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Telecom Regulatory Authority of India

सत्यमेव जयते

Consultation Paper

On

Migration to IP based Networks

30th June, 2014

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New Delhi - 110002

Stakeholders are requested to send their comments preferably in electronic form by 21st July, 2014 and counter comments by 28th July, 2014 on email id advqos@trai.gov.in. For any clarification / information, Shri A.Robert . J. Ravi, Advisor (CA & QoS) may be contacted at Tel. No. +91-11-23230404, Fax: +91-11-23213036.

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Introduction

1. Traditional telecommunications systems are nearing the end of their product lifecycles, and worldwide, operators are strategizing whether to repair/ replace these systems or head down a completely new and potentially more viable path — migration towards an Internet Protocol (IP)-based telecommunications systems. Modern digital technology allows different sectors/services viz. telecom, data, radio and television, to be merged together. This phenomenon, commonly known as convergence, is taking place on a global scale and is drastically changing the way in which both people and devices communicate. The backbones for making such convergence possible are IP-based networks. The opportunities presented by IP based networks are immense and will help the telecom service provider (TSPs) to converge their network infrastructures, provide huge bandwidth, consolidate terminating traffic and reduce long-distance charges.

2. Integrated consumer devices for providing various services such as telephony, entertainment, security or personal computing are constantly being designed and developed. These are based on communication standard that is independent from the underlying physical connection.

3. Legacy networks are based on circuit switched technology. In circuit switched networks, calls are routed through a hierarchy of several layers of exchanges. A circuit-switched network creates a dedicated between two nodes in the network to establish a connection. The established connection is thus dedicated for the period of communication between the two nodes. This uses a variety of transmission media; as a result they are technically and operationally complex. This in turn, makes the maintenance and operational costs of legacy networks expensive.

4. Service providers face a considerable risk in committing significant investment in upgrading the infrastructure for migration towards IP based networks in the current regulatory environment. The current regulatory environment is mainly based on TDM networks. On the flip

side, service providers who do not migrate to IP based networks face the risk of becoming less competitive, as their costs would be higher in comparison to an operator running a single converged network. Moreover, they would not be able to commercially exploit new emerging services. In this scenario, clear policy direction and enabling regulation could help the industry reap the benefits of migration to IP based networks as well as reduce their investment and commercial risks. Therefore, the migration to IP based network offers both a huge opportunity to service providers, as well as poses some risks.

5. Major TSPs in India have implemented IP based core transport network for carrying voice and data traffic, by deploying IP/Ethernet elements extending into access and aggregation networks. Data networks are already IP/ Multi-protocol label switching (MPLS) based, with major parts of the network being optical (Dense Wavelength Division Multiplexing (DWDM) or Ethernet instead of Synchronous Digital Hierarchy (SDH)). The present world scenario indicates that IP has become a ubiquitous means of communication, and the total volume of packet-based network traffic has surpassed traditional voice (circuit-switched) network traffic.

6. Popularity of IP based Networks is increasing as indicated by tremendous rise in global IP traffic. As per the forecast by CISCO VNI, 2013 (Table 1), global IP traffic in 2013 stood at 44 exabytes[1] per month and is likely to grow threefold by 2017, to reach 120.6 exabytes. In India the number of mobile internet users increased from 3.6m in June 2012 to 228m in February 2014. The data carried over 3G technologies has also seen a cumulative growth of 72 % between April 2013 and February 2014.

[1]Exabytes = 1 EB
= 1000^6bytes = 10^{18}bytes = 1000000000000000000B = 1000petabytes =1millionterabytes =1billiongigabytes

Table 1: Global IP Traffic, 2012-2017

IP Traffic (byType)	2012	2013	2014	2015	2016	2017	CAGR 2012-2017
Fixed Internet	31,339	39,295	47,987	57,609	68,878	81,818	21%
Managed IP	11,346	14,679	18,107	21,523	24,740	27,668	20%
Mobile data	885	1,578	2,798	4,704	7,437	11,157	66%
Total (PB per Month)	43,570	55,553	68,892	83,835	101,055	120,643	23%

Source: CISCO VNI,2013

7. In India, the volume of IP based services is increasing every year. Internally, Voice traffic is also being carried over IP. However, QoS and Interconnection between networks are still guided by TDM based regulatory framework. As IP-based networks continue to proliferate and traditional circuit switched networks are gradually being phased out, there exists need to have direct interconnection among the IP-based networks of different TSPs. This will throw up various regulatory challenges involved in migration from TDM to IP based networks - Interconnection issues, issues relating to Quality of Service and operational issues (Numbering, Emergency Access, Security Aspects, etc.) requiring timely action by the administrations. In order to identify & address various issues related to migration towards IP Networks, the Authority conducted a seminar on Next Generation Networks – Implementation and Implications from 25 to 26 August 2011 and a workshop on 29 & 30 November, 2012. With an objective to address these issues, taking into account the issues discussed during the seminar, this consultation paper has been issued by TRAI, suo-motu, to engage the industry in establishing appropriate policy and regulatory framework on IP based networks by TRAI.

8. The consultation paper is structured in five chapters. Chapter I of this Consultation paper on 'IP based Networks' mainly discusses the need & impact of IP based networks, status of IP based network in India and current regulatory environment. Chapter II, III & IV deliberate on Interconnection issues, QoS issues and operational issues respectively. Chapter V gives the summary of the issues for consultation.

Chapter 1: IP based Networks

Status of the networks in India

1.1 Currently, the status of telecom networks in India is a combination of the legacy circuit switched (TDM infrastructure) and packet switched (IP based switches) networks. However, it is clear that there is shift from the traditional Circuit Switched (CS) to Packet Switched (PS) environment. Major TSPs in India have already installed IP based core transport network for carrying voice and data traffic. In some cases, fixed line service providers have replaced their Tandem/Tax switches with NGN soft switches and interfaced with existing network through Media Gateway. Media Gateway converts TDM voice to Voice over IP. In some cases IP/Ethernet elements have extended into access and aggregation networks. Data networks are already IP/MPLS based with major parts of the network being optical (DWDM or Ethernet instead of SDH). For access network or the 'last mile' connectivity to the end users, the Government is also implementing National Broadband Plan through a special purpose vehicle (SPV) created in the form of Bharat Broadband Network Ltd. (BBNL).

1.2 In mobile, the core networks are primarily IP-based and supported by an all-IP intra-soft-switch, MPLS-based backbone. With regard to the mobile access networks, the rollout of high speed networks like 3G and 4G (LTE) have commenced and the reality of an all IP access network is not a distant dream.

Benefits of Migration to IP based networks

1.3 Migration to IP based network requires extensive changes in the network and in service provisioning. This migration has number of benefits and challenges which includes the following:

- **Economy of scale**: The IP based network integrates all telecommunications traffic of an operator into one network. Due to the high proportion of fixed costs, the unit cost decreases as the traffic grows. IP architecture allows a service provider to aggregate all of its branches into a single ingress and egress location, or gateway site.

- **Economy of scope**: Due to high proportion of fixed cost in the telecom networks, Networks which are separate today are integrated into a single network and the volume of traffic in these IP based networks increases. This results in significant savings to the cost of the service providers.
- **Flexibility**: IP-based systems are extremely flexible and can be easily modified as per the requirements and technological developments over time. They can work with legacy TDM facilities, and enable a number of features and applications not available with TDM.
- **Easier integration of applications**: IP is the widely accepted standard upon which most of today's applications are built.
- **Efficiency of IP**: Transporting telecommunications traffic as IP packets instead of reserving a complete channel for each voice call increases the network efficiency. The packet switched network routes the packets through those parts of the network which have sufficient resources and it is able to dynamically reroute packets when a router is busy.
- **IP based network enables new business models**: The implementation of new services in the network can be made faster by influencing only a part of the network. These new services will facilitate new business models. Further, the disintegration of the network function might imply that new, vertically disintegrated networks can be the basis for a new type of service providers. The implementation of traffic management will also enable new services and business models.
- **Benefit to End Users**: End users will receive increased number of services with higher overall quality than that offered by traditional networks, while the price that they have to pay for those services reduces.

