POLICY AND REGULATORY FRAMEWORK FOR NGN INTERCONNECTION IN SRI LANKA

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Degree of Master of Science in Telecommunication

Department of Electronic and Telecommunication Engineering

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DECLARATION

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ABSTRACT

Policy and regulatory framework for NGN interconnection in Sri Lanka

The NGN represents a synthesis of existing world of the traditional Public Switched Telephone Network (PSTN) with the world of the Internet. The economic and regulatory arrangements for the two have historically been very different. Many of the networks created over the past ten years contain most of the key elements of an NGN. Most, if not all, of the technology necessary for IP-based NGN interconnection has been available for five to ten years. Advanced approaches to interconnection have been slow to deploy, even where the technology has been mature or within hailing distance of maturity.

In order to propose a regulatory and policy framework to interconnect NGN in Sri Lanka, it is analyzed existing technologies, standards, and practices of other countries and regions. It is analyzed the future telecommunication trends and impact to the new NGN interconnection model from those future trends. The current interconnection model and future predicted network structure in Sri Lanka is analyzed in order to make sure the proposing interconnection structure is a future proof one. It is selected one major mobile telecommunication operator in Sri Lanka and analyzed the characteristics of traffic distribution. It can be identified that traffic distribution of selected operator is correlated with population distribution in Sri Lanka. Therefore it is proposed a new interconnection topology to Sri Lanka based on that traffic analysis.

It can be identified that more than 50% of traffic is originated and terminated in same region. Therefore it is proposed five regional interconnection hubs with ENUM registries for Sri Lanka. Interconnection hubs are positioned at population centers not in geographical centers. It is proposed to mandate every operator to connect in to interconnection hub. Interconnection hub will be managed by TRCSL as independent non for profit entity. The view of TRCSL on proposed model and regulatory framework is taken and analyzed at the end.

Keywords: Next Generation Network, Interconnection, Regulatory & Policy Framework

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ABBREVIATIONS

NGN- Next Generation Networks

PSTN-Public Switched Telephone Networks

GSMA- Global System for Mobile Association

IP-Internet Protocol

IPX- IP Exchange

VoIP- Voice over IP

CPNP- Calling party network pays

CPP-Calling party pays

RPP- Receiving Party Pays

EBC -element base charging

UC-Unified communication

MGW- Media Gateway

SGW- Signaling Gateway

SBC- Session Border controller

IPX- IP Exchange

GRX- GPRS Roaming Exchange

QoS- Quality of Service

OPEX- Operation Expenditure

SPIT- Spam over IP telephony

DoS– Denial of service

NBN– National Broadband Network

UNWP– Uniform National Wholesale Price

POI- Point of interconnection

LTIE -long-term interests of end-users

ACCC- Australian Competition and Consumer Commission

RACS- Resource and Admission Control Subsystem

CHAPTER 1
INTRODUCTION

1.1 Background

When the global telecommunication market is considered, number of mobile subscribers overtook that of the fixed networks in year 2002. At the present the growth of mobile network is several times higher than fixed networks. Therefore IP becomes unified carrying network for all these networks. So Most of the networks are migrated from a TDM-Based PSTN to a packet based NGN.

Technological and market forces are driving network operators and electronic communication service providers throughout the world to migrate their networks to an Internet Protocol (IP) basis. In most of the world, the resultant networks are referred to as Next Generation Networks (NGNs). At an abstract level, one might imagine that a change in underlying technology would have little impact on regulation. However this evolution to a packet based network (generally based on the IP protocol) implies substantial changes throughout the entire value chain of electronic communications service provision, and thus implicates significant challenges for regulators. Different regulators in different countries are finding somewhat different solutions to these challenges.

Interestingly, the telecommunication service providers consider NGN as a means of significantly reducing their network operating costs and complexity, while on the other hand, the market players from the IT world believe that NGN has the potential to change and revolutionize the organizational model of the entire communication network.

One of the main issues is to determine the most appropriate interconnection model, which could possibly be based on IP interconnection model such as peering, transit and multilateral hub or possibly could be some form of modified PSTN interconnection and tariff regime.

1.2 Research Problem

One of the most important parts of NGN regulation is interconnection with other networks. Regulation and policy framework should be clearly defined in following interconnection scenarios.

I. Interconnection with PSTN fixed and mobile networks
II. Interconnection with existing IP-based networks

1.3 Importance of the chosen problem

The Government of Sri Lanka has received a grant from the Institutional Development Fund (IDF) of the World Bank to develop its knowledge base and implementation capacity, enabling it to design and implement the second generation of regulatory reforms in the Information and Communication Technology (ICT) sector. This project will be implemented by TRCSL. TRCSL has published a Policy and Regulatory Framework for Next Generation Networks in Sri Lanka on 1st of September 2013. TRCSL publishes below incentives to interconnect in Sri Lanka.

"The current interconnection and access regulatory regime in Sri Lanka was created in the era of traditional telephony-based operators. However, as service, including voice, migrates to NGNs, this interconnection model may become increasingly obsolete as internet interconnection is based on commercial negotiation and may involve unpaid exchange of traffic.

NGN interconnection results in exchange of higher levels of internet traffic, which may increase the significance of IXP (Internet Exchange Point). In Sri Lanka, a number of operators have created exchange points for commercial reasons but international best practice is to establish an independent IXP. The issue of establishing a virtual IXP is under study by the TRCSL and will be a topic of discussion for the NGN Advisory Committee." [22]

Therefore I have taken this opportunity to prepare a policy and regulatory framework for NGN interconnection in Sri Lanka.

1.4 Objective of the Research

I. To perform literature survey about NGN interconnection models
II. To propose a NGN interconnection model suitable to Sri Lanka
III. To propose a policy and regulatory framework for NGN interconnection

1.5 Scope of the Research

I. Analysis about currently existing models to interconnect NGN
II. Analysis about provisions need to be kept to an interconnection model in order to support future technologies
III. Analysis about current and future predicted network structure of Sri Lanka
IV. Proposing a new model to interconnect NGN in Sri Lanka
V. Proposing a new regulatory and policy framework to interconnect NGN in Sri Lanka

CHAPTER 2

EXISTING MODELS TO INTERCONNET NGN

2.1 Results of Literature Survey

It could be able to find some academic research papers which analyses NGN interconnection models and NGN interconnection regulatory and policy framework. But there were lot of consultancy papers, discussion papers and white paper which were written on NGN interconnection. Also researches performed by ITU are referred in literature survey.

The ITU T defines a Next Generation Network (NGN) as:

"A packet-based network able to provide telecommunication services and able to make use of multiple broadband, QoS-enabled transport technologies and in which service related functions are independent from underlying transport-related technologies. It enables unfettered access for users to networks and to competing service providers and/or services of their choice. It supports generalized mobility which will allow consistent and ubiquitous provision of services to users".

Findings of literature survey can be analyzed under following main aspects.

1. Interconnection between PSTNs
2. Interconnection of a NGN with a legacy PSTN Network
3. Interconnection between NGNs
4. Migration from PSTN to NGN
5. NGN interconnection topologies
6. GSMA IP Exchange Vs. Interconnect Exchange
7. National NGN interconnections regimes of different countries
8. NGN interconnection charging models

2.2 Interconnection between PSTNs

The public switched telephone network (PSTN) is the aggregate of the world's circuit-switched telephone networks, that are operated by national, regional or local telephone operators providing infrastructure and services for public telecommunication. The PSTN consists of telephone lines, fiber optic cables, microwave transmission links, cellular networks, communications satellites, and under-sea telephone cables. All are interconnected by switching centers, thus allowing any telephone in the world to communicate with any other. The PSTN is now almost entirely digital in its core network and includes mobile and other networks as well as fixed telephones.

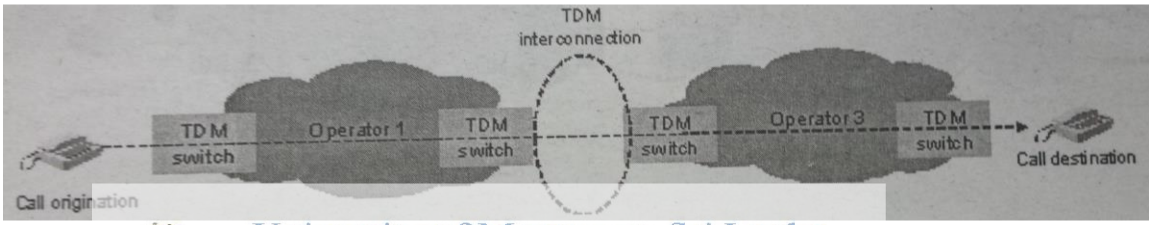


Figure 2.1- Typical interconnection between PSTN operators [Source: Analysys Mason]

The call can either go directly from Operator 1 to Operator 3 if direct interconnection exists between the two operators or has to go through a transit operator.[22]

The Key network element is TDM switches which perform both the signaling and transport functionalities. TDM switches of operators which connecting clients are usually referred as Class 5 switches. In marked contrast, if the call has to go through a transit operator, then a Class 4 switch would typically be used as the transit switch which does not need to retain any information regarding the calling party. In PSTN interconnection, it is always possible to identify the origin and destination of a call, which is not the case in data interconnection.

2.3 Interconnection of a NGN with a legacy PSTN Network

With the emergence of Voice over IP (VoIP) service, IP-based network providers are now able to compete with telecommunication operators in offering voice services. Since both telecommunication and IP-based networks use different technologies, they cannot be interconnected directly. As of today, those networks are interconnected through two intermediate elements that ensure voice and signaling translation, which are media gateways (MGWs) and signaling gateways (SGWs). Both MGWs and SGWs are usually incorporated into one piece of equipment, often known as simply a gateway. Gateways are owned by one of the interconnected operators, usually the operator of the IP-based network. The use of gateways has essentially resolved interoperability challenges, making interconnection between telecommunication and IP-based networks widespread.

There are two main types of interconnection methods that can be implemented between NGN and a legacy PSTN network.

I. TDM-based interconnection
II. IP-based interconnection

2.3.1 TDM-based interconnection

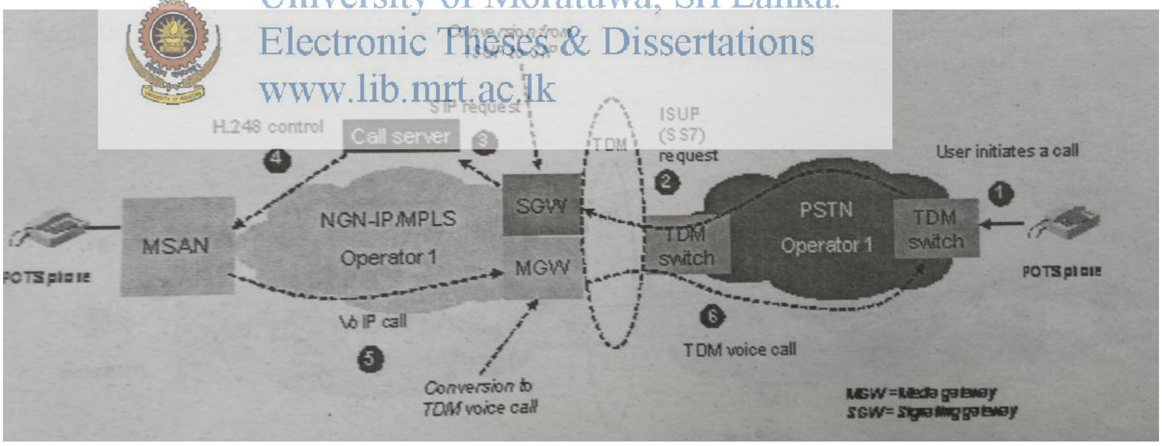


Figure 2.2-TDM-based interconnection between NGN and a PSTN [Source: Analysys Mason]

In this method, the PSTN doesn't need any additional network nodes as the translation from TDM protocol to IP. Both the signaling and media planes are carried out in the NGN at little extra cost.

2.3.2 IP-based interconnection

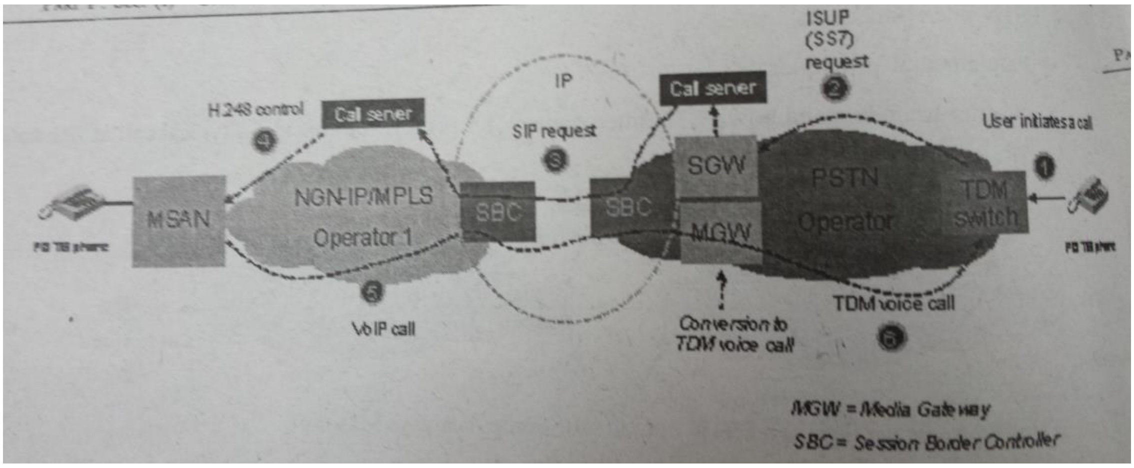


Figure 2.3- IP-based interconnection between NGN and a PSTN [Source: Analysys Mason]

The PSTN has to implement the conversion functions between the TDM protocol and IP. This means that a media gateway (MGW) needs to be put in place in the PSTN to convert TDM voice to VoIP. An additional signaling gateway controlled by a call server is also required to convert the legacy SS7 signaling message (such as ISUP) to signaling initiation protocol (SIP) or H.323 signaling message. Also a session border controller (SBC) must be added.

2.3.3 TDM-based interconnection Vs. IP-based interconnection

TDM-based interconnection	IP-based interconnection
PSTN doesn't need any additional network node	MGW & SGW needs to be put in place in the PSTN
Inexpensive to implement	Expensive to implement
Session border controller is not required	Session border controller is required

Dedicated link can provide some functions of session border controller	Session border controller can perform number of functions such as: Support for redundant physical interfaces Protocol translation Inter-working and protocol interoperability between networks Network security management Denial of service attacks and overload control Network device resources and bandwidth control Network Address Translation and firewall traversal Lawful interception Quality of Service (QoS) and SLA management

Table 2.1- Comparison of TDM based & IP based interconnection

2.4 Interconnection between NGNs

As the migration to NGN is completed, the ultimate goal is to interconnect all networks using IP, because this is more cost effective than TDM.

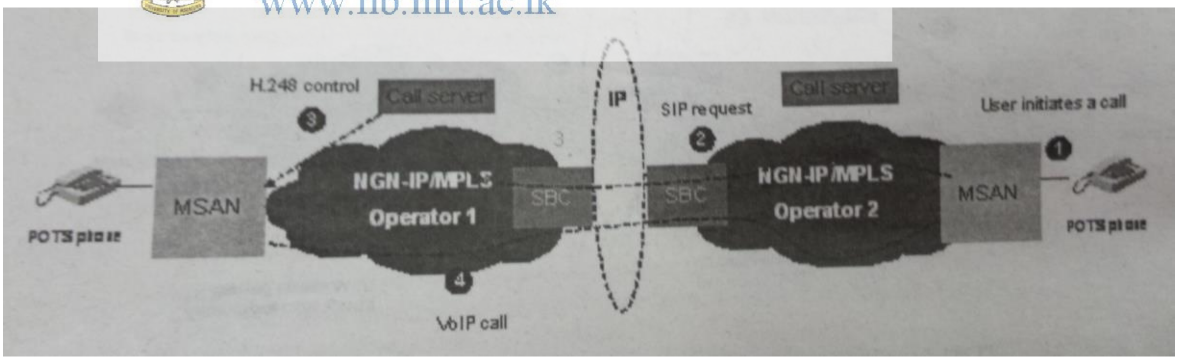


Figure 2.4- IP based interconnection between two NGNs [Source: Analysys Mason]

There are three different versions of SIP that could be used for signaling with NGNs.

I. Generation 1 – SIP- I , which encapsulates the legacy circuit switched ISUP signaling protocol within the SIP protocol
II. Generation 2 – pure SIP, where SIP is used without encapsulating ISUP

III. Generation 3 – the IMS version of SIP which is being developed by the 3GPP that is hosted by ETSI, and which will be a common protocol suitable for both fixed and mobile networks

2.4.1 Session Initiation Protocol (SIP)

The Session Initiation Protocol (SIP) is a communications protocol for signaling and controlling multimedia communication sessions. The most common applications of SIP are in internet telephony for voice and video calls as well as instant messaging all over Internet Protocol (IP) networks.

The protocol defines the messages that are sent between end points, which govern establishment, termination and other essential elements of a call. SIP can be used for creating, modifying and terminating sessions consisting of one or several media streams. SIP is an application layer protocol designed to be independent of the underlying transport layer. It is a text-based protocol, incorporating many elements of the Hypertext Transfer Protocol (HTTP) and the Simple Mail Transfer Protocol (SMTP). SIP works in conjunction with several other application layer protocols that identify and carry the session media. Media identification and negotiation is achieved with the Session Description Protocol (SDP). For the transmission of media streams (voice, video) SIP typically employs the Real-time Transport Protocol (RTP) or Secure Real-time Transport Protocol (SRTP). For secure transmissions of SIP messages, the protocol may be encrypted with Transport Layer Security (TLS) [23].

2.5 Migration from PSTN to NGN

The drivers for migrating to NGN are the same for all the players. If possible, reducing their network infrastructure and maintenance costs, but most of all, enabling faster service deployment for the provisioning of enhanced services. Therefore it creates new sources of revenue. The high flexibility, low cost and wide support throughout the world of the Internet Protocol nominates it as the best option for building NGNs, even though it has some limitations that need to be overcome, as for instance the lack of guaranteed QoS.

Each network operator will potentially choose a different migration path depending on their actual assets. This path will therefore involve different technologies and happens at different speeds.

ITU-T recommendation Y.2261 gives guidance when operator builds up a migration plan [4]. There are two technologies that support migration to NGN. Those are emulation and simulation.

