provides a major barrier to the efficient transition to a competitive IP convergence

environment. It needs to be changed for more effective subsidy methods as rapidly as possible. Although TRAI plays a major role in implementing the existing subsidy program, it does not have the powers to change it. Nevertheless it can undertake the necessary research to document the need for change and the implications of more appropriate alternative subsidy methods.

5. Conclusion

It is clear from the evidence and analysis presented here that VoIP brings all the major issues of IP and ICT convergence to a head. There are no unique VoIP issues that stand dramatically apart from the generic issues raised by IP convergence, which must be examined with a view to designing and implementing an appropriate policy and regulatory model for the convergence environment. The sensitivity of the VoIP issues arises because traditional sources of public voice revenue for dominant incumbent operators are coming under threat. Resisting convergence and attempting to preserve historic privileges can, and will be done in some countries, but only temporarily and at great cost to their national ICT sector and economies. The sooner that operators, service providers, policymakers and regulators develop and implement their new "business models" for the convergence environment, the greater will be the benefits for the ICT sector and future economic growth.

National telecom regulators will play an important role in facilitating, and in some cases leading the transition process to the new converged ICT information infrastructure. This role cannot be confined only to the task of resolving the range of issues outlined above. Success will require a major effort to educate the key players who influence policy and regulation. It will require a strategy for managing the transition process, involving prioritizing the regulatory transition issues in light of the circumstances in each specific country, and developing plans and procedures for the effective implementation of the new policies and regulations.

Like most countries, Indian telecom policy and TRAI regulation has had some successes and some major difficulties during its first stage of telecom reform, with its most notable successes in recent years. If TRAI is to be fully effective in driving the Indian transition to a productive IP convergence environment, the highest priorities for attention by the Indian government, including TRAI, would seem to be,

1) to fully integrate India's economic planning, policy development and regulation around a rapidly converging ICT sector. This will demonstrate that India's telecom network deficiencies are a major bottleneck restricting growth opportunities in IT, call centre and BPO services, rural development, electronic commerce and e-service delivery in government and education. This will demonstrate the pressing need for continued rapid telecom reform to overcome the increasing digital divide in India.

2) to establish a credible policy/regulatory structure by removing the government's conflict of interest as the owner of major industry players, and the Department of Communications prior approval of TRAI decisions.

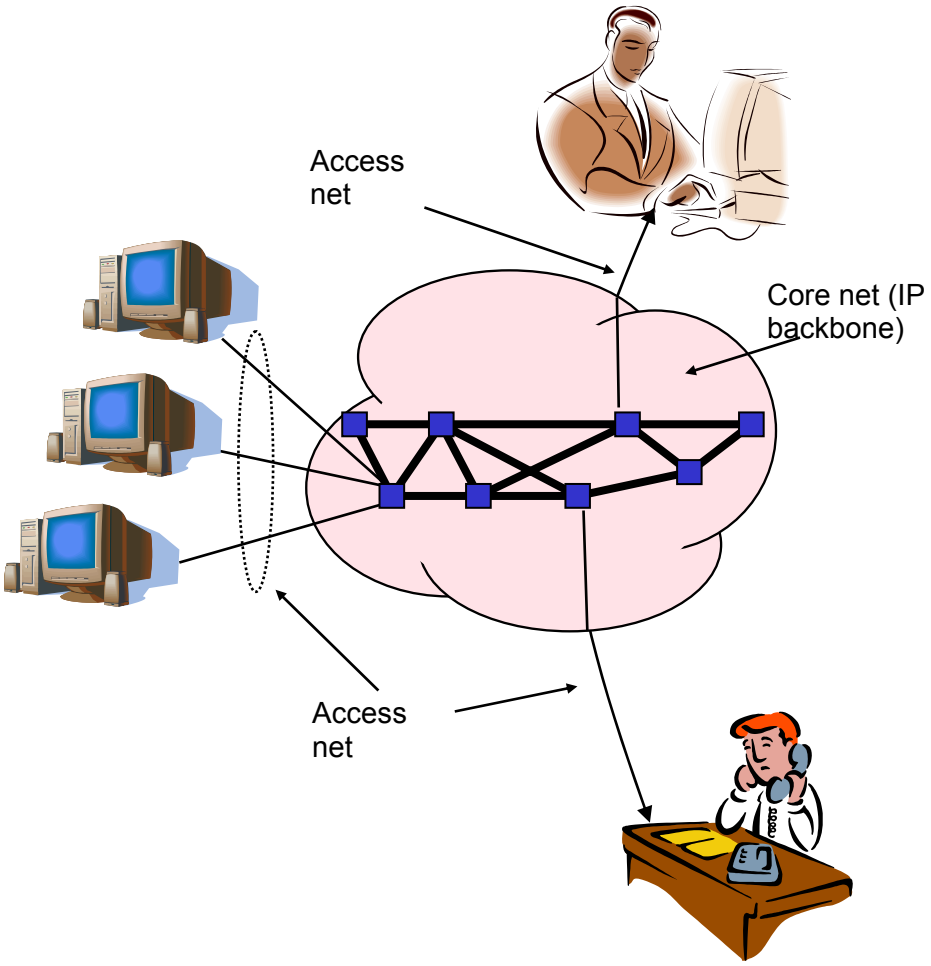
3) to recognize the new horizontal structure of telecom markets in the new IP convergence environment, and fully exploit the benefits from greater participation and competition in the industry by appropriate policy and regulatory changes.