Regulatory Initiatives So far

1.4 With an objective to build awareness, the Authority released a Study Paper on NGN in July 2005. Subsequently a consultation paper on "Issues pertaining to Next Generation Networks (NGN)" was issued in January 2006 and the Authority sent its recommendations to the Department of Telecommunication (DoT) in March 2006.

1.5 Thereafter, an expert committee called 'NGN eCO' was constituted on 20th June, 2006. NGN eCO created three core sub-groups to study the three key areas of licensing, interconnection and quality of services (QoS) related issues in detail. Based on the reports of these core groups, NGN eCO submitted its final report to the Authority in August 2007.

1.6 A consultation paper on Licensing Issues relating to Next Generation Networks was issued by the Authority on 27th January 2009. In addition, the Authority has taken various initiatives which interalia include the following:

- Recommendations on Improvement in the Effectiveness of National Internet Exchange of India (NIXI) dated 20th April 2007.
- Recommendation on provision of IPTV services dated 4.1.2008: In January 2008 TRAI released recommendation on provisioning of IPTV services addressing the Licensing issues, Content Regulation and Down-linking Policies. These recommendations were accepted by the Government and it paved the way for provisioning of IPTV services by telecom service providers. Cable TV Act was modified and Telecom services providers were permitted to provide IPTV services.
- Recommendations on Issues related to Internet Telephony dated 18th August 2008: TRAI recommended that "Internet telephony maybe permitted to ISPs with permission to provide Internet telephony calls to PSTN/PLMN and vice-versa within country. Necessary amendments may be made in the licence provisions".

- Recommendations on National Broadband Plan were issued during December 2010: The plan envisages creation of optical fibre based National Broadband Network in India.
- Recommendations on Guidelines for Unified Licence/Class Licence and Migration of Existing Licences dated 16th April 2012. Under Unified Licence, an operator could provide any kind of telecommunication services supported by the infrastructure.
- Recommendations on "Application services" on 14th May 2012. Application providers were recommended to be brought under Licensing regime to enable them seek interconnection and QoS from service providers.
- Recommendations dated 5.08.2010 to the Ministry of Information & Broadcasting, regarding implementation of digitisation with addressability of cable TV network. The Government has accepted the recommendations and issued the notification for implementation of digital addressable cable TV system in the country in a phased manner to be completed by December, 2014. This will also enable provisioning of broadband service through cable TV networks.

1.7 In addition, to facilitate the migration towards NGN, licenses of Access providers have been amended in April, 2009 by the DoT to include the placement of following network elements:

- Media Gateway Controller (MGC)
- Media Gateway (MG)
- Trunk Media Gateway (TMG)
- Access Gateway (AG)
- Signalling Gateway (SG)

New Licensing Regime recommended by TRAI and accepted by DoT.

1.8 In view of the fact that the convergence of markets and technologies is forcing reassessment of the present Licensing regime, the Authority has already recommended that the current licensing framework should be replaced by a new Unified Licensing regime in its recommendation on “Spectrum Management and Licensing Framework” dated 11th May 2010. It has recommended that all future licences should be Unified Licences and that spectrum be delinked from the licence. Subsequently, the Authority has sent its Recommendations on ‘Guidelines for Unified Licence/Class Licence and Migration of Existing Licences’ dated 16th April 2012 wherein the scope of the Unified, Class and Licensing through Authorisation licenses were recommended.

1.9 After considering the recommendations of TRAI for Unified Licenses, the Government has decided to grant Unified License (UL). The basic features of UL were that the allocation of spectrum was delinked from the licenses and has to be obtained separately as per prescribed procedure. The unified licensing regime consists of a transition towards a flexible and technology neutral licensing framework paving the way for the migration to IP networks.

Chapter 2: Interconnection issues

What is Interconnection?

2.1 Interconnection is the lifeline of telecommunication network. It involves commercial and technical arrangement under which service providers agree to connect their equipment, networks and services to enable their customers to have access to the customers, services and networks of other service providers.

2.2 As per Section 11(1)(b)(iii) of the TRAI Act, 1997, the Authority has the mandate to "ensure technical compatibility and effective inter-connection between different service providers". The efficiency and quality of service would suffer if efficient interconnections are not enforced in a timely manner.

Types of Interconnection:

2.3 In order to understand the regulatory issues in interconnection, technical aspects of TDM interconnection and IP interconnection are discussed in brief below.

TDM Interconnection

2.4 In the present telecom scenario in India, voice interconnection between any two networks is governed by TDM interconnection architecture rule. In such an arrangement, all networks use the same signalling system (Signalling System Number 7, or SS7), numbering scheme (E.164), media transport (Time Division Multiplexing or TDM) and interfaces (E1/T1 or their multiples). In this arrangement, by use of media gateway at the interconnection point, Next Generation Networks (IP based networks) can be introduced within a network without changing the interconnection arrangements.

2.5 In the present scenario, for voice calls, three different types of interconnections are possible:

A. **Between Legacy Network operator and IP based network operator:** In this arrangement, conversion functions from IP to

TDM protocols and vice versa is required. Since the current regulations mandate TDM base interconnection, the legacy network (TDM) operator does not need any additional network nodes for translation from TDM protocol to IP protocol for both the signalling and media planes. Conversion functions from IP to TDM protocols and vice versa are being carried out by IP based operator at its own cost.

B. **Between two Legacy Network operators (TDM Base):** The signalling between the networks is based upon SS7 and the interconnection between them continues to be TDM based. This arrangement is well established.

C. **Between two IP based network operators:** The interconnection between the networks is IP based. There will be no conversion required in this case. This arrangement is gradually becoming popular among network operators.

IP Interconnection

2.6 In case of mandatory IP interconnection regime, three different scenarios will be possible:

A. **Between legacy network operator and IP based network operator:** In this arrangement, conversion functions from TDM to IP protocols and vice versa will be required. In case of mandatory IP interconnection, TDM operators will have to deploy Media Gateways to convert TDM voice to voice over IP and Signalling Gateway/Soft switch to convert SS7 signalling into SIP or H.323 signalling as shown in figure 2.1.

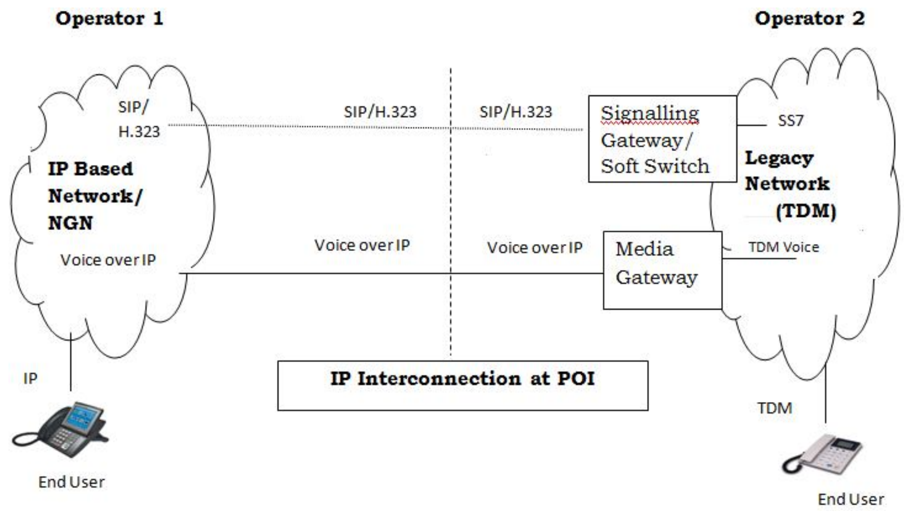


Figure 2.1: IP interconnection between legacy network operator and IP based network operator

B. **Between two legacy network operators (TDM Base)**: In this arrangement, both TDM based network operators will have to implement the conversion functions from TDM to IP protocols, as shown in figure 2.2.