- Emulation supports provision of PSTN/ISDN service capabilities and interfaces using adaptation to an NGN infrastructure using IP.

- Simulation supports provision of PSTN/ISDN-like service capabilities using session control over IP interfaces and infrastructure.

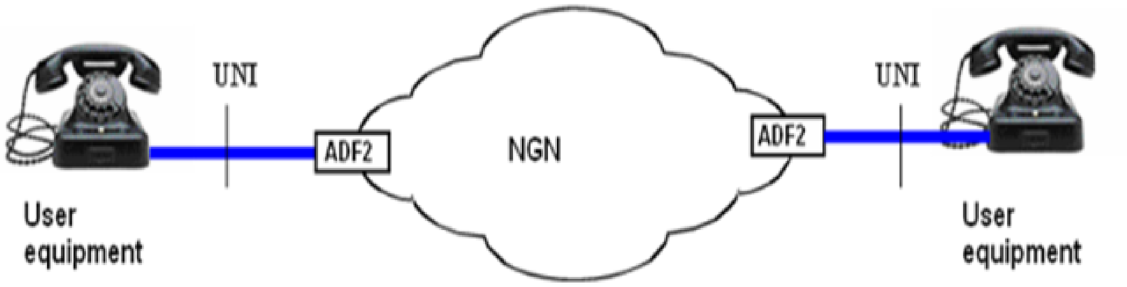


Figure 2.5- Emulation scenario [Source: ITU]

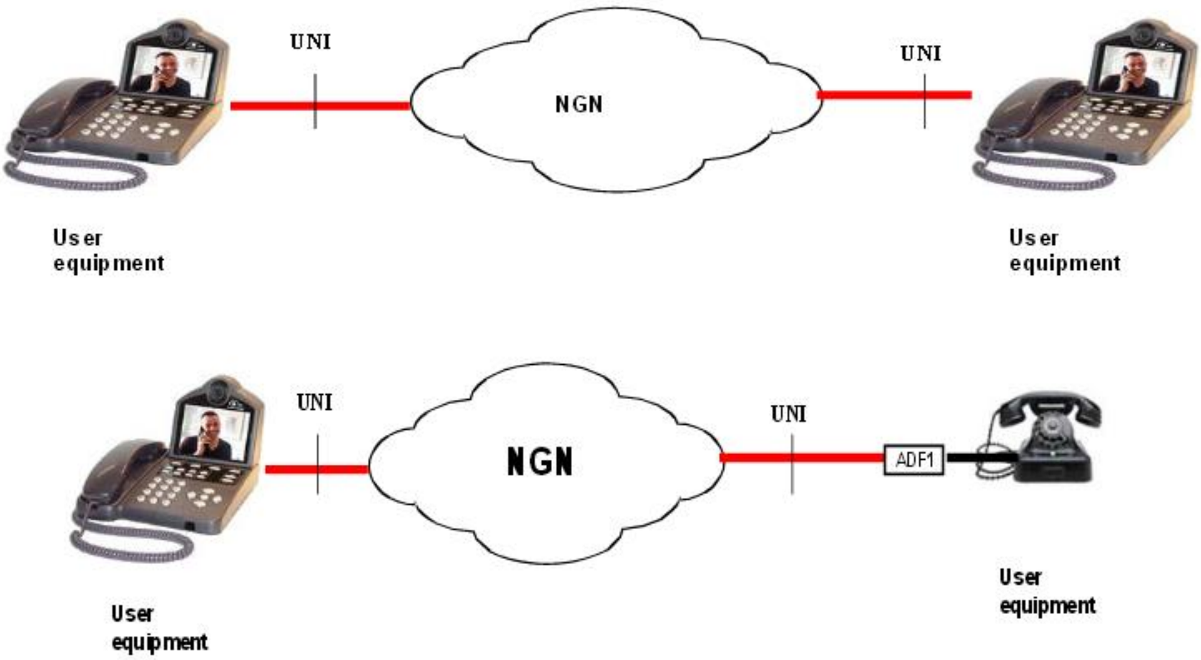


Figure 2.6-Simulation scenario [Source: ITU]

Emulation Scenario	Simulation Scenario
Provides adaptation function (ADF) for legacy terminal devices such as legacy phone connects to the NGN	Simulation is providing PSTN/ISDN like service to the NGN users
An encapsulation process	NGN user will communicate with PSTN/ISDN users using this simulation capability
All services available to PSTN/ISDN users	Availability of possible new services
User experience is not changed by the network transformation	User experience is changed by the network transformation

Table 2.2- Simulation Vs. Emulation

There are three main strategies to replace existing legacy networks by NGNs.

1. Replacement strategy
2. Overlay strategy
3. Mixed strategy

2.5.1 Overlay migration strategy

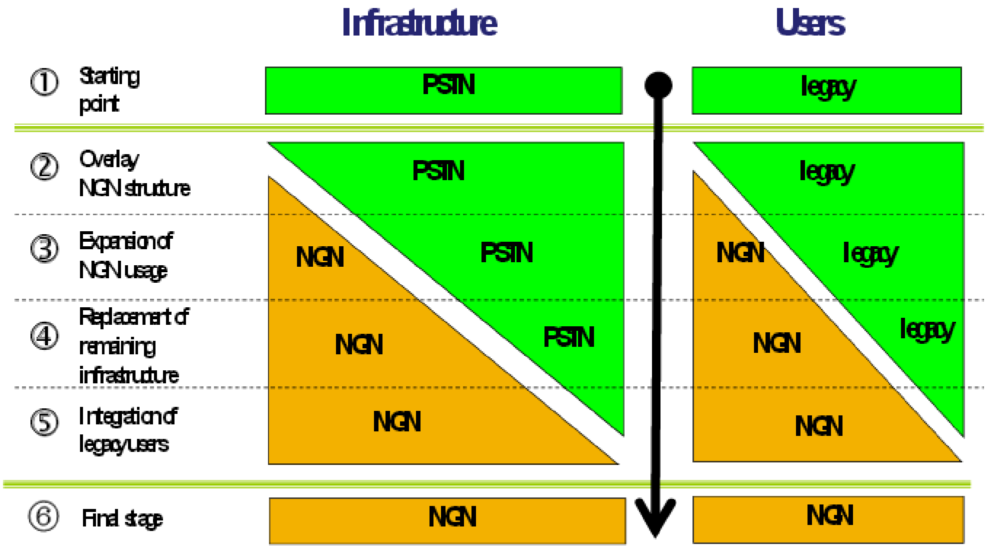


Figure 2.7- Overlay Migration Strategy [Source: ITU]

2.5.2 Replacement migration strategy

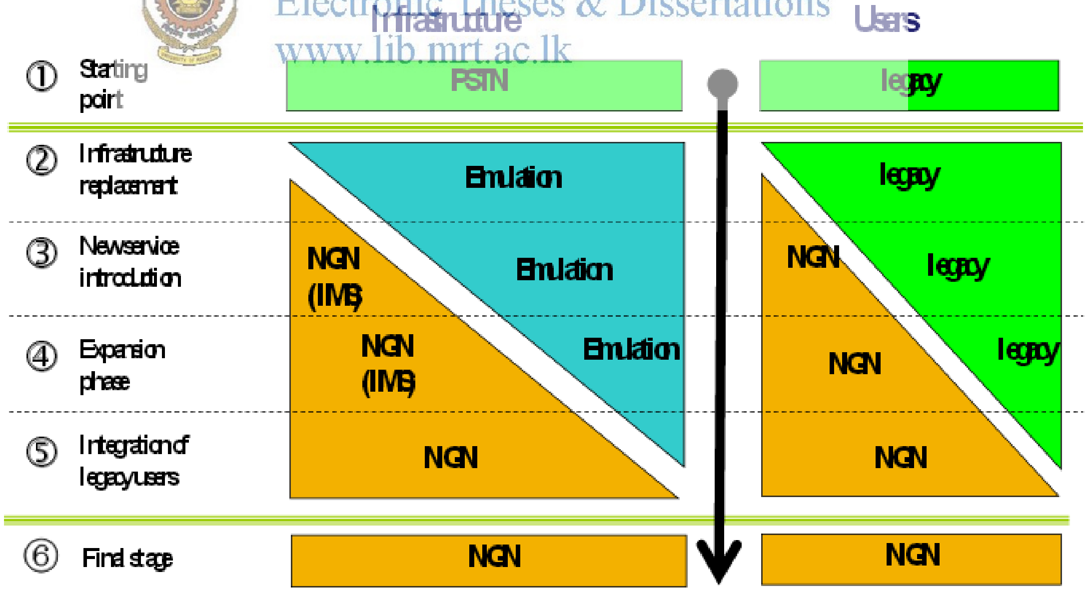


Figure 2.8- Replacement Migration Strategy [Source: ITU]

2.5.3 Mixed migration strategy

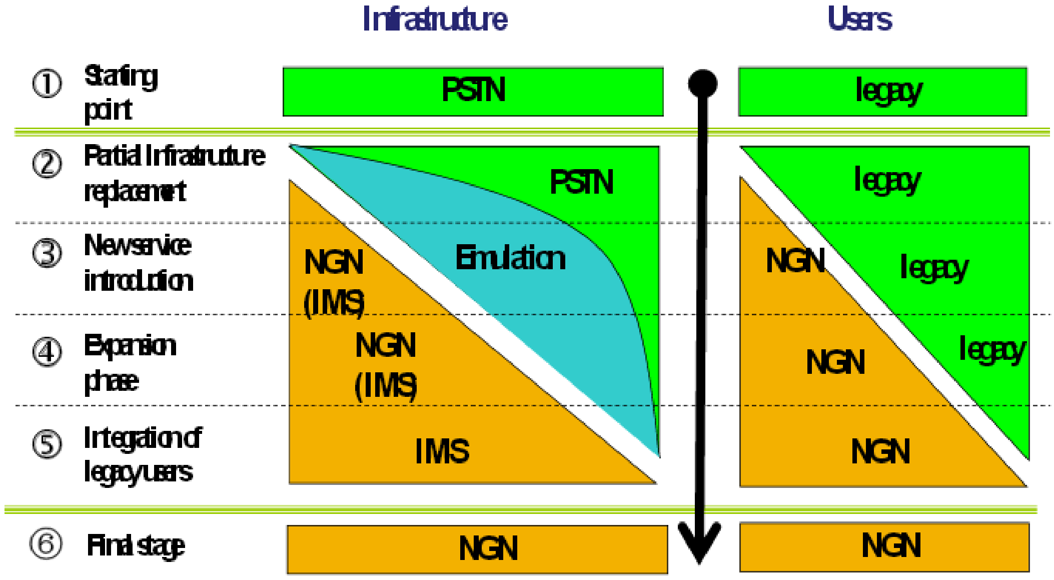


Figure 2.9 -Mixed Migration Strategy [Source: ITU]

2.5.4 Interworking using emulation and simulation

- Taking into consideration the importance of voice services, NGN voice oriented services should be linked with voice services in PSTN/ISDN environment.
- To support this requirement, emulation and simulation jointly are used for interworking between NGN and legacy networks such as PSTN/ISDN.
- It will be decided according to the interworking situation which technology would be used in which area.
- Simulation is used in NGN side while interworking with legacy side is using emulation.
- Key requirement of Emulation and Simulation technology is supporting voice oriented services.
- PSTN/ISDN is a major network infrastructure as at today to support voice services including various supplement services especially in case of ISDN.
- In addition, there are continuously increasing end users who uses voice services over legacy IP environment.

- Therefore NGN should support its voice related capabilities such as emulation and simulation to cover PSTN/ISDN and legacy IP based networks.
- Combination of these capabilities with proper interworking scenarios will help to support end user voice service requirements in the cases of end user device connected to fixed, mobile, legacy and IP based networks.

2.6 NGN interconnection topologies

Bilateral IP service peering follows a model similar to a standard PSTN interconnection, where service providers create a separate technical and commercial relationship with every other provider to which they peer. Bilateral peering works well in the PSTN environment with established and stable technical standards, a limited number of participants and simple rules for call routing. By contrast, the emerging IP services environment is less suited to bilateral peering due to the continuing evolution of standards and services.

Without a central call-routing registry, bilateral peering requires a daily exchange of data between each pair of peered carriers, so that each can maintain its own routing registry information. This process also introduces security and trust concerns, which limits scalability. Bilateral peering is viable for a number of significant direct peering relationships, but it will not facilitate more universal interconnection between the many hundreds (and soon to be thousands) of IP-enabled service providers globally.

Multilateral hub-based federations operated by neutral third parties, infrastructure vendors or wholesale service providers enable service providers to more intelligently route sessions in the most cost-effective manner and increase the reach of services for their member subscribers. Their role is to provide a central point of interconnection among like-minded operators at the signaling layer, media layer or both.

Hub-based interconnect can provide advantages for other fast growing services, including enterprise IP services such as UC and video conferencing, as well as OTT IP services, and it can have an impact on local number portability[11].

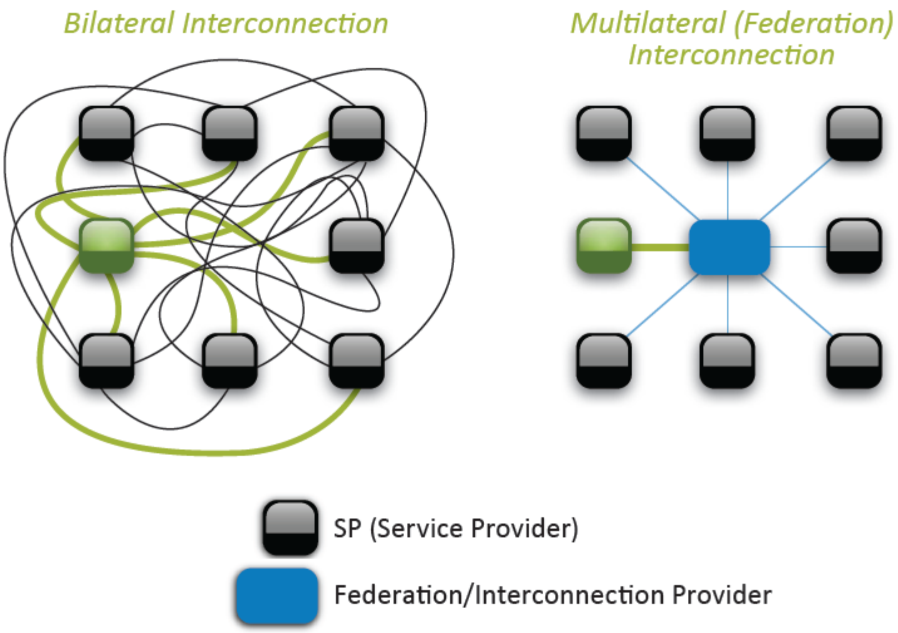


Figure 2.10-Interconnection Topologies [Source: Yankee Group]

2.6.1 Bilateral interconnection Vs. Multilateral interconnection

Bilateral interconnection	Multilateral interconnection
Inter operator IP backbone network	Communication networks interconnect indirectly
support connectivity between any type of service provider for interworking	Interconnection occurs for special session based services using a transit operator
A range of IP service on a bilateral basis with end to end QoS	Interoperate IP backbone network with guaranteed QoS
	Transit service is multilateral

Table 2.3-Bilateral Vs. Multilateral Interconnection

2.7 GSMA IP Exchange Vs. Interconnect Exchange

2.7.1 GSMA IP Exchange

The GSMA IP exchange (IPX) builds on the GRX concept by incorporating connectivity to non-GSM service providers such as fixed line operators and application providers. But the IPX also leverages the infrastructure and experience with circuit-switched and packet-switched interconnects as well as the conversion being done today between the two technology domains. While the IPX concept has been around for several years, the integration of IP connectivity standards, commercial interconnection models and attention to QoS provides a foundation for seamless interconnection of IP-based services between different types of service providers.

The IPX enables service providers, regardless of the type of network they operate, to exchange IP packets in a manner that supports several commercial and technical goals. The IPX is not the public Internet, nor does a portion of the services provided by the IPX go over the public internet. The customers of IPX operators are service providers, but the IPX is more than just what has historically been termed as a "carrier's carrier network."

The IPX provides multiple connectivity options such as IPX transport and service transit interconnect. The multilateral IP service hub arrangement enables a service provider to connect to multiple termination providers through a single connection between it and an IPX operator. What that effectively allows the service provider to do is to deliver end-to-end services to their customers without the need to establish individual bilateral connections and agreements with each of the hundreds of fixed and mobile operators around the globe. However, bilateral arrangements are also supported through an IPX, in case that particular interconnection model makes the best sense.

The IPX architecture is also service aware as such it enables the IPX operator to provide specific service level SLAs for the more standardized offerings. While the GRX was primarily volume-based from a charging perspective, the IPX has additional charging models, as well as support for both bilateral and multilateral commercial arrangements, and it incorporates the concept of cascading payments. What that implies is all participants in the service delivery supply chain can charge accordingly for their contribution and value-add in the form of transport and usage-based pricing elements.

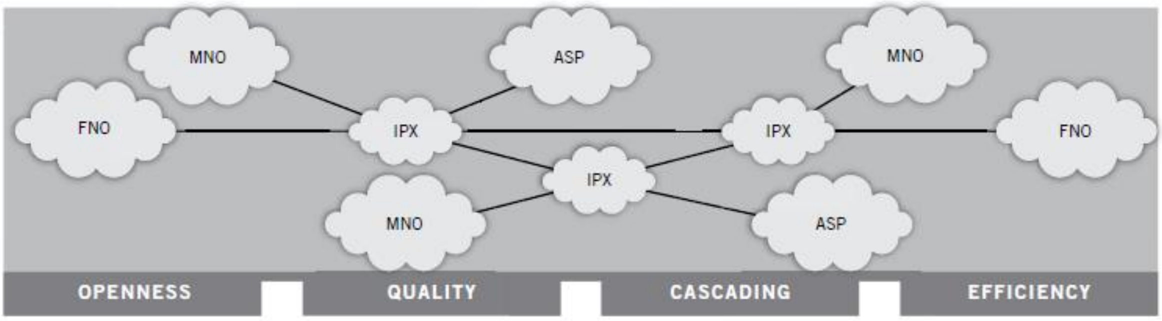


Figure 2.11 - Architecture of IPX [Source: Dialogic]

The IPX concept is standards-driven and is built upon some key concepts which are Openness, Quality, Cascading Payments and Efficiency [13].

I. Openness is foundational to the IPX concept in that any operator willing to meet the standards for QoS and IP interconnectivity can connect to the IPX, not just GSM operators.