4) to change India's current methods of universal access subsidy, which are not producing demonstrable benefits and are creating perverse incentives, to more effective methods appropriate for a convergence environment that fosters participation by a diversity of players.

VoIP and IP convergence can be seen as a threat to the established order, or an opportunity to prepare the ground for economic growth in information economies. The future lies with those who see it as an opportunity and act upon it.

Annex I. VoIP Components

In the following figure a simple VoIP architecture is depicted.



The main components necessary for a VoIp network are:

- **Terminals**
  - Soft phone
  - Hard phone
- **Packet based networks**
  - Access network
  - Core network
- **Network components**

  - Servers
  - Gateways
  - Routers
  - ….
- **Media Transport Protocols:** For transmission of packetised audio/video. Like RTP and RTCP
- **Coding protocols**: Different types of Audio (video) coding. Like G711, G722,
- **Supporting Protocols:** QoS, security, etc. Like COS, Diffserve, Intserve, …
- **Signaling protocol:** To establish presence, locate users, set up, modify and tear down sessions. Like SIP, MGCP, SCCP and H323
- **Numbering plans**: Global numbering plans are necessary to establish interoperability between different IP standards and between the new IP systems and the legacy systems. Examples: ENUM, GDS

Annex II. Scenarios

Scenario I

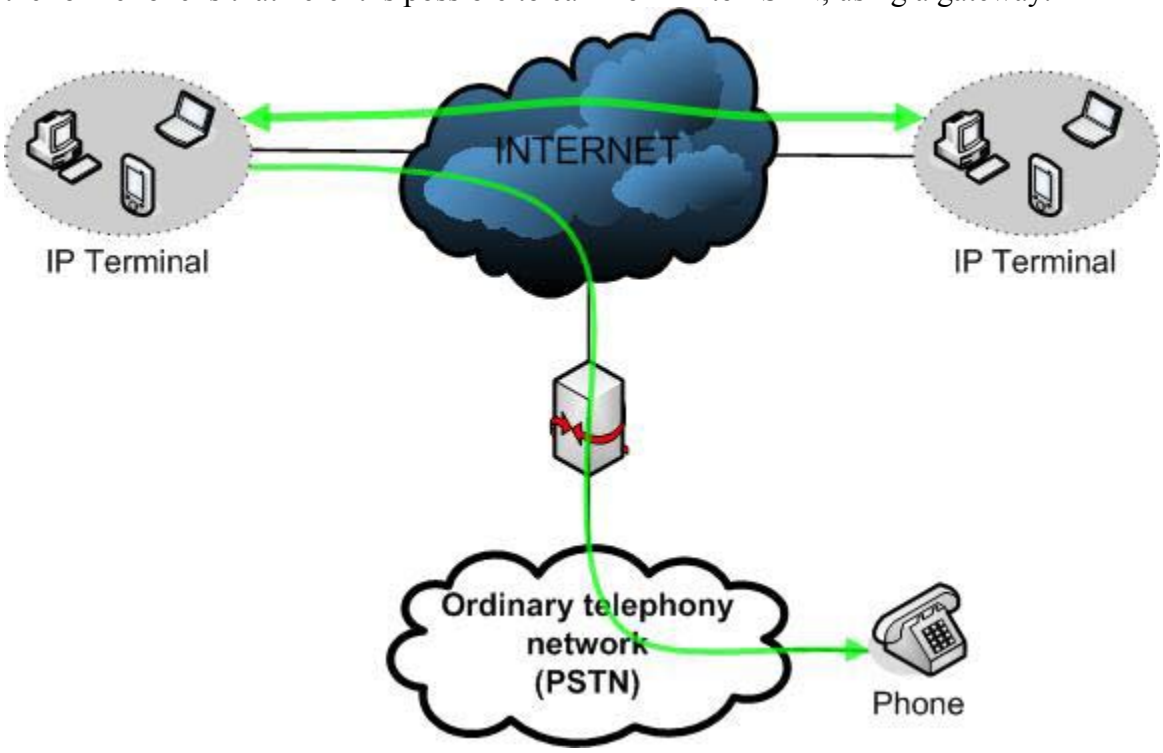
The first scenario depicted in the following figure is the VoIP between two Computers or other IP terminals. The communication takes mainly place over the Internet but also over closed IP networks. This is the oldest implementation of VoIP.

Major characteristics of this scenario:

- Relative small amount of VoIP communication. Mainly early adopters.
- Terminals are mainly computers
- Calls can only placed within IP networks, but are free of charge
- Only basic signaling systems are deployed
- Providers are Messenger, Skype, Teamspeak, ICQ etc.

Scenario II

Scenario II is depicted in the following figure. The difference between this scenario and the former one is that here it is possible to call from IP to PSTN, using a gateway.