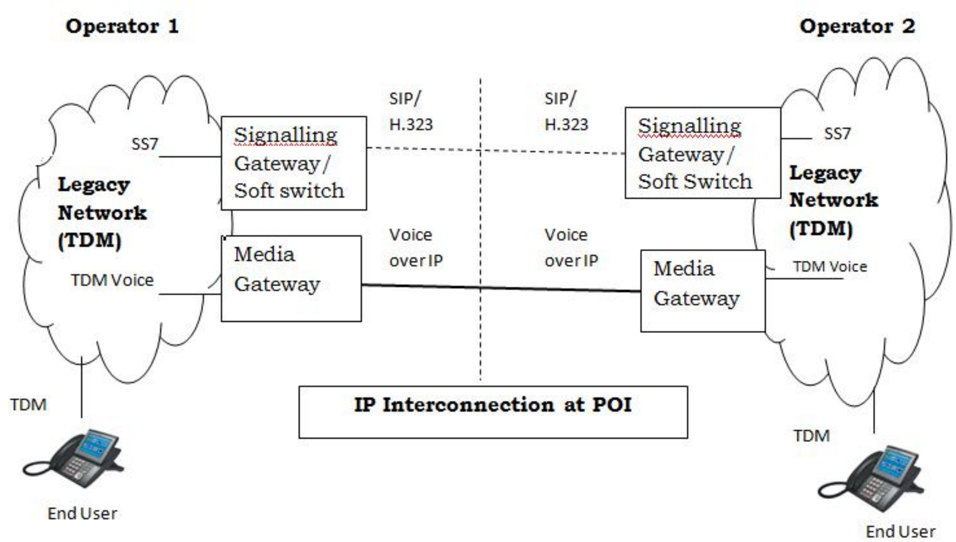


Figure 2.2: IP interconnection between two Legacy Networks

C. **Between two IP based network operators**: In this arrangement, as shown in figure 2.3, gateway is replaced by Session Border Controllers (SBCs).For interconnected networks, the main function of SBC is to perform the functions of a "fire wall" and

Network Address Translator (NAT).The, SBC protects the softswitch from signalling overloads, denials of service attacks and other attacks from the intruding in the IP world.

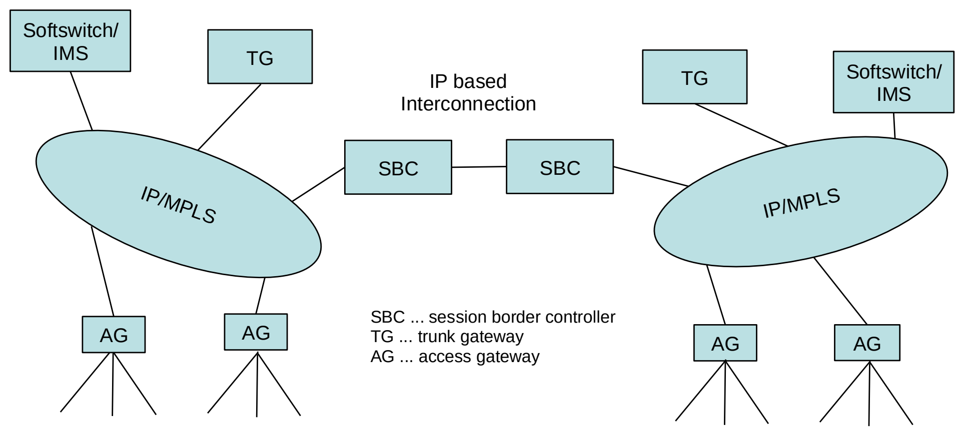


Figure 2.3: IP Interconnection between IP based networks

Advantages of IP Interconnection:

2.7 During the phase of migration from TDM to IP networks, operators may have a mix of TDM and IP networks. Since most new networks that are being deployed are based on IP technology, there is a need to shift the interconnection regime from TDM towards IP interconnection.

2.8 Interconnection between two IP based networks under IP interconnection regime, leads to cost saving and reduction in end to end transmission delay of calls. The cost savings arise from avoiding back-to-back media gateways used for conversion from TDM to IP protocols and vice versa.

Issues in IP Interconnection

A. Mandatory IP interconnection or Demand Based IP Interconnection

2.9 As explained earlier, different operators in India are at various stages of migration to IP based networks. However, interconnection regime continues to be TDM based. With increase in deployment of IP based elements in the network, the need of an IP interconnection framework has arisen. IP interconnection may be implanted in two major ways. **One** way is to make it obligatory on the access provider to provide IP-based interconnection as and when the seeker of interconnection requires this to be done on an IP basis. **Another** option is to mandate IP interconnection only from a certain date in the future. The second option would have the advantage that parallel regimes (TDM and IP) are avoided and it would give all stakeholders time to prepare. On the negative side, the IP-based interconnection would be forced between operators who would both prefer the interconnection to be TDM based. Italian regulator AgCom, Norway and Denmark have gone with the latter option, while the Canadian Regulator CRTC, Germany and New Zealand has implemented the first option.

2.10 If IP interconnection becomes mandatory, the question arises whether the enforcement of interconnection agreements should rely on:

- **Bilateral agreements and dispute resolution (ex-post)**
- **Mandatory reference offer (ex-ante)**

2.11 As networks develop differently, the option allowing bilateral agreements for IP interconnection would enable the two involved service providers to agree on the solution most suitable for them, even if it deviates from the preferred solutions of other service providers. But the problem with bilateral agreements and dispute resolution is that the cost of negotiations and testing would be higher for operators and the implementation could get delayed due to a larger number of time consuming dispute resolution processes. The other option could be to consider implementing a reference interconnect offer (RIO) instead of leaving it to the service providers. The main advantage of RIO is that standard terms and conditions are set out in advance and are equally applicable to all parties seeking interconnection.

Reference Interconnection Offer (RIO) Regulations

2.12 In order to ensure efficient interconnection between service providers, TRAI had issued a regulation called 'Reference Interconnection Offer (RIO) dated 12th July 2002'. This includes Point of Interconnection, interconnection principles, interconnection provisioning procedures, charging mechanism, billing & settlement and commercial terms and conditions.

Q1. Is there a need to mandate IP interconnection? If so, what should be the time frame for implementation of the same? Please comment with justifications.

Q2. Whether both TDM and IP interconnection should be allowed to coexist? If so, whether the existing regulation i.e. 'Reference Interconnection Offer dated 12th July 2002' addresses the requirements of IP interconnection also? Please comment with justifications.