II. Quality is the ability to provide end-to-end performance and reliability on a per service basis at both the service layer and transport layer. IPX participants are required to execute agreements that actually define the service, establish the hand off points, and formalize performance levels based on the QoS required for the traffic.

III. Cascading payments are supported for specific services in the IPX and described in the individual service definitions so that participants in the value chain can charge accordingly.

IV. Efficiency comes into play from a connectivity standpoint. The application of a multilateral interconnection model provides an efficient means for service providers to extend connectivity in a secure and deterministic manner to other service providers over one connection.

The IPX provides a framework for mobile, fixed and converged service providers to connect disperse networks. Service providers currently doing TDM and VoIP interconnect and termination opportunities for enhancing their revenue streams.

From an architectural perspective, the IPX is divided into two layers. The Service Layer that provides the hub and transit capabilities for a service such as voice, and the Transport Layer, which provides the communications path to support the end to end service.

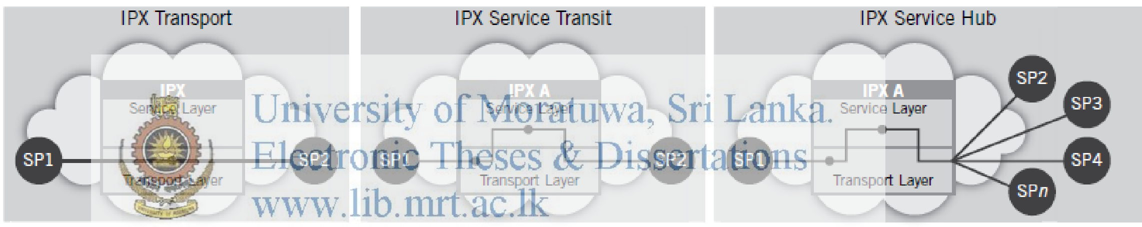


Figure 2.12 - Connectivity Models of IPX [Source: Dialogic]

There are three types of connectivity models established in the IPX, each of which can support specific interconnect between service providers. The first interconnect type is IPX Transport, which is basically a bilateral transport layer connection between two service providers. In this connection option, the IPX operator basically provides a pipe and no service level visibility or service level QoS, although transport level SLAs is supported.

The next level of interworking is the bilateral IPX service transit arrangement. This interworking model is service aware and can leverage IPX proxy services along with the transport layer services. End-to-end QoS for both the Service and Transport Layer is supported. This arrangement can include not only transport charge elements but also service usage based charging, e.g., minutes of use. IPX operators are required to support cascaded charging in this scenario in the event that more than one IPX network is necessary to provide the end-to-end connectivity.

The third type of connectivity mode is multilateral hub. This is driving lot of interest in the IPX. The IPX Service hub model provides multilateral connectivity that is service aware and has guaranteed end-to-end QoS. In this model, the service provider needs only to have one agreement and one connection to the IPX operator, and through that connection, can gain access to multiple other service providers. In this case, cascading payments apply as well. A multilateral arrangement with only one connection to the IPX can help to reduce OPEX and improve efficiency by greatly reducing the need to manage and negotiate multiple bilateral agreements as well as reducing the need to support the associated physical interconnections and peering points.

The IPX service transit and IPX Service hub arrangements utilize an IP proxy service to support service awareness and cascading charges. So what specifically constitutes an IP Proxy? It depends on the service and how it is defined, but for the most part, an IP proxy is defined by the functions it performs, which can include:

• Accounting and CDR generation
• Security from the standpoint of supporting blacklists
• The ability to process both the user and control plane for a given service
• Access Control Lists
• IPv4 to IPv6 interworking
• Media transcoding
• Signaling interworking
• Routing lookups
• Transparency from a service perspective
• Route identification

An IPX with IP proxy capabilities allows the IPX operator the ability to offer the connectivity model that best suits its customer's needs, and gives service provider customers more options from a connectivity standpoint.

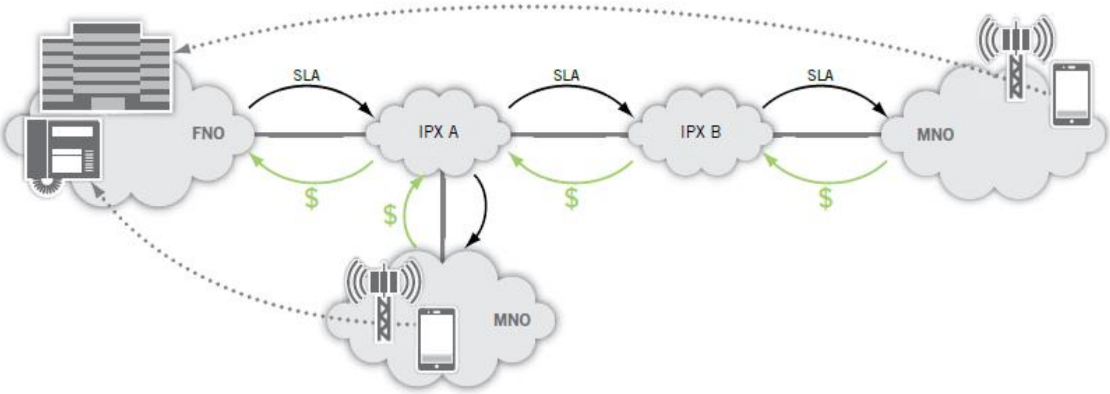


Figure 2.13 - Cascading revenues and SLAs [Source: Dialogic]

Support of cascading payments is a critical feature of the IPX framework. The current model for terminating voice is well understood by service providers. From a charging perspective, "calling party pays", transit charges, and usage based pricing are used in the IPX for conversational services such as voice, and each participant in the service delivery supply chain is compensated for their portion of carrying the traffic. Along with the "calling party pays" concept, there are other commercial charging models that can be applied to a service, for example "called party pays", session-based pricing, event-based pricing and so on. The "calling party pays" charging model is a core aspect of the IPX commercial framework and it helps drive usage and limit spamming. As part of the cascading revenue model, the serving IPX operator is responsible for the other participants in the value chain used to connect the session to the appropriate terminating network. This includes any other IPX intermediary operator, if used in completing the end-to-end service. The SLA for a given service is established across the IPX operator's network between the agreed upon demarcation points. Since the IPX operator has the responsibility for the overall service quality, end-to-end traceability of the service flow is important to providing QoS and maintaining a good user experience. With established SLAs, measuring performance becomes easier.

2.7.2 Interconnect Exchange

We are entering a period of time in which next-generation hub-based IP interconnection models will become a critical success factor and TDM interconnections will become a dead end. Next-generation hub-based IP interconnect exchanges should not be confused with Internet peering or Internet exchange (IX) peering points where Internet networks are interconnected. An IP IX only provides standard IP/Ethernet Layer 1/2/3 network layer interconnects where IP packets are exchanged. An interconnect exchange will provide additional services beyond the network layer, such as service-aware protocol interworking and interoperability, ENUM registry, security, identity and commercial/clearinghouse functions.

The benefits of IP services come with new security risks such as toll fraud, identity theft, and spam over IP telephony (SPIT) and denial-of service (DoS) attacks. Traditional network security measures like firewalls and intrusion prevention systems (IPSs) mitigate some of those risks, but they are not designed to handle complex signaling/media sessions using protocols such as SIP. IP-to-IP interconnect requires some interworking in cases where different SIP signaling variants or the legacy H.323 protocol are used by IP network elements.

Soon, consumers and enterprises will require critical services delivered over IP. The inevitable adoption of IP services is good for service providers, who will reap economic value from the services' popularity. The realities of an iterative transition of this magnitude are complex. Hub-based IP interconnect can help reduce many of the complexities by providing a ready-made environment to maximize service reach and interconnection costs. By combining interoperability services with ENUM, interconnection delivers the features, quality and cost benefits of IP and eliminates use of the PSTN as the medium through which calls are delivered between operators. Service providers face a number of critical investment decisions about how best to manage the transition to IP in order to maximize profitability of existing services, minimize operational complexity and open the doors to new services and business models not yet commercialized. One of these critical decisions is choosing the methods for interconnection of IP services [11].

A hub-based provider of ENUM registries and multi-protocol, multi-vendor VoIP/NGN interconnection infrastructure can enable communications service providers to join multilateral interconnection relationships with IP service providers, either at the regional level or around the globe.

2.7.2.1 ENUM History and Definitions

ENUM began when the IETF Telephone Number Mapping Working Group set out to define a domain name system (DNS)-like architecture and protocol for mapping a traditional E.164 telephone number to an IP address via Uniform Resource Identifier (URI). This process of association between telephone number and IP address is very similar to the way in which URL addresses are resolved to IP addresses through DNS infrastructure supplied via the Internet. While this appears to be a rather straightforward proposition, the term ENUM often leads to confusion, given all the different types of ENUM in the marketplace and how they relate to intra-carrier peering architectures.

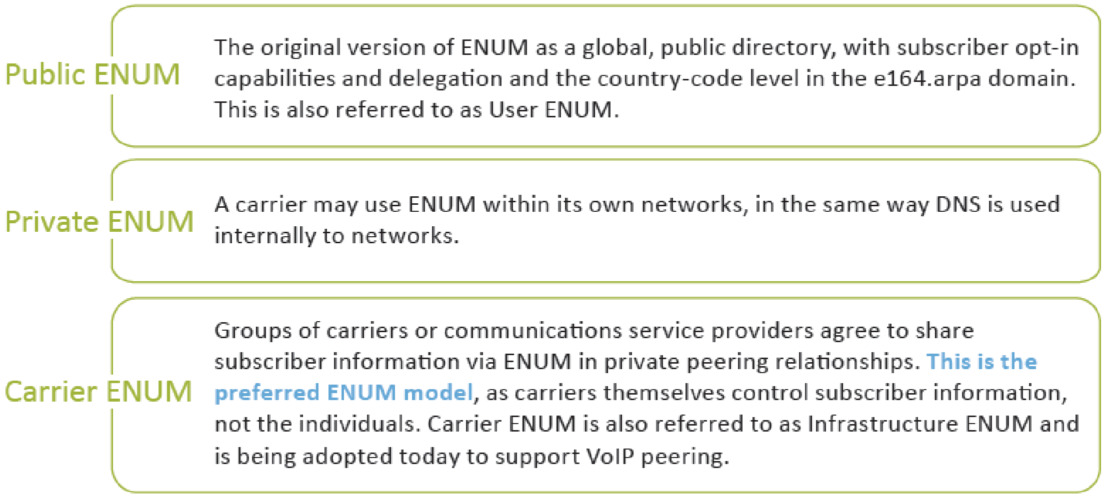


Figure 2.14 - ENUM Definitions [Source- Yankee Group]

Proponents of ENUM have adopted the benefits of operational cost savings and service quality made possible by avoiding traditional PSTN routing infrastructure (i.e., SS7) to complete VoIP calls destined for a non-local VoIP endpoint. For some, this has been a benefit in search of a problem to address, as the islands of VoIP have been small enough that the percentage of originating VoIP calls that are actually destined for an IP endpoint are sufficiently small estimates range from 15 percent to less than 5 percent of overall call volume, depending on the operator. From a wholesale interconnect perspective, though, the benefits gained from direct or hub-based IP interconnect (e.g., cost, quality) are applicable for voice even if the endpoint is not IP provided, interconnect is IP-enabled [11].

Despite some clear advantages, some operators have deemed the existing SS7 routing infrastructure "good enough" and find the cost of TDM routing dips insufficiently prohibitive to motivate a move to a new model. However, this is not a static situation, as user demand and competition will force the hand of operators who have yet to commit to a hub-based peering approach. As the islands of IP grow and the number of endpoints that can consume IP services grows exponentially, several Tier 1 operators have publicly committed to a complete decommission of their PSTN infrastructure during the next several years. Furthermore, there is decreasing support for existing TDM gateway equipment as these products transition to end-of-life status.

2.8 National NGN interconnections regimes of different countries

2.8.1 Methodology used in Australia

The discussion in Australia with respect to Next Generation Networks has focused on Next Generation Access and the development of a National Broadband Network (NBN). Australia took the decision to build the National Broadband Network (NBN) as a public broadband infrastructure.

On 7 April 2009, the government announced the establishment of NBN Co that would build a national, wholesale only, open access broadband network that would be rolled out simultaneously in metropolitan, regional and rural areas.

The network would be a mix of fiber, wireless and satellite services designed to provide a basic wholesale product to retail service providers. In September 2010, the government committed to the provision of uniform national wholesale prices (UNWP) with the aim that wholesale broadband prices would be the same for households and businesses regardless of where they are located in Australia.

This implies that under the direction of the government the NBN builds layer 1 and 2 and invests up to 43 billion AUD. The goal was to enable 100 Mbit/s for 90% of the population, and 12 Mbit/s for the last 10%. The specific measures focused on have had the following characteristics [18]:

I. NBN Co builds and operates the network
II. The NBN is owned to more than 50% by the government
III. Privatization of NBN Co after 5 years of completion of the network
IV. Open access, the network is providing wholesale services to other operators on a fair basis
V. Non-discriminatory basis
VI. The NBN Co does not provide any retail services

Points of interconnection (POI) are defined in NBN network for retail service providers to connect their network for national network. Therefore all the networks are interconnected through NBN.

POI in the NBN architecture is the inter-network location where end-user traffic is handed over from the NBN onto a retail service provider’s own network or onto a transmission provider’s network for transport to the retail service provider’s point of presence. If end-user traffic is handed over to a transmission provider, the retail service provider is required to obtain the transmission capacity necessary to carry this traffic to their point of presence, usually located in a capital city.

POIs define the geographic boundaries of NBN Co's network. Their locations determine the extent to which backhaul is required by each retail service provider to carry traffic between the POIs at which they are interconnected and their point of presence. In order to achieve aggregation and distribution of traffic, the NBN POI uses switching equipment (an Ethernet fan out/aggregation switch) to aggregate/distribute traffic from/to the premises connected to the NBN [18].

NGN Co proposed three options to select POIs. Those are follows.

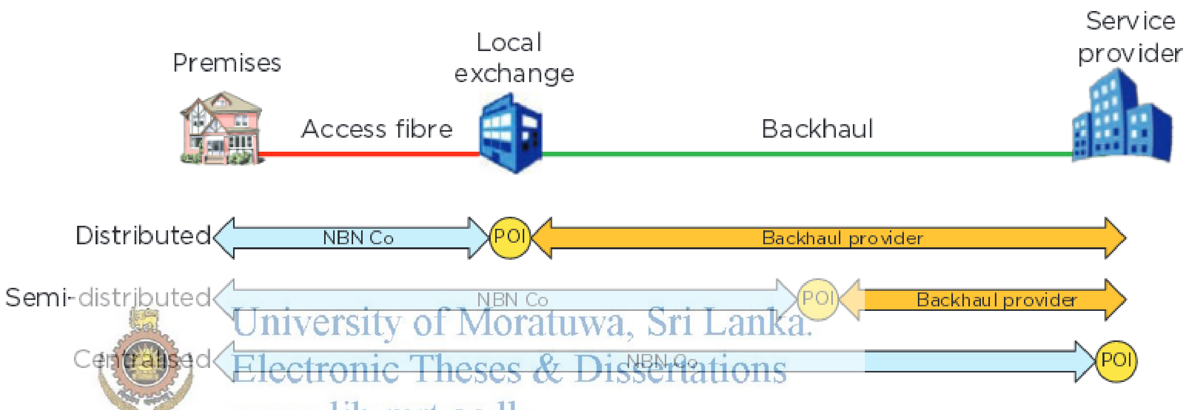


Figure 2.15 -Proposed options to select POIs in Australia [Source- Australian Competition and Consumer Commission]

Option 1—fully distributed POIs: this option would result in the largest number of POIs estimated to be between 718 and 950. This approach would likely preserve existing competition in transmission markets and theoretically provide the maximum opportunity for future competition to develop. It would also promote the efficient use of and investment in transmission infrastructure on competitive routes. However, given the likelihood of Telstra remaining in control of natural monopoly transmission routes (that is, regional routes), it considered that this could constrain the development of retail and wholesale competition in areas where Telstra was the sole provider of transmission.

Option 2—semi-distributed POIs: the number of POIs in this option could vary considerably depending on the test for identifying the POI locations. Competition in retail and wholesale markets would likely be promoted under this option, particularly in regional areas that are served by natural monopoly routes. This approach would also significantly reduce the risk of asset stranding and promote the LTIE (long-term interests of end-users).

Option 3—centralized POIs: under this option, there would only be a small number of POIs (estimated to be 14). The ACCC was concerned that the implementation of either a consolidated or composite approach (as articulated by NBN Co) would not be consistent with NBN Co's stated objective to "occupy as small a footprint as possible in the overall value chain". The extension of NBN Co's network beyond the access network to also include a transmission network would represent a considerable departure from regulatory orthodoxy—namely that regulatory intervention should only focus upon markets where competition is not effective. This option would likely have a detrimental effect on competition in transmission markets as it would result in the removal of existing competition and the foreclosure of opportunities for future competition in the relevant markets.

Option	Number and location	Rationale
Option 1: Distributed (No consolidation)	718—950 POIs	POIs are fully distributed and located at every FSA
Option 2: Semi-distributed (Low consolidation)	Indeterminate, depending on definition of contestable transmission	POIs are partially distributed, at the edge of where contested transmission currently exists
Option 3: Consolidated (High consolidation)	14 Aggregation POIs(4 x Sydney, 4 x Melbourne, 2 x Brisbane, 2 x Adelaide,	Traffic is carried to 'Aggregation POI' locations. POIs are centralized at five capital cities

	2 x Perth)	
Option 4: Composite	14 Aggregation POIs + up to ~195 CSAs	POIs available at five mainland state capital city locations, plus additional interconnection at up to ~195 Connectivity Serving Areas (CSAs)

Table 2.4 - POI selection options of Australia

Having considered each of the options, the Australian Competition and Consumer Commission (ACCC) concluded that the semi-distributed approach to identifying the initial POIs would be likely to best promote the efficient use of and investment in transmission infrastructure and to promote retail and wholesale competition across all geographic markets.

2.8.2 Methodology used in India

Telecommunication regulatory commission of India introduced bellow techniques to interconnect NGN.

Networks of two NGN operators are to be interconnected through Session Border Controller (SBC).

NGN and traditional PSTN/PLMN are to be interconnected through Media Gateway and Signaling Gateway.