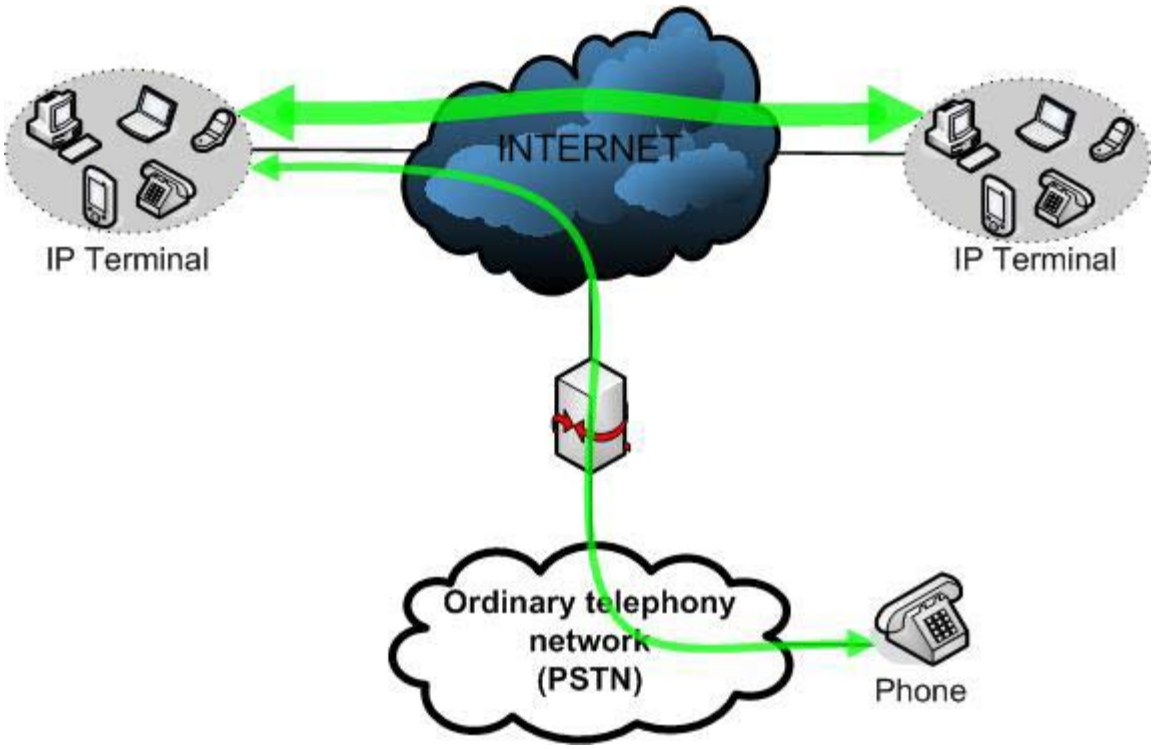


Major characteristics of this scenario:

- Amount of pure VoIP communication (scenario I) grows primarily due to reduced costs.
- IP terminals are now mainly computers and some PDA's
- Calls can be placed to a traditional PSTN telephone from an IP terminal, but not the other way around.
- Calls are free of charge within the IP networks. Calls to the PSTN network can be placed through service providers, at reduced cost.
- Providers are NettPhone, Callserve, Skype out, etc.

Scenario III