Q3. In case IP interconnection is mandated in India, whether the enforcement of interconnection agreements should rely on

(i) Bilateral agreements and dispute resolution; or

(ii) Mandatory reference offer

C. IP Interconnect exchange

2.13 The other option of interconnection is through an IP interconnect switch. Most interconnections are established by variants of the two forms of interconnection:

(a) Transit

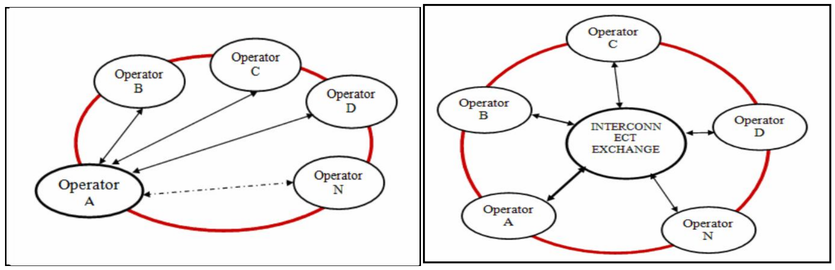
Transit, where one network (the transit provider) agrees to carry the other's traffic not only to its own customers, but also to third party. Transit arrangements represent a seeker-provider relationship between interconnected parties, in contrast to equal barter in the case of peering. Basically, a seeker IP based network pays for traffic to be routed through the network of a provider. There is no cost distribution among interconnecting parties; the seeker IP based network has to pay for all the interconnection costs.

(b) Peering

Peering happens when two networks agree to exchange traffic between their respective customers. The two main types of peering arrangements are:

(i) Public peering (multi-party interconnection): public peering is interconnection between more than two networks at a specialized facility that is specifically designed to enable large-scale peering. Such facilities are known by various names, including "telco-hotels," "network access points" or "Internet exchange points" (IXPs). The facility's operator provides physical security, climate control, a "house" network, and electric power that is backed-up to ensure that there is no disruption in service. Space is then leased to operators, who in turn install routers and other networking equipment in order to obtain physical interconnection. Public peering provides an opportunity for IP based network operator to reduce interconnection costs by interconnecting with many other providers through a single port.

(ii) Private peering: Private peering represents a direct interconnection between two service providers via dedicated circuits that are not shared by any other parties. Because private peering requires dedicated resources for interconnection with a single provider, the value gained from interconnection with any one service provider has to be sufficient to justify the costs of interconnecting with it.



Peer-to-Peer Interconnection   Interconnect Exchange

Figure 2.4: Peer to Peer Interconnection and Interconnection Exchange

2.14 Internationally interconnection exchanges are used for IP traffic. The main difference with the interconnection regime in TDM is that these exchanges are service agnostic. An initiative has also been started by the GSM Association (GSMA) alongwith i3 forum to adapt interconnection exchanges for the exchange of IP based network traffic between mobile operators. They have launched a deployment initiative to accelerate the take up of IP eXchange (IPX) based interconnect through live commercial pilots for voice traffic. Use of IPX creates the future pathway for interoperable voice services based on IP networks, such as Voice over LTE (VoLTE), and also provides an alternative to today's current best-effort IP interworking. Mobile and fixed operators including Deutsche Telekom, Orange, Telecom Italia, Telefónica, TeliaSonera and Vodafone have commenced pilot testing of voice over IPX this year.

2.15 It would be possible for operators to exchange their IP traffic through a common interconnect exchange for all services. One approach could be that all operators connect to a common interconnect exchange. A sharing model for the costs could be worked out. In this case there could be a need for regulatory intervention in order to ensure any-to-any communications. Other alternative could be to allow market forces to decide about the suitable IP interconnection regime.

Q4. In an IP based network scenario, which mode of interconnection is preferable to carry traffic: - peer-to-peer, Interconnect Exchange or combination of both? Please comment with justifications.

Q5. In case an Interconnect Exchange is required, should such Exchange be placed within each licensed service area or a single Interconnect Exchange will be adequate for the entire country? Please comment with justifications.

D. Location and Number of Points of Interconnection (PoI)

2.16 As explained earlier, existing interconnection arrangements in India are TDM based. IP interconnection facilities could potentially be much more concentrated than existing interconnection facilities.

2.17 In migration, some operators may plan to upgrade core of their network to IP based network but not necessarily to make changes to the access network. Some operators might place greater emphasis on upgrading the access network to IP-based facilities that bring fibre close to the subscriber's home, if not into it outright. Still others might decide to upgrade the core and the access at once. Some may emphasize only the fixed network, while others will look to use IP based network (often in conjunction with the IMS) to integrate their fixed and mobile services. These different scenarios may have somewhat distinct implications for regulation in general, and for interconnection in particular.

2.18 In a report on the future of IP interconnection[2], it has been argued that migration from TDM interconnection to IP interconnection will reduce the number of interconnection to a couple of points in each country. There are several reasons mentioned for the reduction in the number of POIs. The main argument lies in the economics of the networks. The transmission technologies are evolving and with IP based networks, the benefits of DWDM and Ethernet technologies,

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[2] Marcus S. and Elixmann D.: "The Future of IP Interconnection: Technical, Economic and Public Policy Aspects", WIK-Consult for the European Commission, 29 January 2008, p. 50

which enable far higher bandwidths, can be utilized. This implies that the cost of common network elements reduces and, a more centralized cost effective network as compared to the PSTN/PLMN. Another reason for the reduced number of PoI is the higher capacity of each network element based on IP based network technologies in comparison to the PSTN/PLMN technologies.

2.19 However, the number of POI cannot be reduced too much as most of the voice traffic (unlike data traffic, which in India is still to a large extent international) is local. Reducing the number of PoIs too much would imply that the traffic is transmitted back and forth for no reason. Further, there are still limitations in capacity of the network elements, which for a country of the size of India may play an important role for the economics of the networks for a considerable period of time. Last but not the least, the redundancy of the networks is important and with centralized network, faults of a few elements could cause extensive availability problems to the networks.

2.20 Currently in India, the UAS licenses are related to each service area and in each service area, active switching technologies (e.g. a switch or a media gateway) must be implemented. As the IP based networks architecture is centralised, keeping all PoIs would imply inefficient routing of the traffic.

Q6. Whether any regulatory intervention is required to mandate the locations and structure of points of interconnection (POI) for IP based network architecture? Please comment with justifications.

E. Wholesale interconnection charges

2.21 Interconnect Usage Charges (IUC) are the charges payable by one service provider to one or more service providers for usage of the network elements for origination, transit or termination of the calls. In TDM interconnection, IUC has several components viz. Origination Charge, Termination Charge, Carriage Charge and

Transit Charge. IUC are wholesale charges payable by subscriber A's TSP to subscriber B's TSP for use of the latter's network for terminating or transiting/carrying a call. Historically, these charges are based on cost and represent a fair compensation for use of one service provider's network resources by another service provider.

2.22 IP based network promises simpler network architectures, higher bandwidths, fewer network elements, lower costs and more functionality. A further outcome of the networks economics due to IP based network is the decoupling of the network and the service layer in IP networks, which implies new Cost-Volume-Relationships (CVRs) as the costs for transmission are reduced (due to all-IP networks, reaping the benefits of economies of scales and scope) while the costs for the control layer and the service platforms increases (due to additional investments in soft-switches and IMS platforms). The decoupling of transport and services will also allow independent evolution of business models, network elements and applications. Hence, IP based networks imply technological changes, changes to products and service offerings and eventually changes in the market structures. Accordingly, costing and charging regime should reflect these developments. This implies substantial changes in the view and analysis of costs in an IP based network environment.

F. Costing Principles for wholesale charging in IP based network

2.23 In the present TDM interconnection, interconnection usage charges i.e. termination charges, carriage charges and transit charges are on per minute basis. However, in the IP based interconnection, different charging principles may evolve which are as below:

(i) Capacity based interconnection charging

(ii) Volume based charging

(iii) Quality of service based charging

2.23.1 **Capacity based interconnection charging:** Capacity Based Charging (CBC) is a regime in which charging takes place according to either ordered or effectively used interconnection capacity. CBC can come in two different variants:

(i) **CBC with pre-booking***:* In this case the fees are determined according to the ordered network capacity. Usually, the number of dedicated links, the number of interconnection links or number of ports is used as the charging unit. The key aspect is that the actual usage does not have an impact on the interconnection payments made.