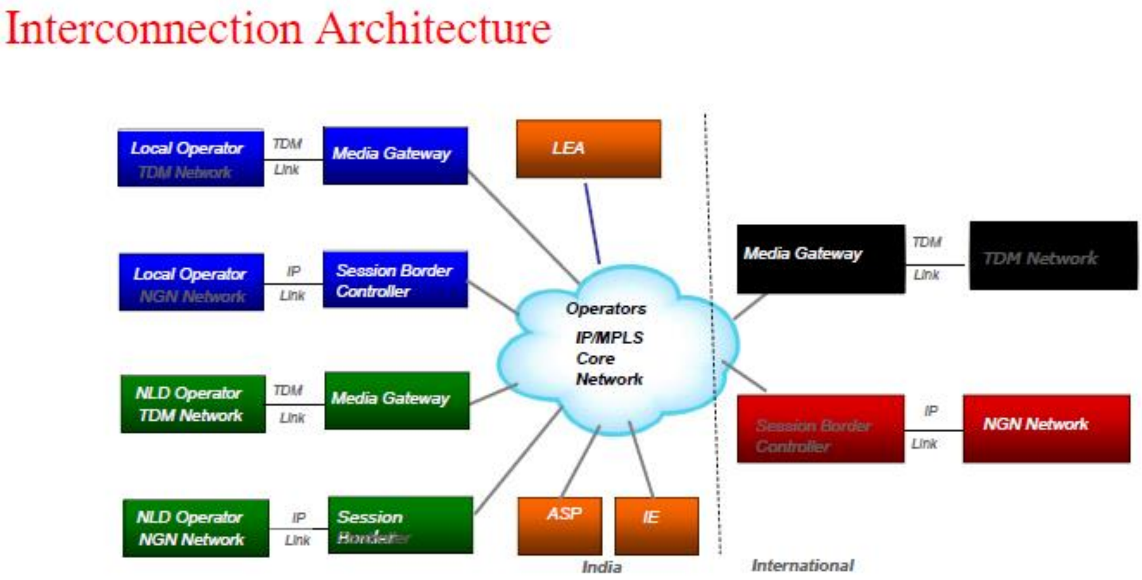


Figure 2.16 -Interconnection Architecture of India [Source : Telecommunication Regulatory Authority of India]

SBCs are located at the edge of a network for enforcing policy on multimedia sessions

SBC can perform a number of functions such as:

I. Support for redundant physical interfaces
II. Protocol Translation
III. Inter-working and protocol interoperability between networks
IV. Network Security management
V. Denial of Service attacks and overload control
VI. Network device resources and bandwidth control
VII. Network Address Translation and Firewall Traversal
VIII. Lawful Interception
IX. Quality of Service (QoS) and SLA management
X. Call accounting

The following standards based signaling protocols are expected to be supported by Next Generation Network (NGN):

Signaling Protocol	Application
SIGTRAN	Between PSTN/PLMN and IP networks
H.248	Between Media Gateway and Media Gateway Controller
SIP,SIP-T/SIP-I	Between two IP networks and between PSTN/PLMN & IP
H.323,SIP-T/SIP-I	For international connectivity
RTP/RTCP	For delivery of content (voice/data/video etc.) , protocol is to be used

Table 2.5- Signaling Protocols used in India

There are two points of interconnection

I. Interconnect Exchange (IE)
II. Peer to peer

Role of Interconnect Exchange can be given as follows.

1. Inter-Carrier billing clearing house
2. Intelligent Network Services
3. Number Portability
4. Carrier Selection
5. Simplification of network architecture

Following concerns are addressed when deciding locations of POIs (Points of Interconnect)

1. It is common for both the peering partners to have TDM based switches at the POI locations.

2. Should the NGN access operator be allowed to have the option of either centralized control point in its network controlling the distributed media gateways or SBCs within the service area without violating any license condition including lawful interception?

3. Should the National Long Distance (NLD) operator be allowed to have centralized control point for the entire country and may place media gateways and/or SBCs anywhere in the country, wherever POIs are desired?

4. Should the International Long distance (ILD) operator may be allowed to have centralized control point for the entire ILD traffic and may be allowed to place media gateways/SBCs within India only? It may then be allowed to backhaul signaling links from outside India to the control points.

5. The requirement of a Signaling point code should be restricted to the control point (Soft switch/ Signaling Gateway) only. This would also help to save the scarce point codes [4].

2.8.3 Methodology used in Hong Kong

Industry need to adopt global standards and adapt for local conditions – no need to regulate [1].

Quality of service (QoS) standards can be left to the market.
Public interest case for a minimum voice QoS, but Operators will naturally seek to equal to that provided on circuit-switched networks.
Move from bilateral agreements to IP exchange points (IXPs).

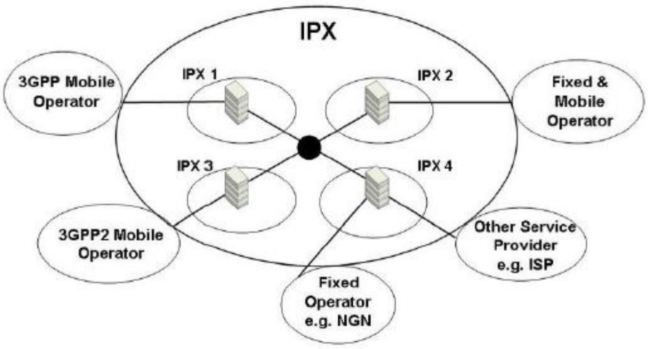


Figure 2.17- Interconnection topology of Hong Kong [Source: ITU]

2.8.4 Methodology used in Malaysia

Malaysia used Interworking Function (IWF) node to interconnect both NGN and legacy networks.

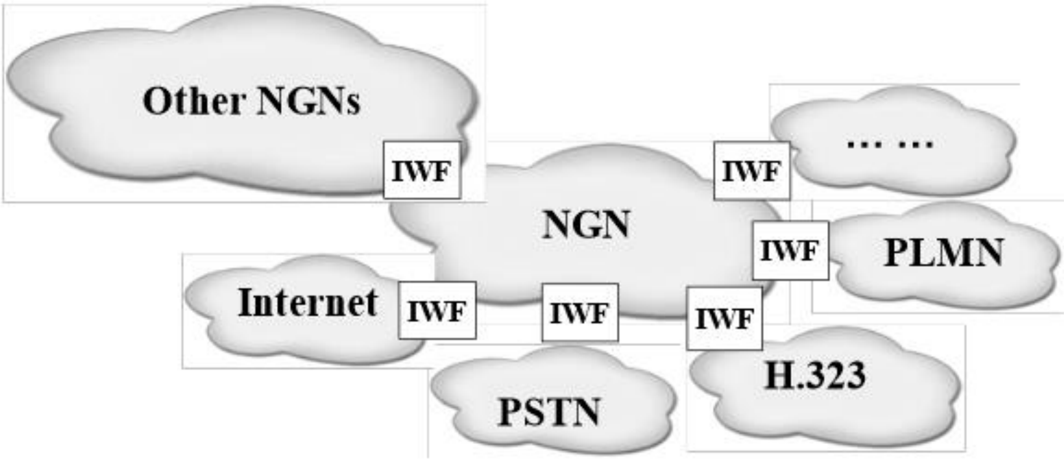


Figure 2.18- Interworking of different types of networks in Malaysia

From ITU-T Recommendation Y.GRM-NGN, it has already been established that the NGN can be divided into two layers in horizontal and three planes in vertical simply. The functions for IWF between NGNs will be distributed in all planes and layers.

The functions for interworking between NGN1 and NGN2, for either service interworking or transport interworking, are provided by an interworking function (IWF) considered to notionally existing between the NGN1 and NGN2, as shown in Figure 2.18. The exact physical location of the interworking unit (IWU) containing the IWF is an implementation issue, but could be contained within NGN1, NGN2, or as an independent unit. IWF should differ from each other in the condition that they are located between different two networks.

In service interworking, the Interworking Function (IWF) of Figure 2.18 terminates the protocol used in network 1 and translates (i.e., mapping) the Protocol Control Information (PCI) to the PCI of the protocol used in network 2 for User, Control and Management Plane functions to the extent possible. In general, since not all functions may be supported in one or other of the networks, the translation of PCI may be partial or non- existent. However, this should not result in any loss of user data since the payload is not affected by PCI conversion at the service interworking IWF.

In transport interworking, the PCI of the protocol used in both of NGNs and the payload information are transferred transparently by an IWF of Figure 2.18. Typically the IWF encapsulates (known as tunneling in some specifications) the information that is transmitted by means of an adaptation function and transfers it transparently to the other network.

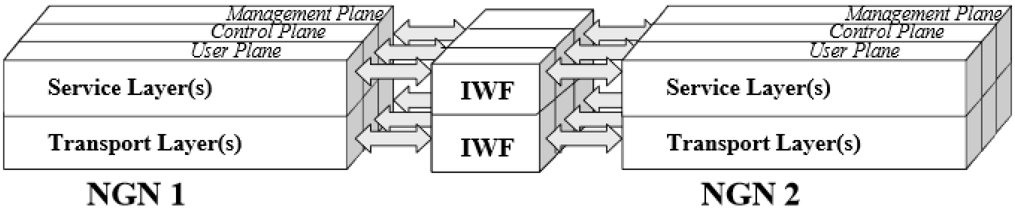


Figure 2.18- Interworking function

Functions of IWF is as follows

1. User plane's interworking has responsibility for media flow processes, such as NAT, firewall, link mapping, QoS-relative processing and codec converting etc.
2. Control plane's interworking has responsibility exchange processing, such as connectivity control, service logical control, user policy negotiations, calling signaling, addressing and routing etc.
3. Management plane's interworking is commonly used for operating when necessary, such as settlement, bandwidth limitation policy and usage measurements etc.
4. IWF can differ from each other when located in different layers

Malaysia uses a self-regulating strategy regarding positioning and management of IWF.

2.8.5 NGN interconnection comparison between countries

Country	Provision of QOS
Australia	Developing guideline for carriage service providers (including ISPs) on IP network QoS. Guidelines are as follows. 1. Define a default set of IP network QoS classes 2. Address performance levels for IP packet delay, jitter and loss 3.Address IP packet prioritization for implementing the IP network QoS classes (e.g. through the use of packet marking and handling) Developing guideline for Australian VoIP service providers and end users. Guidelines are as follows. 1. Provide a measure of VoIP quality in a usable format for end-users (e.g. a rating based on the ETSI E-model) 2. Consider IP Network QoS service classes and requirements 3. Consider interworking with existing voice networks (e.g. PSTN/ISDN) 4. Consider standards and requirements for VoIP QoS
India	Provide different QoS for bellow three main service types 1. Best effort services 2. Differentiated services 3.Guranteed services
Hong Kong	Not defined specific QoS requirements Quality of service (QoS) standards can be left to the market

Table 2.6-Provision of QoS

Country	Security
Australia	Mainly considered bellow areas to ensure security 1. Authorization e.g. deciding who should have premises ion to access/use the equipment, permission to make changes to its configuration (and in doing so, possibly affect protection against attack) 2.Authentication e.g. processes such as using password ds for logging in, restricting physical access in order to secure and protect networks, equipment, services and applications 3.Identification e.g. confirming that the person or organization one is dealing with is actually the one being represented online. Alternately, protecting against identify theft and theft of personal information.
India	Component of NGN security 1. Network domain security 2. IMS access security 3.Application security 4.Security of open services/ application frameworks ITUT- SG 13,16 ,17 recommendations are considered

Table 2.7-Security

Country	Point of Interconnection
Australia	Semi-distributed POIs the number of POIs in this option could vary considerably depending on the test for identifying the POI locations. Competition in retail and wholesale markets would likely be promoted under this option, particularly in regional areas that are served by natural monopoly routes. This approach would also significantly reduce the risk of asset stranding and promote the LTIE (long-term interests of end-users).

India	Following concerns are addressed when deciding locations of POIs (Points of Interconnect) 1. It is common for both the peering partners to have TDM based switches at the POI locations. 2. Should the NGN access operator be allowed to have the option of either centralized control point in its network controlling the distributed media gateways or SBCs within the service area without violating any license condition including lawful interception? 3. Should the NLD operator be allowed to have centralized control point for the entire country and may place media gateways and/or SBCs anywhere in the country, wherever POIs are desired? 4. Should the ILD operator may be allowed to have centralized control point for the entire ILD traffic and may be allowed to place media gateways/SBCs within India only? It may then be allowed to backhaul signaling links from outside India to the control points. 5. The requirement of a Signaling point code should be restricted to the control point (Soft switch/ Signaling Gateway) only. This would also help save the scarce point codes.

Table 2.8- Point of Interconnection

Country	Interconnection Topology
Australia	Points of interconnection (POI) are defined in NBN network for retail service providers to connect their network for national network. Therefore all the networks are interconnected through NBN. In order to achieve aggregation and distribution of traffic, the NBN POI uses switching equipment (an Ethernet fan out/aggregation switch) to aggregate/distribute traffic from/to the premises connected to the NBN
India	1. Interconnect Exchange (IE) 2. Peer to peer
Hong Kong	Move from bilateral agreements to IP exchange points (IXPs).

Table 2.9-Interconnection topology

Country	Investment strategy
Australia	NBN Co to build a national, wholesale only, open access broadband network that would be rolled out simultaneously in metropolitan, regional and rural areas.
India	Government Invested on Interconnect Exchange
Hong Kong	Total investment is done by private sector

Table 2.10-Investment Strategy

2.9 NGN interconnection charging models

Currently different wholesale charging principles are used. Such as element based distance dependent, capacity based, bill and keep etc. For retail, different charging schemes are used as CPP and RPP which impacts the wholesale termination fees (CPP termination leads to a problem that is known as the termination monopoly).

The transition towards NGNs entails several structural changes. Each transition stage implies a change in the topology of the networks in terms of the kind and number of elements used as well as their geographic position within the network. The fact that it is expected that less elements will be used as compared to TDM networks, impacts directly CAPEX and OPEX and therefore the wholesale tariffs. Furthermore NGN interconnection may be differentiated according to quality of service classes or not differentiated at all.

A main difference between TDM networks and NGN architecture is the separation of the main functional levels. This means a clear separation of transport, control and service layers. Therefore, transport, control and service layers can be technically and commercially separated and provided by different market players. Thus, unlike TDM networks, interconnection costing methodologies may apply for each layer. This fact may lead to more segmented interconnection market products and more interconnection markets to analyze for Ex-ante regulation purposes.

2.9.1 Issues regarding interconnection charging and regulation

I. Regulation of charges
   a. Interconnection is mandated for all operators both dominant and other operators
   b. What is regulatory approved rate?
   c. Should price cap and/or symmetry obligation?

II. Charging regime
   a. Which charging regime should be used?
   b. Calling party network pays (CPNP/CPP), bill & keep or other regime?

III. Charging unit
   a. If interconnection traffic is paid for, which charging unit may apply?
   b. Time based (minute) charges?
   c. Volume based (bit/s) charges / Capacity based charges?

Cost driver in NGN is bits in peak and not call minutes. Therefore following main points should be considered when developing charging unit for NGN.

I. A change in charging unit to bits/s would better reflect the costs than minutes
II. Due to generally low net payments (low rates combined with reasonably symmetric traffic) and the effort needed to change charging unit (regulatory procedure, negotiations), removing the compensation for traffic (B&K) is a viable alternative
III. Hence, the likely future alternatives to the current system are volume charges or B&K
IV. But for specific cases (e.g. roaming) billing systems have to be maintained

2.9.2 Alternative charging methods

I. Call party pay (CPP) using element base charging (EBC)

   a. Cost based per minute rates. Typically there are different symmetric rates for fixed and mobile networks.

II. Bill and Keep

   a. The Bill & Keep principle is widely applied for internet traffic and to some extent to voice traffic interconnection (mobile sector in the USA and previously in France, local interconnection in New Zealand). Thus, the interconnection services costs are confined to capacities costs engaged by each carrier to convey the traffic to be terminated in the competitor network.

   b. This principle could be applied under the strict condition that the traffic between carriers is symmetric. Moreover, in the case of NGNs, the symmetry requirement should be met for each QoS class. We may ask the question if investment costs in QoS may be recovered through retail tariffs in the case of B&K principle.

III. Capacity based charging

   a. Charging based on actually exchanged amount of capacity or booked amount of capacity. Charging unit is bits or links. Typically used for bit stream access, interconnection joining links and managed capacity.

IV. Volume based charging

   a. Charging is based on volumes. This is comparable to the current regime but with bytes as charging unit.

V. IP Peering

   a. This is a charging regime for interconnection of networks in the WWW. This offers free exchange of traffic between equal networks. Payment may apply if exchanged traffic is strongly asymmetric in volume .Transit usually paid.

Advantages	Disadvantages
Transaction cost can be reduced by determining the right termination rates	Providers have an incentive to handover their traffic to another network for termination, as close to the point of origination as possible
Reduced need for regulatory intervention	Can be entails underinvestment. But could be solved by specifying a minimal number of POIs
No termination monopoly problem under bill and keep	The bill and keep option would require the determination of the adequate topology of POIs
The problem of arbitrage is avoided because no termination payments	

Table 2.11- Pros & Cons of Bill and Keep

CHAPTER -3

FUTURE DEVELOPMENTS OF NGN

3.1 Key technologies of wireless telecommunication networks

The fourth generation wireless communication systems have been deployed or are soon to be deployed in many countries. However, with an explosion of wireless mobile devices and services, there are still some challenges that cannot be accommodated even by 4G, such as the spectrum crisis and high energy consumption. Wireless system designers have been facing the continuously increasing demand for high data rates and mobility required by new wireless applications and therefore has started research on fifth generation wireless systems that are expected to be deployed beyond 2020.