Scenario III is depicted in the following figure. The difference between this scenario and the former one is that here it is possible to also call from PSTN to IP, using a gateway.



Major characteristics of this scenario:

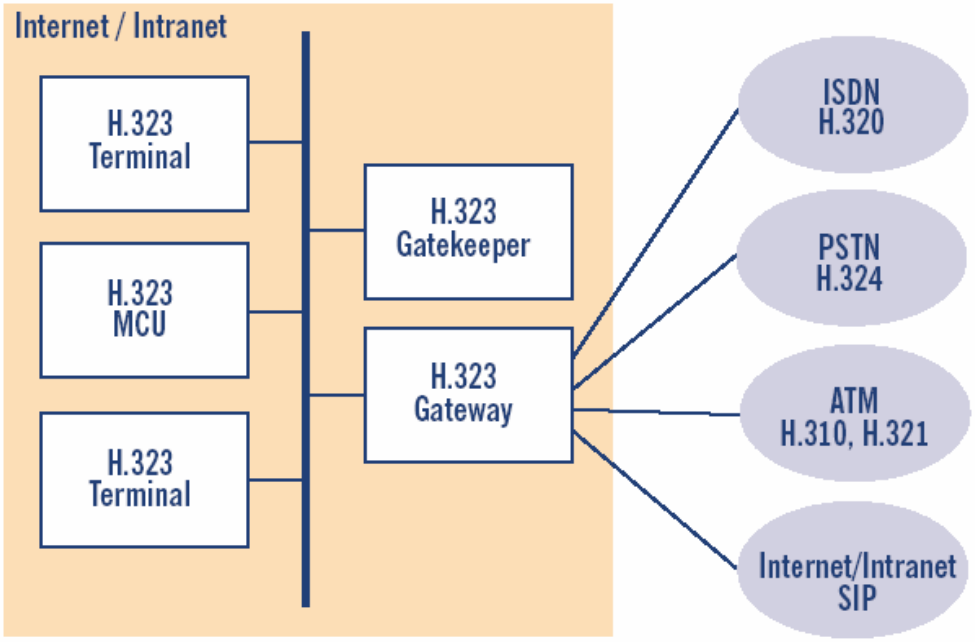
- Amount of pure VoIP communication (scenario I) grows continually.
- IP terminals are both computers, mobile phones PDA's and dedicated IP phones.
- Calls can be placed to both and from a traditional PSTN telephone.
- Traditional telephony systems are now being replaced by VoIP solutions.
- Value-add services appear.
- More advanced signaling systems is being used (e.g. H.323 and SIP).