(ii) **CBC without pre-booking***:* In this case, fees are determined on the basis of the actually used network capacities for interconnection in a defined period (e.g. in peak-time). The charging unit thereby is the transmission capacity required in the peak time in kbit/s, Mbit/s or Gbit/s.

2.23.2 **Volume based charging:** With volume based pricing, operators compensate each other not on the basis of measured minutes but based on the data volume exchanged. The unit which is paid for depends on the granularity of the volumes of data (MB, GB, etc.).

2.23.3 **Quality of service based charging:** This charging regime implies that interconnection prices differ according to quality parameters, such as e.g. delay, jitter, latency etc. In some countries, in voice communications, it is a standard to pay different prices for different quality classes of transmission. This charging system allows differentiated pricing at the wholesale level according to the quality offered.

Q.7 What are your views on the migration from the existing interconnection regime-measured in terms of minutes of traffic to an IP interconnection regime replaced by measures of communication capacity? Please comment with justifications.

Q.8 In an IP interconnection between networks, comment on the type of charging principles that should be in place-

(a) Capacity based in terms of Mbps.

(b) Volume based in terms of Mbps.

(c) QoS based.

(d) a combination of the above three.

Q9. What should be the criteria to estimate the traffic minutes in IP environment if interconnection charges continue to be minute based? Please provide justification in support of your answer.

Q10. In addition to the above, any other modifications or components of IUC which are required to be reviewed in the IP based network scenario? Please provide all relevant details?

G. Charging of content and data services

2.24 With the proliferation of mobile data services, many operators will become mere channels for data services. This opens up a new channel of charging – capacity based charging. Some of the operators commenced use of package traffic charging platform (PTCP), as the foundation of its transformation from a pipeline operator to a smart operator.

2.25 As content services will be packet based, the capacity based charges could probably be the suitable charging regime. If and when IP interconnection for content services are implemented and regulated, the charging will have to be aligned towards different service classes. IP based networks could easily help the content providers to interconnect and offer services to the customers. Content charging platform could realize access via multiple technologies, and separate service control from network access, which could help in reduced investment. In future, there will be a layered segmentation in the value networks between content players and operators, wherein operators provide the network layer and content players the application layer, the control layer being split according to countries' particularities.

2.26 Increasingly sophisticated policy control features are likely to evolve in the future, encompassing more advanced charging mechanisms, exhibiting complexity which has not been seen previously. For example, an LTE Operator could implement a number of EPS bearers with specific charging models on each due to its varying demands and requirements on the network i.e. some services may require frequent charging plan, while VoLTE and Video on Demand services may call for complex charging due to high cost specific network routing or traffic optimization services that they may require.

2.27 However, it may be noted here that in its recommendation on 'Guidelines for Unified Licence/Class Licence and Migration of Existing Licences' dated 16th April 2012, the Authority recommended that Application Service Providers (ASP) should be covered under Licensing through Authorisation. These recommendations are under examination with DoT.

Q11. Do you envisage any interconnection requirement for application & content service providers? If so, what should be the charging mechanism? Please provide all relevant details justifying your comments.

Chapter 3: Quality of Service issues

3.1 The word quality, in the context of telecommunications, can have various meanings. For example, quality can be used in relation to speech quality in telephone calls or picture quality in video delivery services. It may also be used in connection with communication services to describe, for example, the degree to which telecommunication equipment operates correctly without faults and the response that a customer receives from a service provider when applying for a service. Measurements of end-to-end quality of service may address all areas listed below:

- Service Quality e.g. customer satisfaction.
- Quality of Experience e.g. voice quality.
- Network Performance e.g. faults.

3.2 End to end QoS in IP based network environment is complex due to different types of users and real-time multimedia service applications with different bearer requirements on a wide variety of infrastructures. In IP network, to achieve the same quality as in the existing TDM network, there has to be either a system of prioritization for network resources or allocation of additional capacity in terms of resources.

3.3 A full QoS support is very complex to implement in IP based packet networks due to the connectionless nature of IP protocols. One way to provide a perfect QoS would be to have unlimited bandwidth all over the network. It may be relevant in the long term but does not seem appropriate in the short and medium terms.

3.4 Several concepts and mechanisms like Integrated Services (IntServ) and Differentiated Services (DiffServ) have been developed to support QoS over IP networks. But, these do not completely meet the QoS requirements. IntServ is a QoS solution based around resource reservation and admission control. The main flaw of IntServ was the complexity, especially since every node in a path from receiver to sender had to be flow aware, that increases the costs of resources to maintain. The use of per-flow state and per-flow processing also raises scalability concerns for large networks. As a response the DiffServ architecture has been developed and is being used in QoS implementation. In contrast to the per-flow orientation of IntServ, Diffserv networks classify packets into one or a small number of aggregated flows or "classes", based on the Diffserv code point in the packet's IP header. Setting up the various classes throughout the network requires knowledge of the applications and traffic statistics for aggregates of traffic on the network. This process of application discovery and profiling can be time-consuming. These shortcomings need to be addressed through establishment of necessary QoS framework in IP based network environment.

3.5 The ITU-T has released two relevant recommendations for addressing QoS. Y.1541 defines the QoS classes that quantify user application needs in terms of IP network performance and Y.1221 defines “traffic contracts” that complement the QoS classes by describing flow characteristics/limits. In order to meet the need for QoS, the ITU-T recommendation Y.1541 defines different Classes of Service, each corresponding to a family of applications with different characteristics as shown in table 3.1 below:

QoS class	Applications (examples)	Node mechanisms	Network techniques
0	Real-time, jitter sensitive, high interaction (VoIP, VTC)	Separate queue with preferential servicing, traffic grooming	Constrained routing and distance
1	Real-time, jitter sensitive, interactive (VoIP, VTC).		Less constrained routing and distances
2	Transaction data, highly interactive (Signalling)	Separate queue, drop priority	Constrained routing and distance
3	Transaction data, interactive		Less constrained routing and distances
4	Low loss only (short transactions, bulk data, video streaming)	Long queue, drop priority	Any route/path
5	Traditional applications of default IP networks	Separate queue (lowest priority)	Any route/path

Table 3.1: Recommendation Y.1541: classes of service [Source: ITU]

3.6 ITU-T Recommendation Y.1541 has explained the network performance parameter of IP based network for assessment of the QoS. These network parameter include the following:

IP Packet transfer delay IPTD

Packet delay is the finite amount of time it takes for a packet to reach the receiving endpoint after being transmitted from the sending endpoint. In the case of voice, this delay is defined as the amount of time it takes for sound to leave the speaker's mouth and be heard in the listener's ear.

Voice and video are delay-sensitive applications while most data applications are not. When voice packets are lost or arrive late they are discarded; the results are reduced voice quality. Upper limit of permissible delay depends on type of traffic and type of network (150 ms – 400 ms).

IP Packet delay variation (IPDV)

It is the difference in the end-to-end delay between packets. For example, if one packet required 100 milliseconds (ms) to traverse the network from the source-endpoint to the destination-endpoint and the following packet required 125 ms to make the same trip, then the delay variation would be calculated as 25 ms.

IP packet loss ratio (IPLR)

Network devices, such as switches and routers, sometimes have to hold data packets in buffered queues when a link gets congested. If the link remains congested for too long, the buffered queues will overflow and data will be lost. The buffered data packets must be retransmitted, adding, of course, to the total transmission time. In a well-managed network, packet loss will typically be less than 1% averaged over, say, a month. When data packets are lost, a receiving computer can simply request a retransmission. When voice packets are lost or arrive too late they are discarded. The result is in the form of gaps in the conversation.