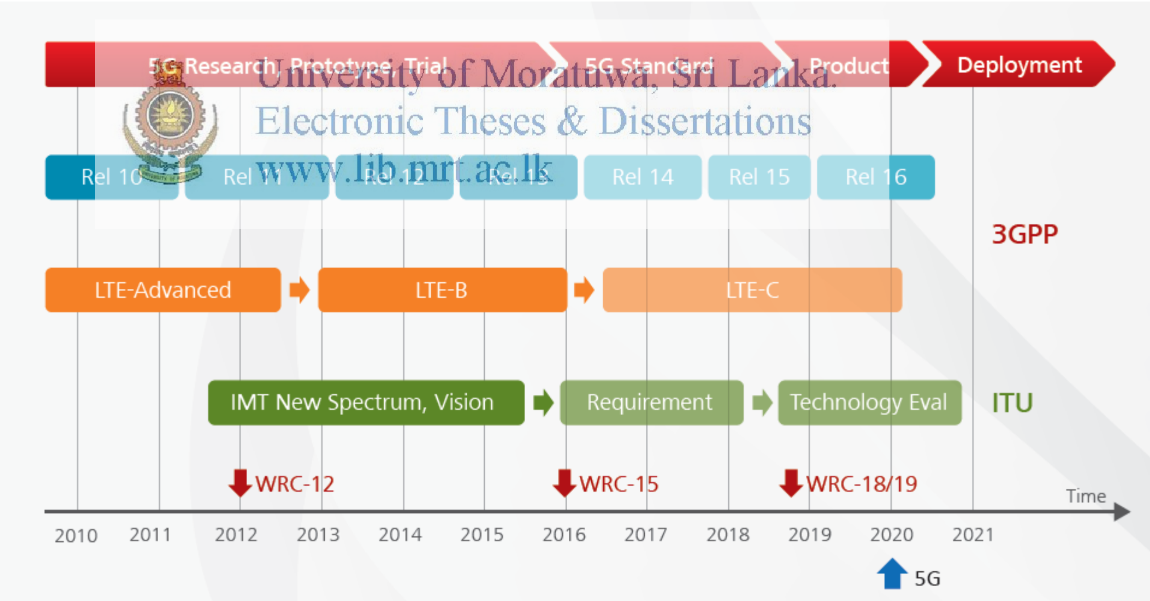


Figure 3.1 -Possible Roadmap of 5G [Source: ITU]

3.1.1 Complex performance requirement of 5G

An increasingly diverse and wide range of mobile services will have differing performance requirements as below.

I. Latency from one millisecond to a few seconds
II. Always-on users per cell from a few hundred to several millions
III. Duty cycles from mere milliseconds to entire days
IV. Signaling loads from less than 1% to almost 100%

The “5G Hyper Service Cube” below gives a multi-dimensional overview in terms of throughput, latency and number of connections required for the many types of services 5G networks will need to run.

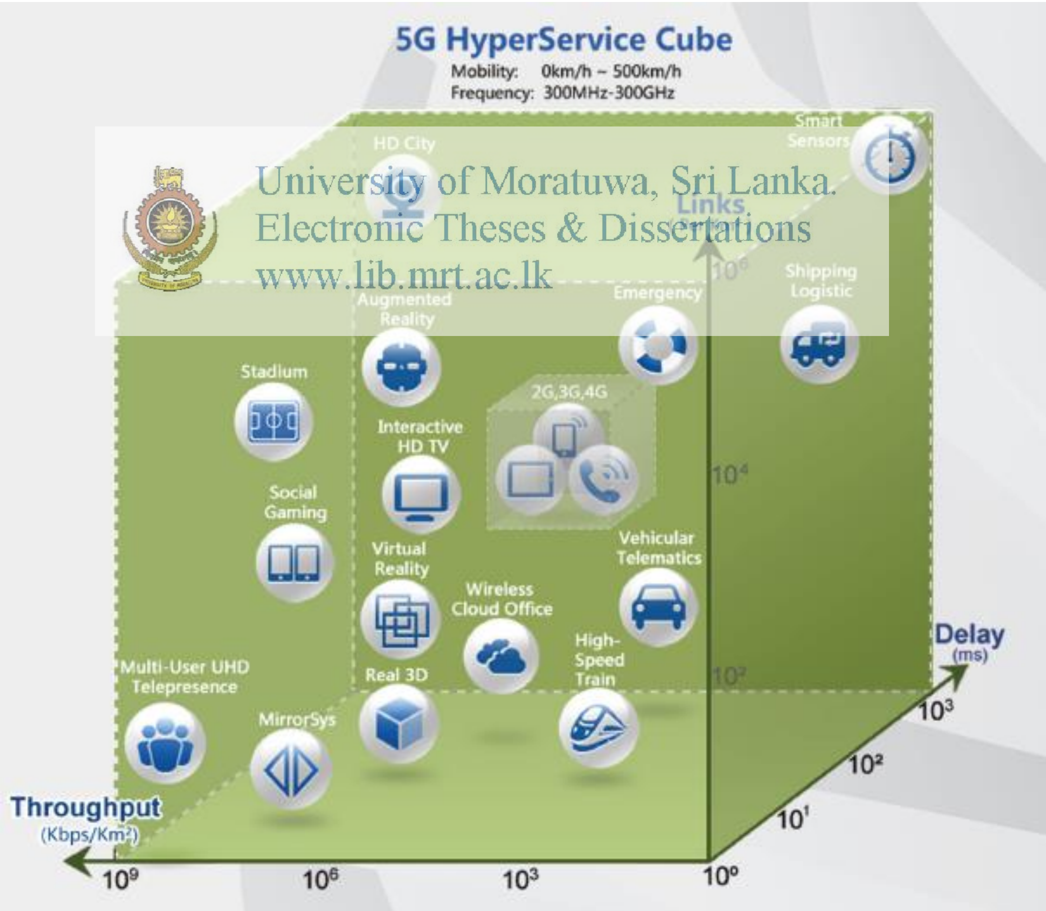


Figure 3.2-5G service and scenario requirement [Source-Huawei]

5G service vision can be given as follows

I. Hyper reactivity

Fast, Low latency, Real time response

II. Hyper connectivity

Connection for everything on wireless/wired

III. Hyper realistic

Augmented reality service, hologram service

IV. Hyper-low cost

Cost effective infrastructure for device & network

V. Hyper-energy saving

Energy efficiency and power-saving system & service

VI. Hyper-reliability

Error-free service for medical service, public safety, etc.

Objective	Enabling Technologies	5G Core Network Requirement									
		Wired and wireless terminal switching	Network on-demand	Context aware best connection	Singe ID for multiple access	Fine grained location tracking	Seamless Mobility	Multiple RAT interworking	Distributed Architecture	Inter GW mobility	Flexible Reconfigure & Upgrade
Highly Flexible 5G core Infra	Flexible service chaining for future mobile services		√								√

	Optimal virtualization of mobile core control functions		√								√
	Dynamic open control protocol for mobile core									√	√
	Virtualized logical GW with distributed switch		√						√		
Flat & Distributed Network	Dynamic mobility anchoring for seamless inter-GW HO								√	√	
	Signaling mitigation for always-on-app and IoT		√							√	
	Unified ID based access control				√						
	Multi-RAT Carrier aggregation			√				√			
Converged access control & transport	Seamless mobility between wire-line and wireless accesses	√		√		√	√				
	HetNet/Multiple RAT mobility control						√	√			
	Integrated resource management and control				√	√	√	√			

	Access condition awarded content delivery	√		√			√				

Table 3.1-5G Core Network Requirement [Source: 5G vision and requirement]

3.2 NGN services Trends of developed countries

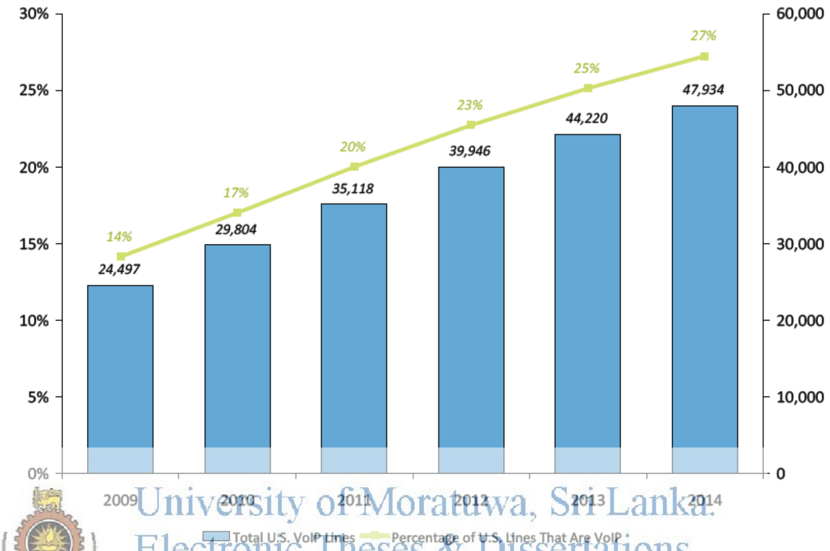


Figure 3.3- VoIP penetration of USA [Source Yankee group]

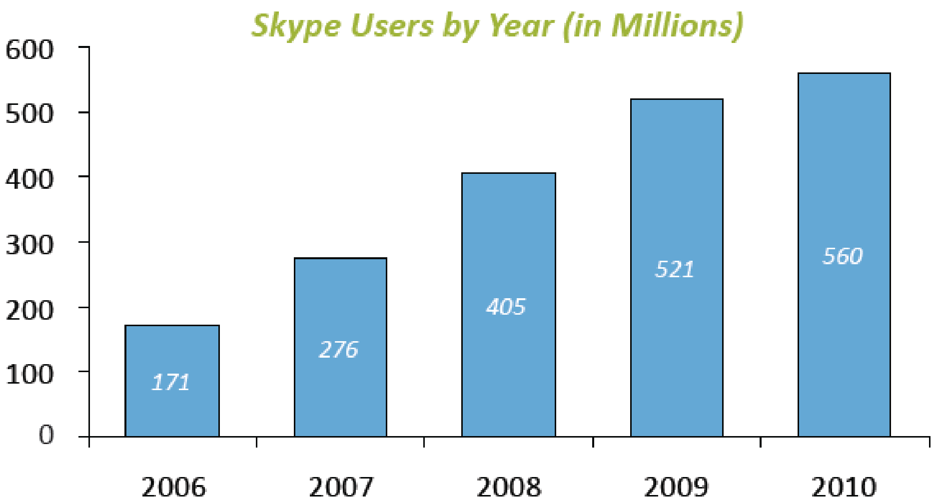


Figure 3.4-Skype users [Source Yankee group]

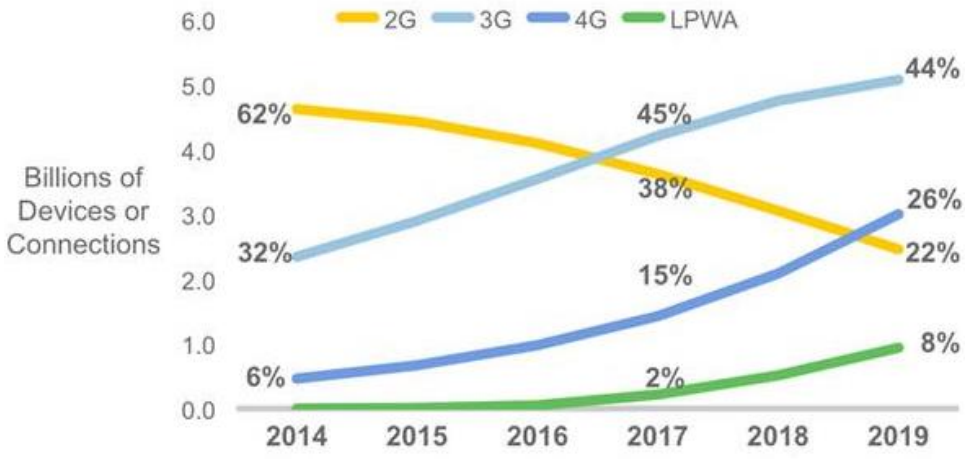


Figure 3.5-Global connection trend [Source: Cisco VNI Mobile, 2015]

CHAPTER -4

CURRENT AND PREDICTED FUTURE NETWORK STRUCTURE IN SRI LANKA

4.1 Present Telecommunication market status of Sri Lanka

- Sri Lanka’s mobile market passed the 100% subscriber penetration milestone in early 2014
- Mobile subscriber numbers had increased fourfold in just six years
- After the leading mobile operators – Dialog and Mobitel - trialed their Fourth Generation (4G) LTE technologies in 2012, both initiated commercial launches of 4G services in 2013
- After a sustained period of healthy growth, the country’s fixed-line market had undergone a levelling off and suffered a significant decline in 2012/2013
- Fixed-line expansion had been boosted by the extensive application of CDMA-based WLL technology
- The number of WLL services peaked, however, in 2010/2011, and had been falling since then
- The country’s internet sector remained underdeveloped, with the take up rate of broadband services being especially low; there were positive signs, however, that this was starting to change, especially with the surge in mobile broadband services
- Fixed broadband penetration (as a percentage of population) was still less than 3% in early 2014

Landlines in use: 2,711,717 (September, 2014)

Mobile Phones in use: 21,727,589 (September, 2014)

[Source: GSMA Intelligence]

Fixed Broadband Service Providers

Brand	Operator	Technology
Dialog	Dialog Broadband Networks (Pvt) Ltd	WiMAX, 4G LTE, Wi-Fi
Lanka Bell	Lanka Bell Limited	WiMAX, 4G LTE
SLT	Sri Lanka Telecom PLC	ADSL2+, VDSL2, 4G LTE, FTTH, Wi-Fi

Mobile Broadband Service Providers

Brand	Operator	Technology
Dialog	Dialog Axiata PLC	GPRS, EDGE, UMTS, HSPA, HSPA+, DC-HSPA+, 4G LTE
Mobitel	Mobitel (Pvt) Ltd	GPRS, EDGE, UMTS, HSPA, HSPA+, DC-HSPA+, 4G LTE
Etisalat	Etisalat Lanka (Pvt) Ltd	GPRS, EDGE, UMTS, HSPA, HSPA+, DC-HSPA+
Hutch	Hutchison Telecommunications Lanka (Pvt) Ltd	GPRS, EDGE, UMTS, HSPA, HSPA+
Airtel	Bharti Airtel Lanka (Pvt) Ltd	GPRS, EDGE, UMTS, HSPA, HSPA+

Fixed Voice Service Providers

Brand	Operator	Technology
Dialog	Dialog Broadband Networks (Pvt) Ltd	CDMA,Wired
Lanka Bell	Lanka Bell Limited	CDMA
SLT	Sri Lanka Telecom PLC	CDMA

Mobile Voice Service Providers

Brand	Operator	Technology
Dialog	Dialog Axiata PLC	GSM,UMTS
Mobitel	Mobitel (Pvt) Ltd	GSM,UMTS
Etisalat	Etisalat Lanka (Pvt) Ltd	GSM,UMTS
Hutch	Hutchison Telecommunications Lanka (Pvt) Ltd	GSM,UMTS
Airtel	Bharti Airtel Lanka (Pvt) Ltd	GSM,UMTS

4.2 Existing interconnection model in Sri Lanka

4.2.1 Analysis about existing voice services interconnection model

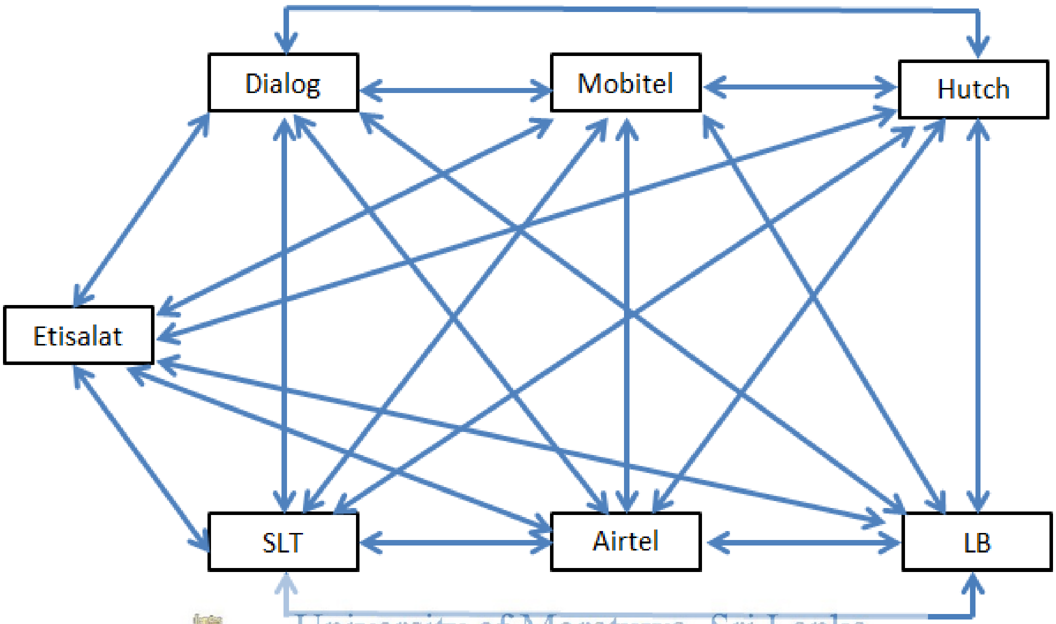


Figure 4.1- Existing voice interconnection topology

The existing voice interconnection topology in Sri Lanka is a mesh topology. Each and every operator has a peer connection with all other operators. Every operator has a legal right to establish a peer connection with other operators. The interconnection link is a dedicated TDM link. Connection is available for both inward and outward traffic from an operator. Inward and outward traffic can be asymmetric. Interconnection charges are calculated by call minutes.