Annex III. Signaling Standards and Addressing

H323

H323 is an ITU-T umbrella standard released in 1996, which consists of signaling and transport and coding protocols. H323 is a multimedia conferencing standard and mainly used in professional video conferencing systems, but also used for pure VoIP applications. Part of the design is to specifically tackle the interconnection with PSTN by means of a gateway.

A simple setup of H323 is depicted in the following figure[13].



As seen in the figure the main components of a H323 system are:

- H323 terminals
- PSTN gateway for connectivity to PSTN
- Gatekeeper, which is the H323 IP telephony server
- MCU (Multipint Control unit), which is a switch for establishing several node communication

SIP

SIP stands for Session Initiation Protocol. It is an application-layer control protocol that has been developed and designed within the IETF. The protocol has been designed with easy implementation, good scalability, and flexibility in mind. SIP was originally defined in RFC 2543.

Opposed to H323 which is an umbrella standard, the purpose of SIP is just to make the communication possible. The communication itself must be achieved by other means and protocols/standards.

SIP has been designed in conformance with the Internet model. It is an end-to-end - oriented signalling protocol which means that all the logic is stored in end-devices

[13] Source: 'VoIP handbook'

(except routing of SIP messages). Basic SIP elements: Are **user agents**, **proxies**, **registrars** and **redirect servers.**
The **user agents** are communication devices like soft and hard phones, **Proxy servers** relay calls and keep track of the status of the users, the **registrar** keeps track of the current location of the users and when a proxy server redirects a call it uses the **redirect server**.

Other standards

SIP and H323 are the dominant standards but also other signaling standards are available on the market. The important ones are MGCP and SCCP.

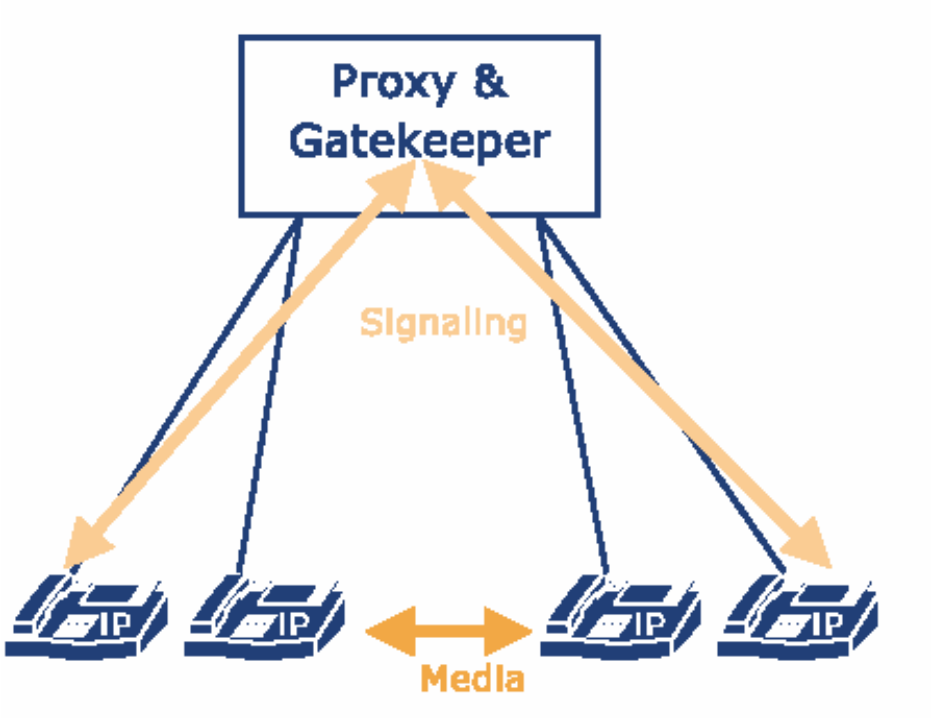
MGCP (Media gateway Control protocol) operates at the backbone of teh network and typically used by network elements like call agents which routes calls between gateways and media gateways. MGCP is documented in RFC2705.