Loss is expressed as the percentage of packets that were dropped. IP packet loss ratio (IPLR) is the ratio of total lost IP packet outcomes to the total transmitted IP packets in a population of interest. Loss is typically a function of availability.

IP packet error ratio (IPER)

IP packet error ratio is the ratio of total errored IP packet outcomes to the total of successful IP packet transfer outcomes plus errored IP packet outcomes in a population of interest.

3.7 ITU-TY.1541 recommendation defines classes of network quality of service (QoS) with objectives for various network performance parameters. These classes are intended to be the basis for agreements among network providers, and between end users and their network providers. Each class of service has different requirements in terms of packet delay, delay variation (also called jitter), packet loss and bit error rate. The ITU formally defines the performance targets for each of class of service as shown in table 3. 2 below.

Network performance parameter	Nature of network performance objective	QoS Classes					
		Class 0	Class 1	Class 2	Class 3	Class 4	Class 5 Unspecified
IPTD	Upper bound on the mean IPTD	100 ms	400 ms	100 ms	400 ms	1 s	U
IPDV	Upper bound on the $1 - 10^{-3}$ quantile of IPTD minus the minimum IPTD	50 ms	50 ms	U	U	U	U
IPLR	Upper bound on the packet loss probability	1×10^{-3}	1×10^{-3}	1×10^{-3}	1×10^{-3}	1×10^{-3}	U
IPER	Upper bound	1×10^{-4}					U

Table 3.2: Recommendation Y.1541: network performance parameter of each class of service [Source: ITU]

3.8 In the above QoS scheme, an application to be run on IP network can be assigned a class of service. The network of the service provider must fulfil the various objectives of that class. These parameters are required to be tested in all the networks under different loads, to ensure that the networks perform similarly, especially if interconnection is required between different networks to provide a given service.

3.9 Apart from the above, ITU recommendation Y.1221 describes the traffic control and congestion control procedures for IP-based networks. Such control procedures are necessary in order to support services with QoS, where the QoS is negotiated between a user and the network. The traffic contract defines conditions under which specified QoS levels can be met. The traffic contract includes IP transfer capability (dedicated bandwidth, statistical bandwidth or best effort) and traffic descriptor (maximum packet size and token bucket).

3.10 It is clear from ITU-T recommendations that different classes will have to be assigned to the packets flowing into networks depending upon the type of application. Agreeing for a type of class for a particular application will ensure that all networks provide similar treatment of the packets/service for ensuring end to end QoS.

3.11 Presently, a regulatory framework is in place for measuring and reporting quality of service parameters for all telecom services. TRAI had laid down the standards of quality of service to be provided by the service providers for wireline and wireless, Internet Dialup Service, Broadband Service and VOIP based International Long distance Services. It can be seen that these regulations define the QoS requirements for both TDM & IP networks. .

3.12 Therefore, the issue for consideration is whether there is a need to define a new regulatory framework of QoS parameters for all IP based network services or the existing regulatory framework for measuring and reporting quality of service parameters may continue to apply, bearing in mind the possibility that if as a result of the change to IP based network technology the definitions of any parameters or the target values become inappropriate or impracticable to achieve then, these parameters would be updated later with subsequent consultation. One of the options could be that during the migration period, end to end QoS be left to the service providers and the service providers deliver the best service without quality of service guarantees at a lower price. In such a scenario, the service providers will be required to appraise the subscribers about QoS before they subscribe to such services. The other option could be to define QoS framework for IP based network services in advance for ensuring QoS through regulations.

Different QoS parameters in IP based network environment

3.13 If it is decided to setup a regulatory framework for measuring and reporting quality of service parameters for all IP based network services also, as defined for PSTN/PLMN network, then the QoS parameters for IP based network services needs to be defined. There are generally three types of QoS parameters that can be used:

I. **Network centric parameters** may include Latency, Jitter, Packet Error, Packet Loss, Toll Quality voice, Call Completion Rate, Availability of Network etc.

II. **Customer centric parameters** may include Service Activation Time, Service De-activation Time, Service Restoration Time, Clarity of Tariff Plans, Ease of switching between plans, Ease of getting Billing information, Ease of Bill payments, Ease of getting refunds, Network Availability, Billing Accuracy, Security of customer information, Grievance Redressal, Access to senior executives/ officers, Round the clock availability of customer care, Fault Repair Service, Redressal of Excess Metering Cases, Service availability etc.

III. **Service specific QoS Parameters:** These parameters focus on the quality of specific services. Service specific QoS parameters may include call set-up delay, call completion rate and speech quality for real-time voice service. Jitter and the Zap time etc. for IPTV.

3.14 In order to identify the parameters most likely to satisfy and/or improve the customer experience, a technical and service perspective is required. In relation to IP based network, it may be useful to differentiate between real-time interactive services, eg voice and video telephony; real-time non-interactive services, eg television transmission; and near real-time interactive services, eg instant messaging.

3.15 As explained above, it is important to meet customer expectations for end-to-end Quality of Service and reliability for all types of IP based network services. In order to build an enabling framework for IP based network services, operators must have the possibility to ensure end-to-end QoS by relying on the required QoS provided by other operators. One of the concepts behind most QoS solutions is that traffic is divided into different classes, each with its own characteristics.

Q12. Whether the existing regulatory framework for measuring and reporting quality of service parameters as defined for PSTN/PLMN/Internet may continue to apply for IP based network services? Please comment with justifications.

Q13. In the context of IP based network Migration, if the parameters in the existing QoS regulation are required to be reviewed immediately then please provide specific inputs as to what changes, if any, are required in the existing QoS regulations issued by the Authority. Please comment with justification.

Q14. In case new QoS framework is desirable for IP based network, do you believe that the QoS be mandatory for all IP based network services. If yes, what should be QoS parameter and their benchmarks?

Q15.What should be the mechanism for monitoring the parameters for end to end QoS in IP based network environment? What should be the reporting requirement in this regard? Please comment with justification.

Chapter 4: Operational Issues

4.1 The migration towards IP based network has thrown up a number of challenges in the existing system. Sharing of Network elements, numbering, addressing, priority calling in case of emergency are some of the operational challenges. These challenges are required to be addressed to ensure a smooth transition to IP based networks.

A-Sharing of network elements

4.2 As per the terms and conditions of the CMTS/UAS Licences, the access service providers were initially permitted sharing of "passive" infrastructure viz., building, tower, dark fibre etc. However, in April, 2008, in order to ensure an optimum utilization of the available resources and to bring down the cost of providing service, the Government issued 'Guidelines on Infrastructure sharing among the Service Providers and Infrastructure Providers'. As per these guidelines, the service providers were permitted to share the active infrastructures limited to antenna, feeder cable, Node B (used in 3G, equivalent to the BTS (base transceiver station)), Radio Access Network (RAN) and transmission system only.

4.3 The DoT, vide its letter dated 9th March 2009 clarified that the scope of IP-I category providers, which was at that time limited to passive infrastructure, has been enhanced to cover the active infrastructure if this active infrastructure is provided on behalf of the licensees, i.e. they can create active infrastructure limited to antenna, feeder cable, Node B, RAN and transmission system only for/on behalf of UASL/CMSP licensees.

4.4 With regard to IP based networks, infrastructure sharing may be in the Access or/and Core network. In case of access network, one operator can access the access networks (Copper or Fiber or mobile network) of another established operator. It is also possible in IP based network scenario, that broadband access products, such as unbundled local loops or "Bitstream" may enable operators, ultimately, to offer their own competitive retail services to consumers on equivalent conditions.