Advantages	**Disadvantages**
Guarantied QoS can be provided.	Cannot use bandwidth-optimized codecs to reduce bandwidth needs.
Voice interconnect is handled using legacy TDM connections with ISUP signaling and the G.711 codec. Over the years ISUP signaling has matured	High capital expenditure (Capex) and operational expenditure (Opex).

and now supports national and international variants, as well as redundancy mechanisms required for telecom grade service.	
	Provide less flexibility in choosing interconnect partners and architecture
	Cannot interconnect multimedia services

Table 4.1-Advantages and Disadvantages of existing voice services interconnection

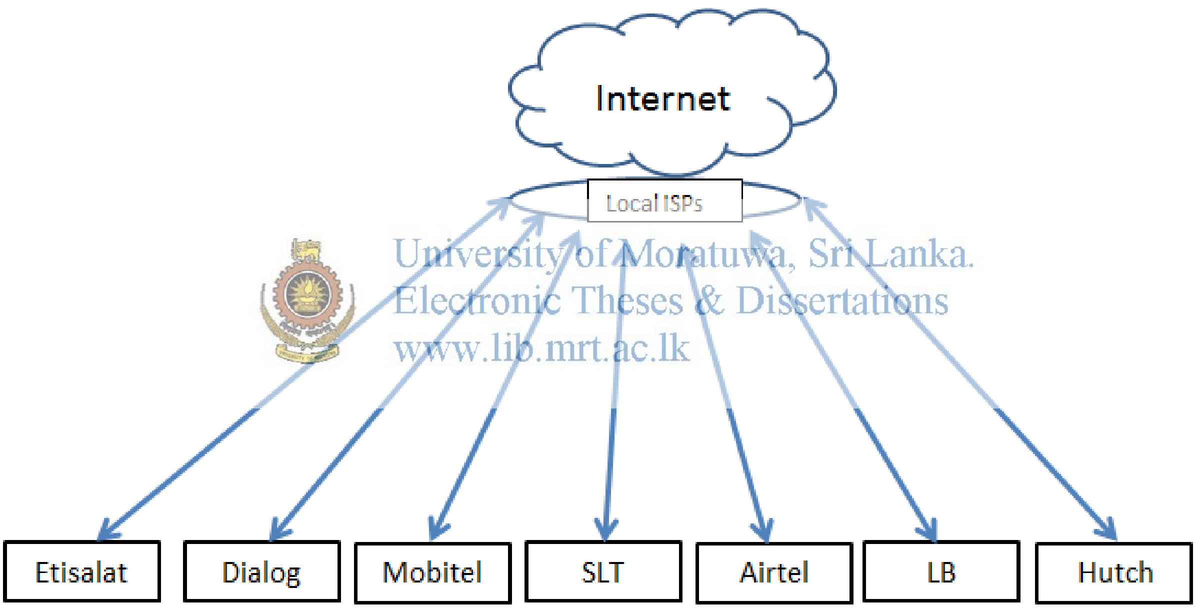


Figure 4.2- Existing data interconnection topology

Actually there is no formal IP services interconnection method in Sri Lanka. If two operators are connecting to one local ISP provider to connect internet, IP connectivity can be establish between those two operators. This is very primitive and none standard method. Currently there is no policy and regulatory framework to interconnect IP services between two operators. Therefore there are many disadvantages of existing methodology to interconnect IP services between two operators in Sri Lanka. Those are can be given as follows.

I. Does not have ENUM registry services
II. Does not have mechanism to provide guaranteed QoS
III. Does not have charging mechanism
IV. Does not have mechanism to ensure security
V. Does not support end to end voice over IP
VI. Does not support end to end video over IP
VII. Does not support multilateral hub based interconnection between several operators
VIII. Does not support machine to machine communication over cross networks
IX. Does not have standard mechanism to interconnect content providers to telecommunication service providers
X. Does not support any to any communication (unified communication)

4.2.2 Existing network structure of network operators

In order to identify network structure of existing operators a survey is conducted. The main target of the survey is to identify the readiness of existing networks in Sri Lanka to interconnect through IP, to identify the topology of transport network of existing networks and to identify the transition plan to NGN. Data is gathered from officials of each network, but some networks did not disclose their data. A summary of identified information is as follows.

Operator	Existence of Session Border Controllers in the network	Physical locations of core network nodes	Current availability of IMS (Yes/No)	Time plan to implement IMS	Plan to phase out legacy core network
SLT	Yes	Petta Welikada	No	2015	2016
Dialog	Yes	Dematagoda Piliyandala Union Place Malambe Kadawatha	No	-	-
Mobitel	Yes	Welikada Kalutara Kotte Kelaniya	No	2016	2020
Etisalat	Yes	Wellampitiya Kotikawatta Granpass	No	2018	2022
Hutch	No	Walpola	No	-	-
Airtel	No	Maligawatta	No	-	-
Lanka Bell	No	Grandpass	No	-	-

Table 12.2- Existing service provider's information

I. All operators are routing traffic through core network nodes which are, located in Colombo.

II. Sri Lankan networks will finish migration to NGN on near 2020.

III. Most of the networks having ability to interconnect through Session border controllers.

IV. Since all the operators having centralized routing mechanism, round trip time is high which can cause a high delay.

V. All the operators spending high cost to route outstation traffic through Colombo.

VI. Main operators are planned to deploy IMS before 2018. Therefore VoIP services can be given across those networks. This will do a high impact to revenue of other operators, since larger share of revenue of those operators comes from CS voice services.

VII. The existing interconnection structure is not providing opportunity for new small scale service providers to enter in to the market.

VIII. All the operators have to depend on SLT and Dialog fiber network when routing long distance traffic. This creates a high cost for other service providers.

4.3 Trends in telecommunication market of Sri Lanka

At the present higher share of the revenue is generated from circuit switched voice traffic .But the circuit switched voice traffic is saturated at the present. Meanwhile data traffic is increasing exponentially. According to analysis conducted by CISCO the fastest data traffic growing region is Asia pacific region. It can be observed that Sri Lanka is also in line with regional trends. Therefore increment of M2M services and VOIP can be expected in Sri Lanka in next five years.

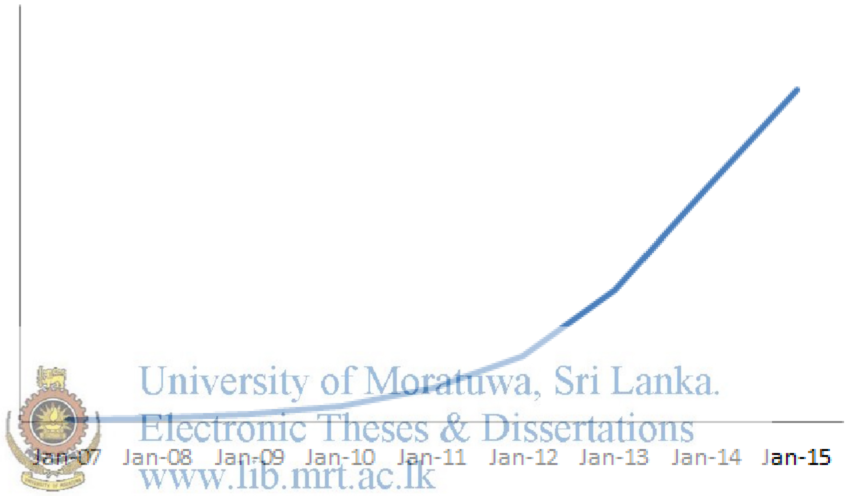


Figure 4.3- Data traffic trend in Sri Lanka (Approximate)

Figure 4.4- Data traffic trend in global regions [Source: Cisco VNI Mobile, 2015]

4.4 Competition Analysis

4.4.1 Demarcation and dimensions of market

Following market shares can be observed in mobile telecommunication market in Sri Lanka.

- Dialog - around 40% market share
- Sri Lanka Telecom (Mobitel) - around 21% market share
- Etisalat - around 20% market share
- Bharti Airtel + Hutchison – have remaining 19% market share between them

Fixed line market is dominated by Sri Lanka telecom. [Source: ITU Regulatory snapshot Sri Lanka]

It can be identified that all operators having similar market characteristics. Therefore it is selected one operator to analyze market segments. It can be identified three main market segments in Sri Lanka. Those are;

I. Colombo and surrounding urban area of western province
II. Main towns of out station area
III. Remaining out station area

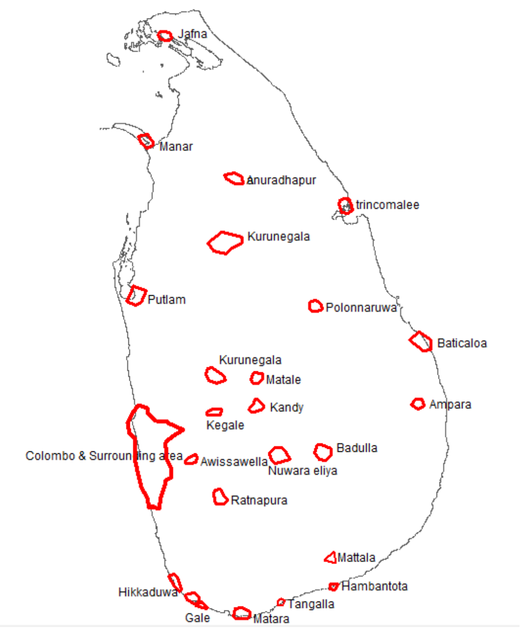


Figure 4.5- Existing market demarcation

These market segments are analyzed by following aspects.

I. Product
II. Geographic
III. Functional
IV. Temporal
V. Customer

I. Colombo and surrounding urban area of western province

1. Most of the people having a higher income compared to other areas and they are willing to pay a higher portion of their income to fulfill telecommunication requirements.
2. There is a higher demand for good voice quality.
3. There is a higher demand for high speed broadband services.
4. Most of the smartphone users are located in this area
5. Most of the high volume of data downloading people are located in this area
6. Most of the people in this area having computer literacy.
7. Machine to Machine communication will be popular in next five years
8. Low latency is required in broadband services
9. There is a high competition exist among service providers.
10. VoIP services like Viber are getting popularize in this area.
11. Voice services across TDM and IP network is required in near future.

II. Main towns of out station area

1. Most of the people having a higher income compared to other areas and they are willing to pay a higher portion of their income to fulfill telecommunication requirements.
2. There is a higher demand for good voice quality.
3. There is a higher demand for high speed broadband services.
4. Smartphone user penetration is high in this area.
5. Most of the high volume of data downloading people is located in this area.
6. Most of the people in this area having computer literacy.

7. Machine to Machine communication will be popular in next five years
8. Low latency is required in broadband services
9. There is a high competition among service providers.
10. Voice services across TDM and IP network is required in near future.

III. Remaining out station area

1. Most of the people in this area mainly need a mobile telecommunication services to fulfill their basic voice communication requirement.
2. Most of the people having a lower income compared to Colombo and other main towns.
3. There is a low demand for broadband services.
4. Computer literacy is low in this area compared to Colombo and other main towns.
5. Return on investment is low in this area.
6. Digital services can be popularizing, if government can intervene in coverage expansions in rural areas.
7. Broad band demand exists in scattered places such as government and private offices,tourist locations etc.
8. There is a low competition among service providers.

Since higher competition exists in Colombo and surrounding urban area of western province, service providers are using a Colombo centered network structure. Therefore deployment of new technology is lagging in outstation areas. At the present government is not regulating these aspects of service providers. If TRSCL can set coverage and technology targets in rural areas to service providers, market structure will be changed significantly.

Centralized and mesh interconnection structure is one important factor which created this asymmetric market. If distributed interconnection structure exists, coverage and technology gaps of rural areas can be filled by small scale local operators.

4.5 Voice and data user behavior analysis in Sri Lanka

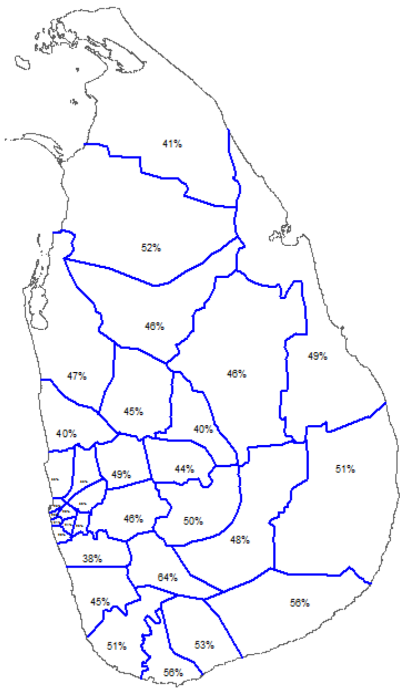
Present and future voice traffic pattern is a critical factor which should be considered when proposing new model to interconnect. It is selected one main operator and analyzed origination and termination locations of calls generated. Originating base station controller area and terminating base station controller area of calls originated and terminated during a one month period are analyzed.

Following results are observed during analysis.

BSC Area	Percentage of Traffic Originated & Terminated in same area
Area1	64%
Area2	56%
Area3	56%
Area4	53%
Area5	52%
Area6	51%
Area7	51%
Area8	50%
Area9	50%
Area10	49%
Area11	49%

BSC Area	Percentage of Traffic Originated & Terminated in same area
Area12	47%
Area13	47%
Area14	46%
Area15	46%
Area16	45%
Area17	44%
Area18	44%
Area19	42%
Area20	40%
Area21	39%
Area22	38%

BSC Area	Percentage of Traffic Originated & Terminated in same area
Area23	35%
Area24	33%
Area25	33%
Area26	28%
Area27	26%
Area28	25%
Area29	24%
Area30	23%
Area31	21%
Area32	21%



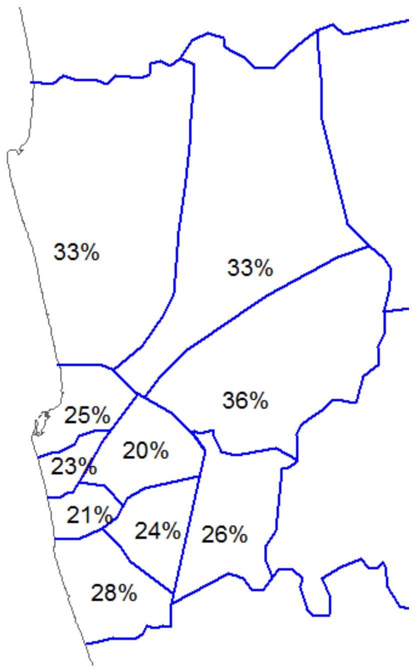


Figure 4.6- traffic termination map

I. It can be identified that more than 40% traffic originated on most of the base station controller areas are terminated at same base station area.
II. When considered the Colombo and sub urban area, geographical area of single base station controller is comparatively small. Therefore most of the traffic originated in this area will terminate at other areas.
III. Operators are spending extra cost to carry out station traffic to Colombo to re-route traffic to same area.
IV. The existing network interconnection structure is inefficient.

When analyzing voice traffic volume, it can be identified the 1/3 of traffic is generated in western province. Remaining 2/3 amount of outstation traffic unnecessarily routing through Colombo.

District	Population Share (%)	Voice Traffic (%)
Colombo	11.40	19.84
Gampaha	11.30	10.39
Kurunegala	7.90	6.63
Kandy	6.80	5.50
Kalutara	6.00	4.88
Ratnapura	5.30	7.44
Galle	5.20	4.27
Anuradhapura	4.20	5.65
Kegalle	4.10	4.36
Matara	4.00	5.71
Badulla	4.00	3.36
Putlam	3.70	2.21
Nuwara-Eliya	3.50	2.38
Ampara	3.20	1.38
Hambantota	2.90	4.73
Jaffna	2.90	0.80
Baticaloa	2.60	0.36
Matale	2.40	2.14
Monaragala	2.20	2.42
Polonnaruwa	2.00	2.11
Trincomalee	1.90	1.32
Vaunia	0.80	0.51
Kilinochchi	0.60	0.41
Mannar	0.50	0.48
Mulathiv	0.40	0.71

Table 4.3- Population and voice traffic distribution

It can be identified that voice traffic of each district is closely correlated to population

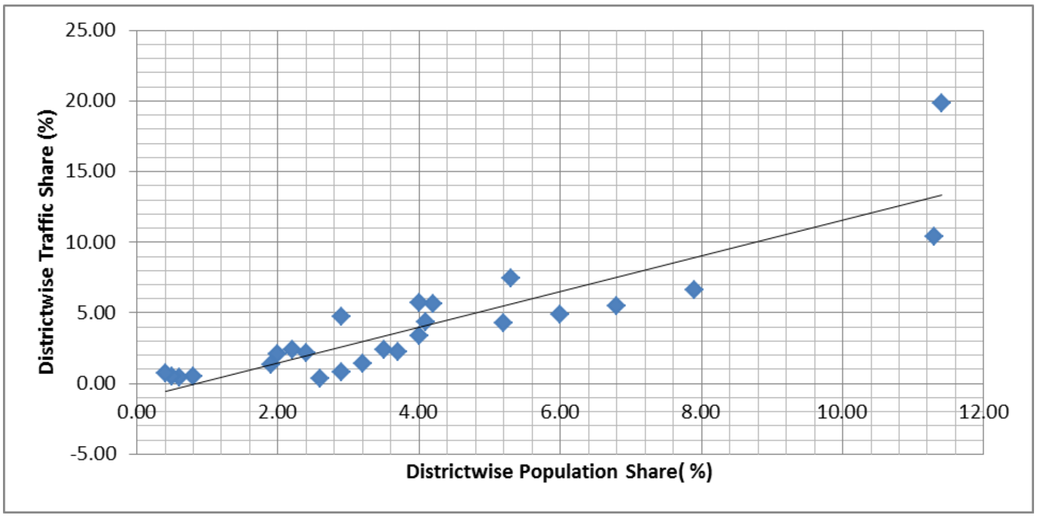


Figure 4.7- Correlation between network traffic and population

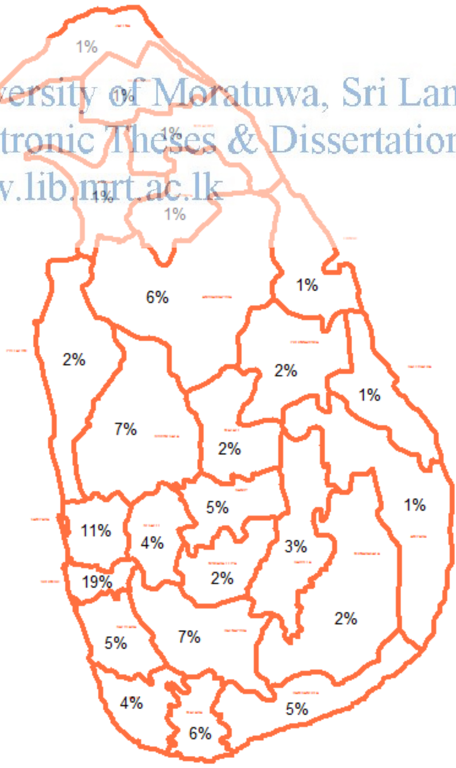


Figure 4.8-Voice traffic distribution of analyzed network

When analyzing data traffic volume, it can be identified the 2/3 of traffic is generated in western province. Remaining 1/3 amount of outstation traffic unnecessarily routing through Colombo.

District	Population Share	Data Traffic
Colombo	11.40	32.98
Gampaha	11.30	15.88
Kurunegala	7.90	5.09
Kandy	6.80	5.23
Kalutara	6.00	5.70
Ratnapura	5.30	3.05
Galle	5.20	3.07
Anuradhapura	4.20	3.01
Kegalle	4.10	3.52
Matara	4.00	2.95
Badulla	4.00	1.77
Putlam	3.70	2.97
Nuwara-Eliya	3.50	1.55
Ampara	3.20	1.17
Hambantota	2.90	2.00
Jaffna	2.90	1.56
Baticaloa	2.60	0.97
Matale	2.40	1.54
Monaragala	2.20	0.86
Polonnaruwa	2.00	1.60
Trincomalee	1.90	1.57
Vaunia	0.80	0.47
Kilinochchi	0.60	0.52
Mannar	0.50	0.51
Mulathiv	0.40	0.46

Table 4.4- Population and data traffic distribution

It can be identified that data traffic of each district is closely correlated to population. Except in Colombo and Gampaha District.