SCCP (Skinny Client Control Protocol) is a proprietary protocol used by Cisco systems. It is a signaling protocol for Skinny clients, like Cisco hard phones and the Cisco call manager which connects the clients

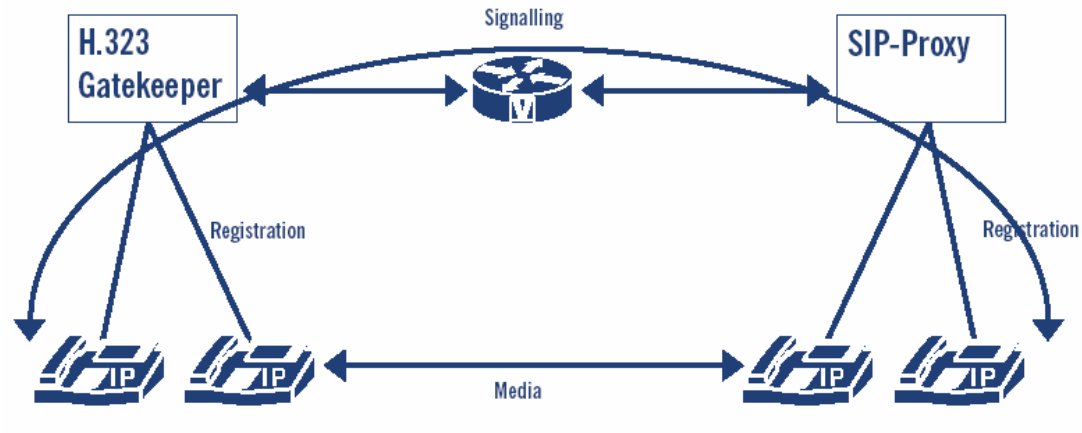
Interoperability between SIP and H323

The interoperability between SIP and H323 can be established either by using proxies and gatekeepers which can handle both standards, depicted in the following figure[14]

[14] Source: 'VoIP handbook'



Or by using standard gateways depicted in the following figure[15].



Addressing / Numbering systems

The most common addressing systems are:

- E.164: The ITU-T recommendation used in PSTN
- URI: Universal resource identifier, used in internet
- ENUM: E.164 addressing plan based NUMber

[15] Souce: 'VoIP handbook'

- GDS: Global Dialing Scheme
- DUNDi: Distributed Universal Number Discovery

ENUM

ENUM is a protocol defined by IETF that facilities resolving of E.164 telephone numbers into other resources or services on the Internet.
E.g.:+4689761234 3: 4.3.2.1.6.7.9.8.6.4.e164.arpa

GDS

GDS is a dialing scheme for enabling global number recognition for H323. the structure of GDS is:

- < IAC><CC><OP><EN>
- **The International Access Code (IAC)**
- Country Code (CC)
- Organisational Prefix (OP)
- Endpoint Number (EN)
- **E.g.: 00(IAC) 1(CC) 189(OP) 7201234(EN)**: **0011897201234**

DUNDi

Opposed to ENUM and GDS which are based on servers for resolving addresses the DUNDi is a p2p standard (one can say p2p version of ENUM). DUNDi is not a numbering standard but an implementation standard. Instead of DNS server registration a client has a record of all nodes connected to it. When a client needs to look up for a number it will contact all connected nodes to find the address, they in turn ask the nodes they are connected to for finally to find the destination.

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