4.5 In case of connectivity over wireless as the Access network, this leads to a new scenario where several core network operators can be connected to the same base station controller (BSC)/Radio Network Controller (RNC) sharing fully the RAN resources. Operators can have shared RAN or own dedicated RAN networks. They utilize one or more shared carriers from multiple operators. Here the RNC routes the user equipment (UE)'s initial access to one of the available Core network (CN) nodes. The Rel-6 UEs are connected directly to own CN. In case of legacy UEs the RNC re-routing functionality is used to find the correct CN.

4.6 Similarly the core network elements of IP based network can also be shared by different operators. The IP based network system offers key convergent multimedia services using a shared network characterised by several essential elements, which allows for sharing of network elements at different levels:

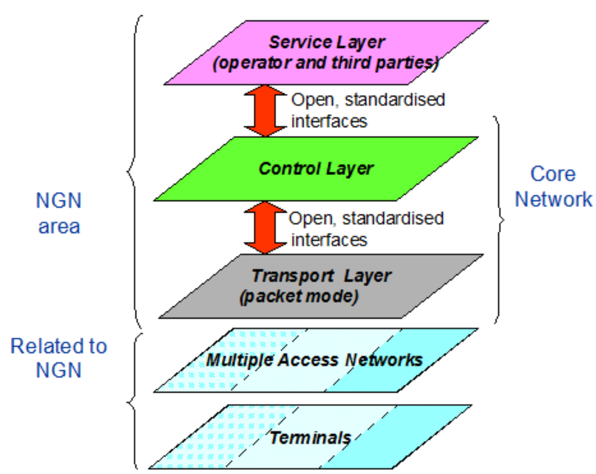


Figure 4.1: General principle of IP based network architecture (Source: ARCEP)

4.7 Traditional telecommunications networks will evolve to an open, distributed model, firmly based on IP and packet mode transmission, in general, which is transparent to users.

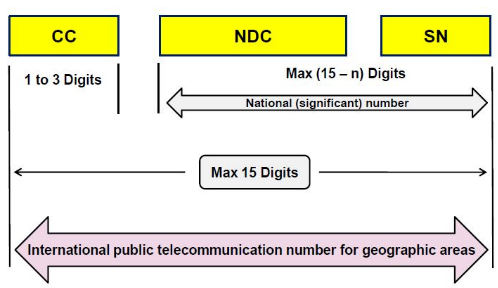
Q16. Should sharing of the IP based core and Access network element by different telecom service providers be allowed in IP based network scenario? What are the challenges, opportunities and problems of such sharing? Please comment with justifications.

B-Numbering and addressing

4.8 In order to understand the issue of numbering in the IP based network environment, it is important to understand the difference between E164 telephone number and ENUM.

E.164:

4.9 Numbering is the Public User Identity by which a subscriber is identified in the Network. E.164 numbering generally identifies the geographical location of the subscriber and the service provider providing such services. The DoT administers numbers for fixed and the mobile networks based on the International Telecommunication Union (ITU)-T E.164 recommendations. The ITU-T recommends that the maximum number of digits for the international geographic, global services, network and groups of Countries applications should be 15 as per the format shown below.



CC Country code for geographic area (1 to 3 digits)

NDC National Destination Code

SN Subscriber Number

ENUM:

4.10 ENUM unifies traditional telephony and IP networks, and provides a critical framework for mapping and processing diverse network addresses. It transforms the telephone number—the most basic and commonly-used communications address—into a universal identifier that can be used across many different devices and applications (voice, fax, mobile, email, text messaging, location-based services and the Internet).

4.11 ENUM is the mapping of Telephone numbers to Uniform Resource Identifiers (URIs) using the Domain Name System (DNS). It consists of a simple algorithm to translate E.164 number into domain names. ENUM enables convergence between the PSTN and IP. It helps to facilitate such services as VOIP & allows network elements to find services on the internet using only a telephone number.

Benefits of ENUM:

- ENUM uses the DNS thus saving the capital expenditure.
- Ultimate solution in number portability.
- Provisioning is only by the destination administrative domain.
- Enables convergence.

4.12 In general, ENUM is a protocol that defines a method to convert a regular telephone number (e.g. +91-11-2925-4780) into a format that can be used on the Internet within the DNS to look up Internet addressing information such as URIs. The Internet addressing Information referred to an ENUM number is stored within the DNS, providing routing information to reach the device with the associated ENUM number. Another feature of the ENUM protocol is that more than one contact information (fax, email etc) can be stored in the DNS record that is belonging to a specific ENUM number.

4.13 There are three types of ENUM- **End User ENUM** (or Public User ENUM) where the end user can provision his or her records in the ENUM registry in the public domain e164.arpa, **Private**

Infrastructure ENUM which uses the concept of creating a domain name from a telephone number (TN) and resolving it to a URI and **Public Infrastructure ENUM** where National number administrators typically assign TNs to communications carriers, not to end users; carriers then assign the TNs to end users.

4.14 ENUM will require allocation of at least one E.164 number to each entity irrespective of services being offered to such entity. ENUM facilitates use of an existing number for an entity to provide multiple services.

4.15 ENUM does not replace the numeric Internet protocol address (IPv4 or IPv6) that will be used to interact within the IP protocol directly. ENUM has also no role in the conversion of signalling messages and media streams.

4.16 Although ENUM will help facilitate VoIP calls, it is important to understand that VoIP phone calls do not require ENUM, and such calls can be made wholly without ENUM by using their defined Internet addressing scheme.

C-Migration Issues related to numbering:

4.17 IP based network are packet based networks where transport is separated from services. The addressing in an IP based network is based on IP addresses. IP addresses will not be used directly by the customers. In the Internet the conversion between names (URI) and addresses (Ipv4 or Ipv6) is achieved by the DNS, a worldwide distributed database.

4.18 In order to achieve the migration to IP based network while enabling subscribers to keep their phone numbers, operators will need a mechanism that maps telephone numbers to IP addressing or the DNS. It may also be required to harmonise naming and addressing conventions on a national basis. The inter-relationship of these numbers and addressing schemes, and their management mechanism will be required during the migration to IP based network, which is a major task.

4.19 In the IP based network, call from any IP device or its adopter can be originated to PSTN/PLMN without requiring any E.164 number assigned to the calling party. The caller can call the PSTN/PLMN subscribers using their existing number if the two networks are properly interconnected. However, if the caller has to receive a call on its IP device or its adopter, it will require E.164 number allocation.

4.20 The deployment of User ENUM is limited to few countries like Romania, Armenia, and characterised by slow growth. The Public ENUM status have been tried and deployed for production at Austria, Finland, France, Germany, Ireland, Japan, Netherlands, Poland, Sweden, South Korea, Switzerland, UK and the US. Many countries are trialing and implementing ENUM systems on a national basis. In the UK, for example, Nominet has been awarded the contract to operate the UK main ENUM database. Individual operators will run other ENUM databases for their assigned numbers ranges and subscribers underneath this. A similar model is expected to apply in other countries.

4.21 In view of the above facts, there is a need for discussion whether the national numbering plans would require changes with IP based networks to accommodate nomadic services.

Q17. Do you see any issues concerning the national numbering plan with regard to the migration towards IP based networks?

Q18. Do you believe that ENUM has to be considered when devising the regulatory policy for IP based networks as it will provide essential translation between legacy E.164 numbers and IP/SIP (Session Initiation Protocol) addresses.

Q19. Which type of the ENUM concept should be implemented in India? What should be the mechanism for inter-relationship between number and IP addressing, and how it will be managed?