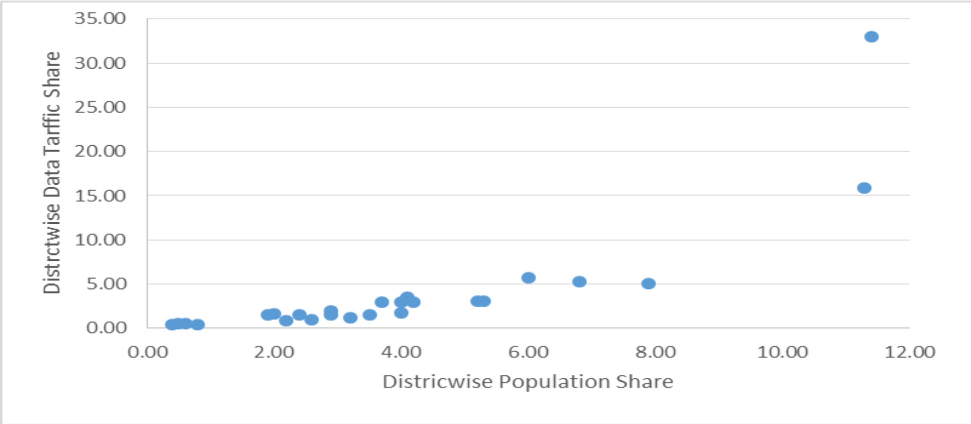


Figure 4.9- Correlation between network data traffic and population

4.6 Analysis done by LIRNEasia to identify mobile phone user behavior in Sri Lanka

LIRNEasia is a regional ICT policy and regulation think tank active across the Asia Pacific. They have carried out a research to analyses mobile network big data and other data to get an insight about mobility zones of Sri Lankan people.

Data used in the research is as follows.

I. Multiple mobile operators in Sri Lanka have provided four different types of meta-data
   1. Call Detail Records (CDRs)
      Records of calls, SMS, Internet access
   2. Airtime recharge records

II. Data sets do not include any personally identifiable information

III. Cover 50-60% of users; very high coverage in Western (where Colombo the capital city in located) & Northern (most affected by civil conflict) Provinces, based on correlation with census data.

Following community zones have identified based on human mobility.
The density of mobility within a zone is higher than across zones and suggests strong socio-economic linkages to mobility

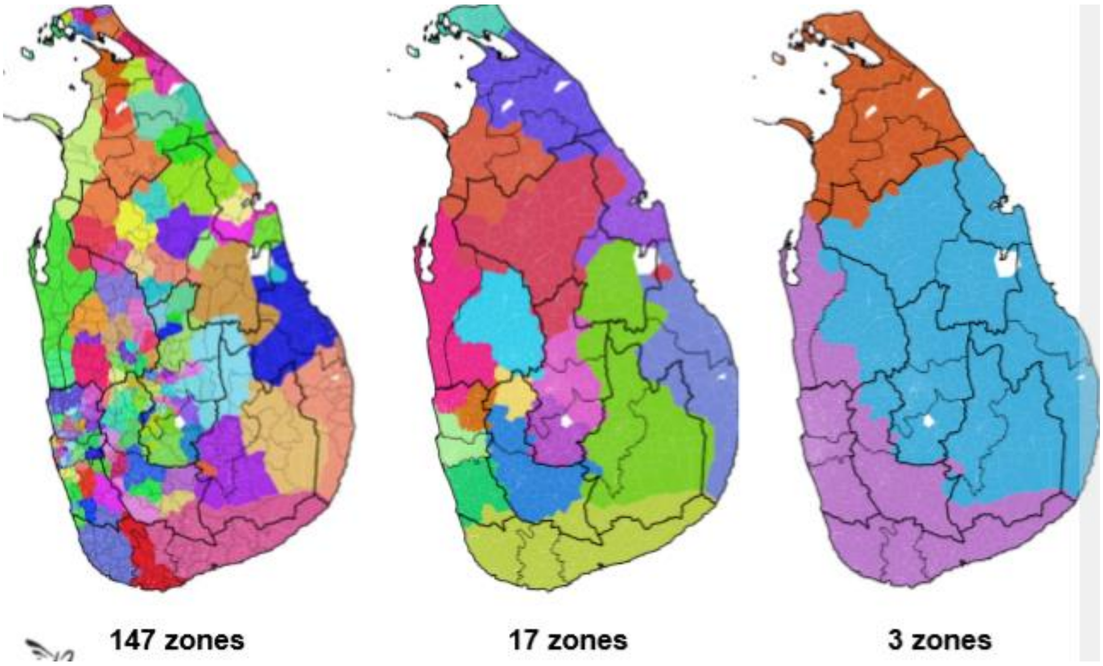


Figure 4.10- Mobility Zones of people

The results of above research carried out by LIRNEasia by using call data of all mobile network proves the availability of closed communication groups in Sri Lanka. The above results justify the requirement of regional interconnection hubs to Sri Lanka.

CHAPTER -5

MODEL TO INTERCONNECT NGN IN SRI LANKA

5.1 Interconnection topology

Expected traffic of each district is forecasted by considering population and traffic analysis of selected vendor. Following results can be given from traffic and population analysis.

District	Population Share	Expected Traffic Share
Colombo	11.40%	15.00%
Gampaha	11.30%	14.00%
Kurunegala	7.90%	7.00%
Kandy	6.80%	6.00%
Kalutara	6.00%	6.00%
Ratnapura	5.30%	5.00%
Galle	5.20%	5.00%
Anuradhapura	4.20%	5.00%
Kegalle	4.10%	4.00%
Matara	4.00%	5.00%
Badulla	4.00%	3.00%
Puttalama	3.70%	3.00%
Nuwara-Eliya	3.50%	3.00%
Ampara	3.20%	3.00%
Hambantota	2.90%	3.00%
Jaffna	2.90%	2.00%
Batticaloa	2.60%	2.00%
Matale	2.40%	2.00%
Monaragala	2.20%	2.00%
Polonnaruwa	2.00%	1.50%
Trincomalee	1.90%	1.00%
Vavuniya	0.80%	1.00%

Killinochchi	0.60%	0.50%
Mannar	0.50%	0.50%
Mullativu	0.40%	0.50%

Table 5.1-NGN Traffic Forecast

According to the call data analysis of the selected vendor, five regions can be identified which having localized traffic pattern. Those areas are as follows.

I. Northern Region-Anuradhapura, Vavuniya, Manar , Kilinochchi , Jaffna
II. Eastern Region-Nuwara Eliya , Badulla , Monaragala , Ampara, baticaloa , Polonnaruwa
III. Northwestern Region- Kurunegala , Putlam , Kandy , Matale, Part of Kegale
IV. Western Region-Colombo , Gampaha , Part of Kegale , Part of Kalutara
V. Southern Region- Hambanthota , Matara , Galle , Part of Kalutara

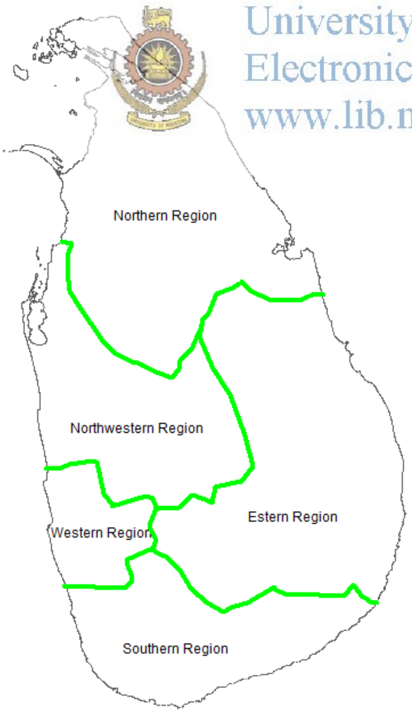


Figure 5.1- Interconnection region demarcation map

Region	Percentage of Traffic Originated & Terminated in same area
Southern Region	67.27%
Eastern Region	57.02%
Northwestern Region	47.32%
Northern Region	59.38%
Western Region	51.10%

Table 5.2-Traffic termination statistics

Therefore five interconnection hubs are proposed for the interconnection model. Each interconnection hub will be interconnected as mesh network. When required connect to internet provision is kept to bypass regional interconnection hubs in order to avoid unnecessary delays.

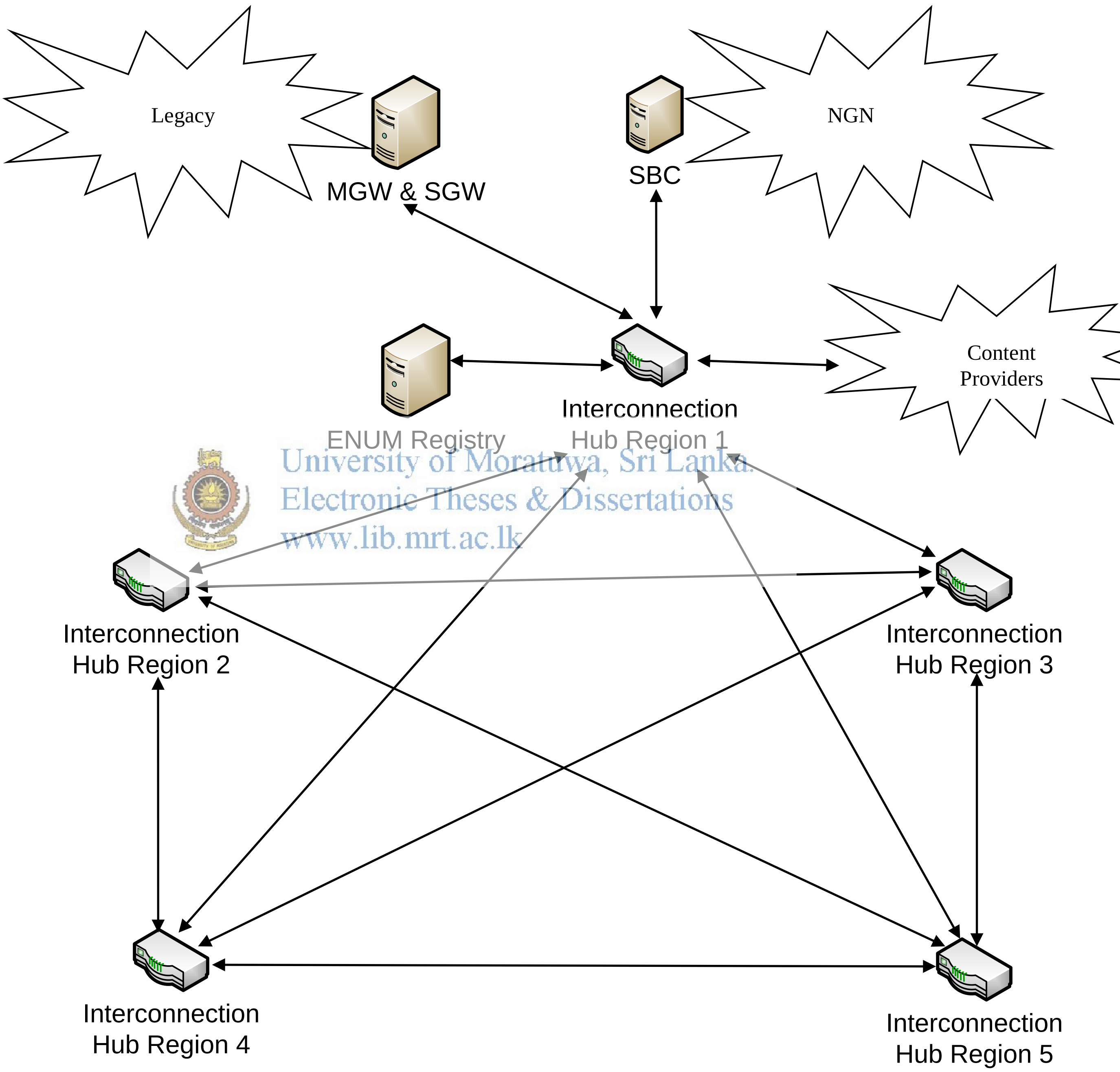


Figure 5.2- Proposed interconnection topology

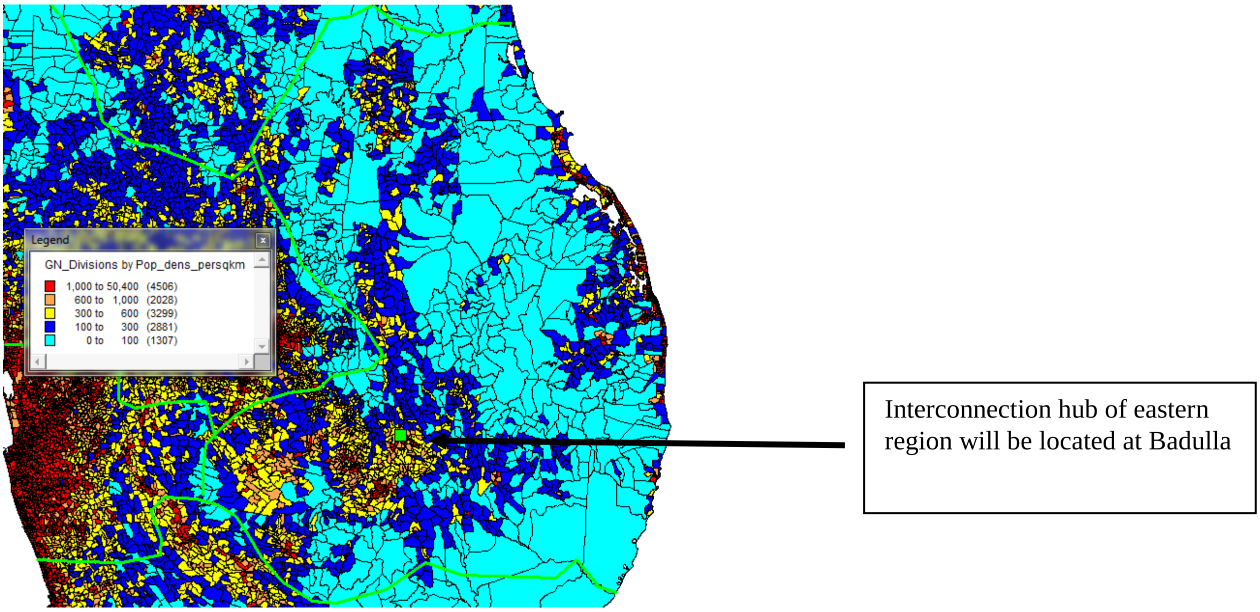
5.2 Interconnect exchange

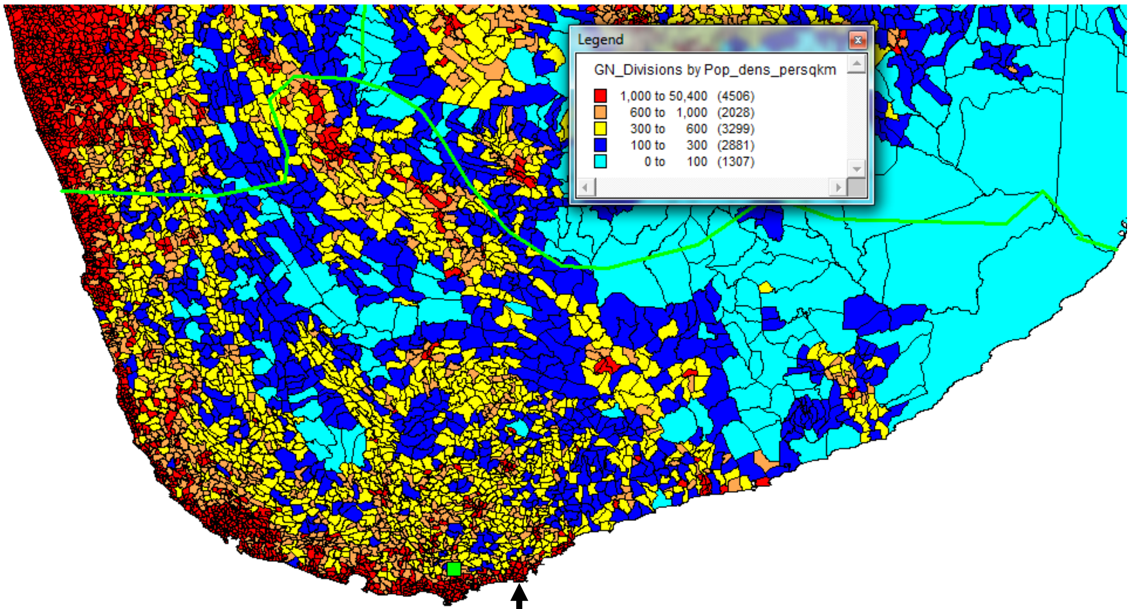
Interconnect exchange is proposed for each region with below functionalities.

I. Multilateral VoIP interconnection
II. Cross network VoIP services
III. Multimedia IP interconnection
IV. SLA based security
V. SLA based quality of service
VI. SLA based availability
VII. ENUM registry service
VIII. ENUM inter registry inter-operability
IX. Ability to generate call data record
X. Ability to billing and reporting

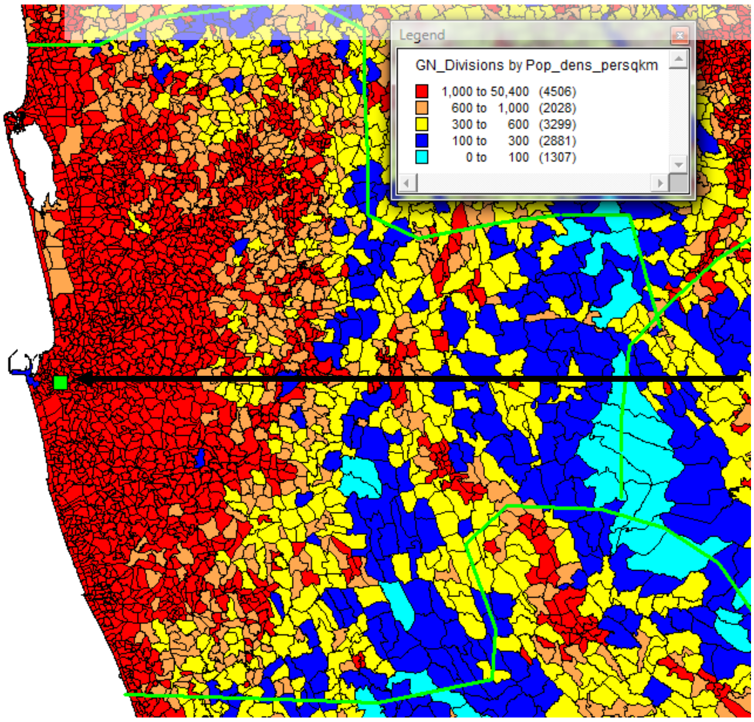
5.3 Point of interconnection

Locations of five interconnection hubs are selected by considering geographical location and distribution of population.