D-Emergency Number Dialling

4.22 Emergency Number Dialling basically refers to access to certain mandatory services such as Police (100), Fire (101) being provided to subscribers by the service providers. Under present PSTN based numbering, the calling location can be identified based on call origination number and routed to appropriate agency of that area. In IP based networks scenario, difficulties may arise to process emergency service calls in absence of the location information.

4.23 With the advent of VoIP technology the routing of calls to the concerned authority becomes more difficult. Although subscribers may use voice over internet as a replacement for ordinary telephony, there are limitations with regard to emergency calling. The current provisions in the IP protocol do not allow for easy identification of the location of the calling party.

4.24 If a call is made using IP-based technology, such as a VoIP service, the caller's current location is generally not known with sufficient certainty. The nomadic nature of the service means the caller could be anywhere in India. Therefore, the service address of the VoIP caller may not accurately reflect the caller's location. In addition, VoIP services also may not provide reliable CLI data. Accordingly, the increased uncertainty regarding location of calls especially in devices having mobility is an emerging issue for the handling of emergency calls. In this regard, several ideas have been explored and standards' bodies are addressing the issues.

4.25 Following are the requirements for emergency calls in an IP based network.

- Identification of the dialled digits as emergency number
- Retrieval of caller location for routing
- Identification of routing destination (emergency center – concerned authority)
- Provision of caller location

4.26 It is desirable to put in place Priority Call Routing (PCR) scheme for persons who are engaged in response and recovery activities during emergencies/disasters so that the likelihood of their calls getting matured during network congestion is increased. TRAI has already issued its consultation paper on the subject and will be shortly making its Recommendations to Government on PCR.

Q20.Is there a need to mandate Emergency number dialling facilities to access emergency numbers using telephone over IP based networks platform? Please give your suggestions with justifications.

Q21.How will the issues, of Caller location delivery and priority routing of calls to the emergency centre in IP based networks environment, be handled? Please comment with justifications.

Chapter 5: Issues for consultation

Q1. Is there a need to mandate IP interconnection? If so, what should be the time frame for implementation of the same? Please comment with justifications.

Q2. Whether both TDM and IP interconnection should be allowed to coexist? If so, whether the existing regulation i.e. 'Reference Interconnection Offer dated 12th July 2002' addresses the requirements of IP interconnection also? Please comment with justifications.

Q3. In case IP interconnection is mandated in India, whether the enforcement of interconnection agreements should rely on

(i) Bilateral agreements and dispute resolution; or

(ii) Mandatory reference offer

Q4. In an IP based network scenario, which mode of interconnection is preferable to carry traffic:- peer-to-peer, Interconnect Exchange or combination of both? Please comment with justifications.

Q5. In case an Interconnect Exchange is required, should such Exchange be placed within each licensed service area or a single Interconnect Exchange will be adequate for the entire country? Please comment with justifications.

Q6. Whether any regulatory intervention is required to mandate the locations and structure of points of interconnection (POI) for IP based network architecture? Please comment with justifications.

Q.7 What are your views on the migration from the existing interconnection regime-measured in terms of minutes of traffic to an IP interconnection regime replaced by measures of communication capacity? Please comment with justifications.

Q.8 In an IP interconnection between networks, comment on the type of charging principles that should be in place-

(a) Capacity based in terms of Mbps.

(b) Volume based in terms of Mbps.

(c) QoS based.

(d) a combination of the above three.

Q9. What should be the criteria to estimate the traffic minutes in IP environment if interconnection charges continue to be minute based? Please provide justification in support of your answer.

Q10. In addition to the above, any other modifications or components of IUC which are required to be reviewed in the IP **based network scenario? Please provide all relevant details?**

Q11. Do you envisage any interconnection requirement for application & content service providers? If so, what should be the charging mechanism? Please provide all relevant details justifying your comments.

Q12. Whether the existing regulatory framework for measuring and reporting quality of service parameters as defined for PSTN/PLMN/Internet may continue to apply for IP based network services? Please comment with justifications.

Q13. In the context of IP based network Migration, if the parameters in the existing QoS regulation are required to be reviewed immediately then please provide specific inputs as to what changes, if any, are required in the existing QoS regulations issued by the Authority. Please comment with justification.

Q14. In case new QoS framework is desirable for IP based network, do you believe that the QoS be mandatory for all IP based network services. If yes, what should be QoS parameter and their benchmarks?

Q15. What should be the mechanism for monitoring the parameters for end to end QoS in IP based network environment? What

should be the reporting requirement in this regard? Please comment with justification.

Q16. Should sharing of the IP based core and Access network element by different telecom service providers be allowed in IP based network scenario? What are the challenges, opportunities and problems of such sharing? Please comment with justifications.

Q17. Do you see any issues concerning the national numbering plan with regard to the migration towards IP based networks?

Q18. Do you believe that ENUM has to be considered when devising the regulatory policy for IP based networks as it will provide essential translation between legacy E.164 numbers and IP/SIP (Session Initiation Protocol) addresses.

Q19. Which type of the ENUM concept should be implemented in India? What should be the mechanism for inter-relationship between number and IP addressing, and how it will be managed?

Q20. Is there a need to mandate Emergency number dialling facilities to access emergency numbers using telephone over IP based networks platform? Please give your suggestions with justifications.

Q21. How will the issues, of Caller location delivery and priority routing of calls to the emergency centre in IP based networks environment, be handled? Please comment with justifications.

List of Acronyms

Acronym	Expansion
AG	Access Gateway
ANI	Application Network Interface
BAK	Bill and Keep
BSC	Base Station Controller
CBC	Capacity Based Charging
CCS	Common Channel Signalling
CoIx	Connectivity oriented Interconnection
CPNP	Calling-Party-Network-Pays
CN	Core Network
DiffServ	Differentiated services
DNS	Domain Name System
DoT	Department of Telecommunication
DWDM	Dense wavelength division multiplexing
FAC	Fully Allocated Costing
GDP	Gross domestic product
GRX	GPRS Roaming Exchange
ICT	Information and communications technology
ILD	International Long Distance
IMS	IP Multimedia Subsystem
IntServ	Integrated services
IP	Internet Protocol
IPDV	IP Packet delay variation
IPER	IP Packet error ratio
IPLR	IP Packet loss ratio
IPR	Intellectual Property rights
IPTD	IP Packet transfer delay
IPX	IP exchange
IR	Interface Requirement
ISDN	Integrated Services Digital Network
ITU	International Telecommunication Union
IUC	Interconnection Usage Charges
IXP	Internet exchange point
LRIC	Long Run Incremental Cost
LTE	Long-term evolution
MDF	Main distribution frame
MG	Media Gateway
MGC	Media Gateway Controller
MPLS	Multiprotocol Label Switching
MSAN	Multi-service access Node
MSC	Mobile switching center
NAPT	Network Address and Port Translation
NGA	Next Generation Access
NGN	Next Generation Network

NIXI	National Internet Exchange of India
NLD	National long distance
NNI	Network to Network Interface
OFC	Optical Fibre Cable
PLMN	Public land mobile network
PoI	Point of Interconnection
PSTN	Public switched telephone network
QoS	Quality of Service
SBC	Session border controller
RNC	Radio Network Controller
RIO	Reference Interconnection Offer
RPNP	Receiving-Party-Network-Pays
SDCA	Short Distance Charging Area
SDH	Synchronous Digital Hierarchy
SG	Signalling Gateway
SIP	Session Initiation Protocol
SLA	Service-level agreement
SNI	Service Network Interface
SoIx	Service-oriented Interconnection
TAX	Trunk Automatic Exchange
TDM	Time-division multiplexing
TEC	Telecommunication Engineering Centre
TMG	Trunk Media Gateway
TRAI	Telecommunication Regulatory Authority of India
UE	User Equipment
UNI	User Network Interface