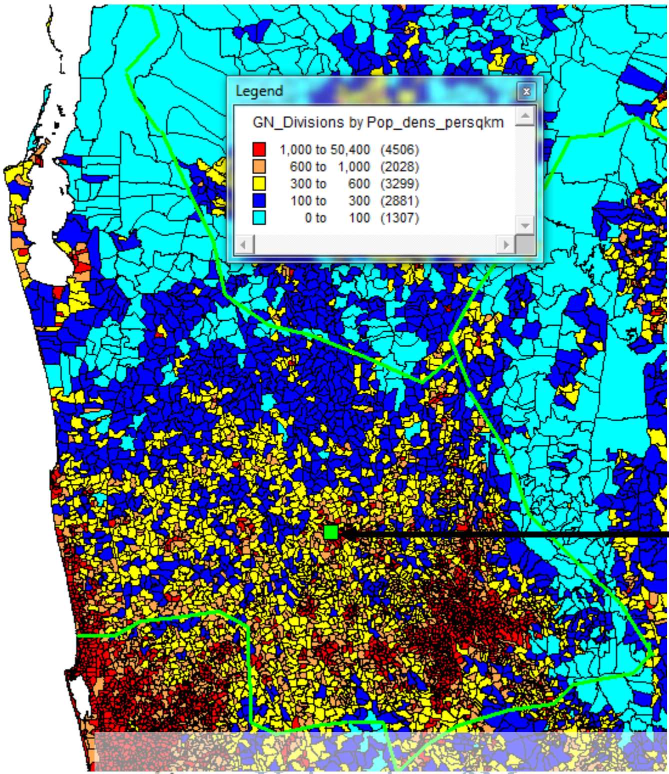




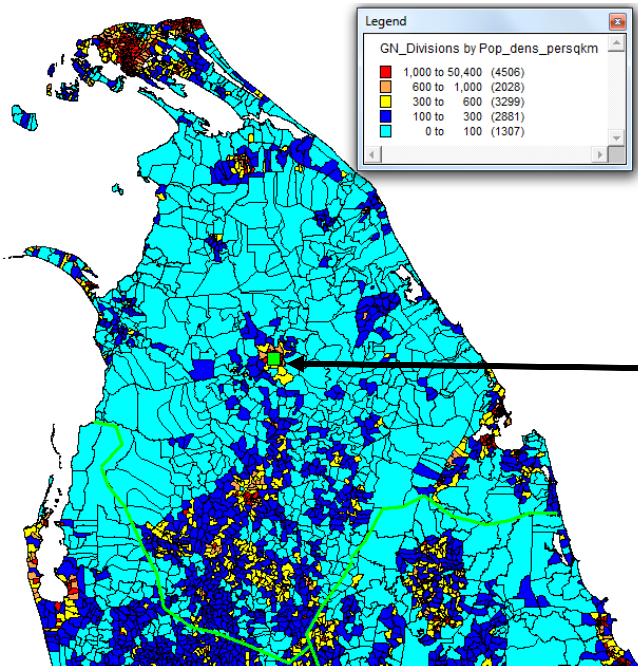
Interconnection hub of southern region will be located at Matara



Interconnection hub of western region will be located at Colombo Fort



Interconnection hub of southern region will be located at Kurunegala



Interconnection hub of southern region will be located at Vavunia

Figure 5.3- Regional interconnection points

5.4 Provision to interconnect legacy networks

Since legacy networks will continue till 2020 in Sri Lanka, it is decided to keep provision to interconnect legacy networks to NGN. The functionality of media gateway (MGW) and singling gateway (SGW) will be incorporate to NGN exchange. That means conversion of TDM voice to call for a PS voice call and conversion of ISUP signaling to SIP signaling will be done by interconnect hub.

5.5 Ensuring QoS at interconnection

A review of literature reveals that while the intra-operator Quality of Service (QoS) in NGN has been researched and applied to a large extent, inter-operator QoS is complex and still being discussed in academia, international standards bodies and industry. But interconnection of networks of different operators is essential as it provides technical possibilities for the customers to connect to other customers and to services irrespective of the network they are on. Therefore it is required to achieve end to end QoS by the proposing NGN interconnection model for Sri Lanka.

The parameters which are required to monitor, when interconnecting two NGNs or NGN-TDM, are not yet standardized. But following parameters are proposed to Sri Lankan model.

I. Bandwidth
II. Jitter
III. Delay
IV. Packet loss

User requested QoS policy push methodology is proposed for the Sri Lanka model. This is a methodology standardized by ITU.

I. User terminal or home gateway is capable of sending QoS requests over layer 3 QoS signaling for its own QoS needs.

II. The authorization for the QoS request is obtained at the time where the QoS request is actually signaled.

III. No communication with a service controller is required for prior authorization of QoS requirement.

IV. Therefore the service setup time will be reduced.

V. Individual operator's ability to provide QoS need to be monitored and regulated carefully.

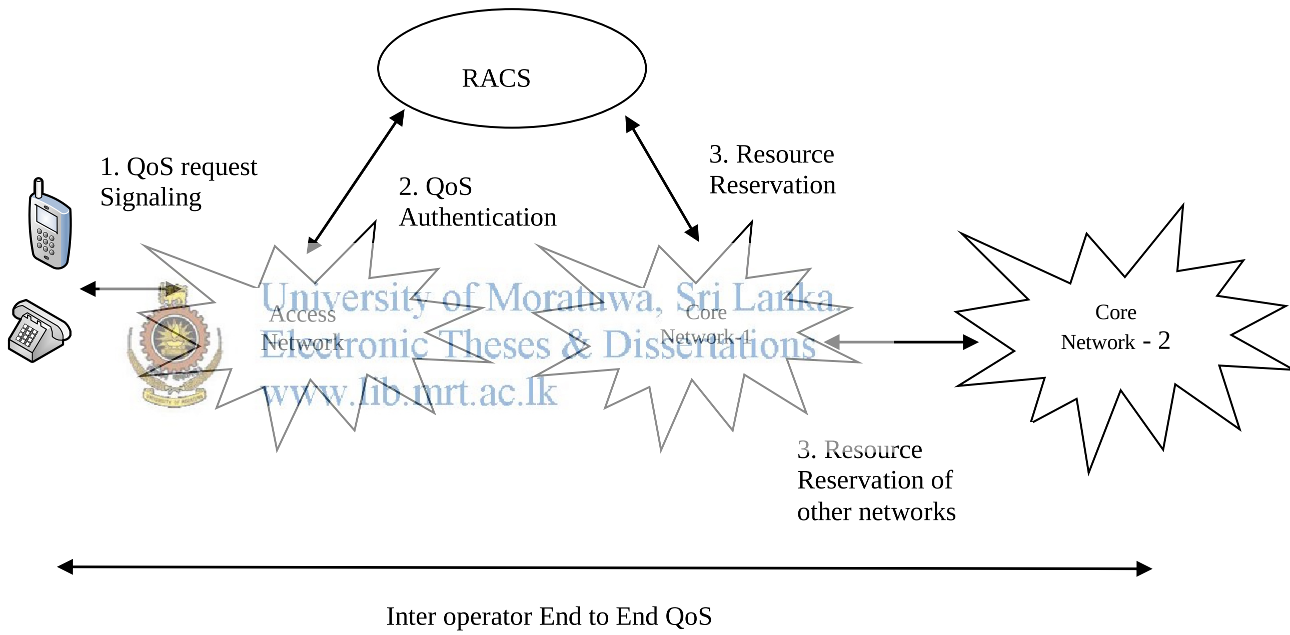


Figure 5.4 -End to End QoS flow

Functions of RACS are as follows.

I. Policy control, resource reservation and admission control in the access and aggregation sections of access networks.

II. Network Address Translation (NAT) at any place, or places, in the access, aggregation or core networks.

III. Request and reservation of transport resources.

IV. RACS supports a Push model in which service requests are pushed to RACS from the Application Function and then, if these requests are compliant with the policies established by the operator and the appropriate transport resources are available, RACS pushes requests to the transport layer to control the appropriate transport resources.

5.6 Level of interconnection

I. It is proposed to interconnect mainly service layer and the transport layer.

II. The core of next generation networks can be considered as having four "layers" in terms of the services which are provided. Interconnection of those service layers can be given as follows.

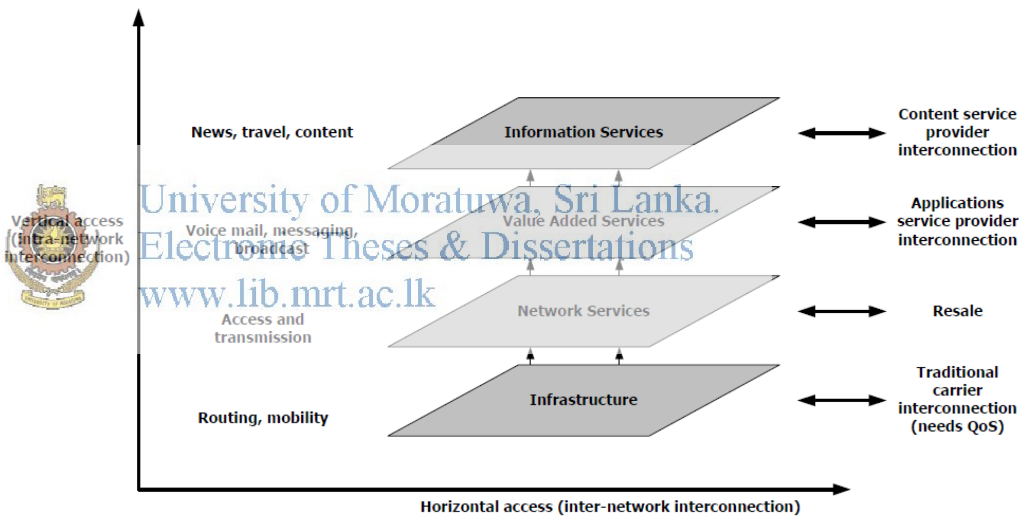


Figure 5.5-service plane interconnection [Source: Rob Nicholls, Gilbert + Tobin]

5.7 Funding and management of interconnect exchange

Two Options are proposed for the management of interconnect exchanges.

1. Managed by TRCSL as independent non for profit organization.

   In order to promote competition and reduce entry barriers most of the countries are going to independent interconnection exchanges. Since Sri Lanka is having technologically and service imbalanced market, the most suitable option is management of interconnect exchanges by TRSL.

2. To promote operators to take the responsibility of at least one interconnect exchange.

   If TRCSL is not willing to take technical resources and funding to deploy and maintenance of independent interconnection exchange, the other option is granting permission to service providers to maintain interconnection hubs. Therefore regulator has to closely monitor operations of interconnection hubs in order to avoid anti-competitive conducts.

CHAPTER -6

REGULATORY AND POLICY FRAMEWORK TO INTERCONNECT NGN IN SRI LANKA

6.1 Key Deliverables of proposing policy and regulatory framework

At the regulatory and policy level, interconnection has always been closely associated with market power of existing service providers and expected level of services to customers. It has been a general article of faith that governments must be prepared to intervene to maintain effective competition which befits for both service providers and customers fairly.

Main objectives of proposed policy and regulatory framework to interconnect NGN in Sri Lanka are as follows.

I. To provide universal access
II. To enable economic development
III. To promote innovation
IV. To create job opportunities
V. To drive towards information society
VI. To increase productivity by the rapid spread of e applications
VII. To fosters both investment and widespread diffusion of ICTs
VIII. To ensure that consumer interests are protected
IX. To increase access to technology and Services
X. To protect consumer interests
XI. To avoid market failure

6.2 Proposed Regulatory framework

There is a competitive telecommunication market in Sri Lanka. Therefore some areas will be automatically regulated by market itself, while some times intervention is required to maintain market stability and government objectives. Also it is difficult to predict future NGN market forces exactly at the present. Therefore regulatory framework is prepared as a Mixture of Ex Ante Regulation & Ex Post Regulation, giving more weight to Ex post regulation.

1. **Interconnection parties (Who pays to whom?)**

Interconnect between legacy networks and NGNs will be important during the transition to an NGN environment. Maintaining any-to-any connectivity for voice and developing other new multimedia services will require inter-working arrangements

In legacy network interconnection charges are made based on the promise that calling party causes cost. The charging mechanism will not change for the existing popular services such as voice services and SMS services (Calling Party Pay –CPP).

But this will be no longer valid to new service of NGN scenario such as multimedia services, gaming services, machine to machine services. Therefor bill and keep methodology is proposed to interconnection charging.

In Bill and Keep (B&K) the calling party's and receiving party's network are each responsible for meeting their own costs through charges made to their own retail customers. No payment is made or received for the exchange of traffic between interconnected networks. That is, one bills the retail customer and keeps all the revenue, rather than billing the customer and passing some of the revenue on to the relevant interconnected network.

When comes to bill and keep, there needs to be a rough balance of traffic between the NGN networks. Therefore it is difficult to apply Ex Ante Regulation because the regulatory mechanism changes with the type of services and amount of traffic generated by each network.

2. **Types of interconnection (At what layer?)**

NGN networks consist of four major layers, which are Access, Transport, Control and Service. The proposed interconnection regime to Sri Lanka will only allow interconnecting Transport, Control and Service layers. Access layer interconnection can be considered in the future when machine to machine communication gets popularized.

3. Interconnection products (For what?)

It is proposed to interconnect voice services, unified communication services and video services and multimedia services.

Unified communication (UC) converges all forms of audio, video, Web, desktop and mobile communications on an IP network, resulting in the breaking down of all distance, time and media barriers. UC enables people to communicate with each other anywhere, anytime, over any device.

All the networks should support emergency services when interconnecting each other.

4. Interconnection charging (usage or capacity?)

Setting of a reasonable price structure for NGN interconnect services will be very important to facilitating migration from the PSTN to NGN. It is proposed to charge according to the usage. Interconnection charges should be calculated for the Usage of data volume.

But additional charges should be made by considering following factors.

I. Service type
II. Level of QoS provided
III. Time of Day

The unit price should be calculated by considering the cost.

Following factors should be considered when calculating cost of operation.

I. In NGN costs may no longer be driven primarily by call volumes in the busy hour. It will be traffic volume of packet data.
II. There may be fluctuations in unit costs as NGN investment leads to greater network efficiencies and traffic volumes change.

5. Point of interconnect (where to be interconnect?)

The arrangement of point of interconnect is a critical factor to decide the market competition. It is proposed five interconnection points which are located at below locations.

I. Colombo- Fort
II. Matara
III. Badulla
IV. Kurunegala
V. Vavunia

It is mandatory for all the operators to connect their regional network for the regional interconnection hub.

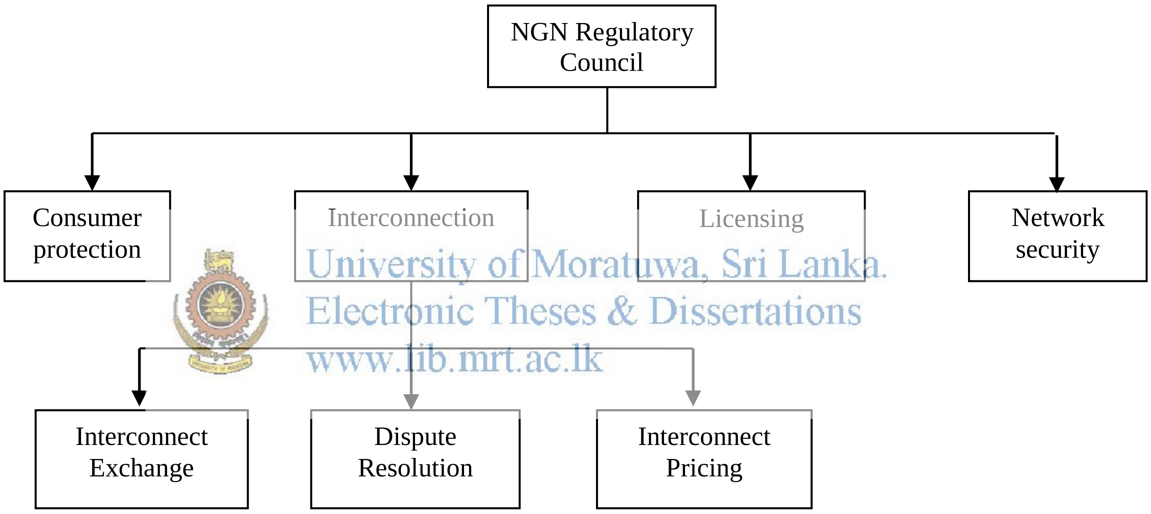
I. This will allow space to new small scale regional operators to enter in to the market.
II. This structure will also create opportunities for regional content providers.
III. This will maximize economic welfare.
IV. This will prevent large operators from leveraging market power by refusing interconnect to small rivals.

Since currently all the operators having Colombo centralized network structure, they have to incur some additional cost for the migration of new NGN interconnection structure. It is proposed to award some monitory incentive to operators in order to encourage them to change for the new interconnection structure.

Lawful interception is allowed at regional interconnection hub points. The telecommunication regulatory commission is the only party which having the authority to interception. The lawful interception is only allowed to protect consumer. Law full interception is subjected to existing law in Sri Lanka. Therefore this should not affect the privacy of the consumer.

6.3 NGN interconnection regulatory authority

It is proposed below functional structure to regulate NGN interconnection in Sri Lanka.



I. Interconnection exchange division is responsible of planning and maintenance of multi-lateral interconnection hubs.

II. Dispute resolution division is responsible of resolution of all interconnection related issues. With the growing capability of third party providers to provide services over the NGN, some or many services may be supplied by foreign companies, who are not subject to local laws. Any solutions to this, such as requiring foreign companies to operate through local subsidiaries, may affect the costs and the time taken to roll out the services.

III. Decision making process should align to the functional structure of Regulatory body.

IV. Consumer protection division having power to over right other divisions when it comes to an issue with end users. This division having responsibility of avoiding entry barriers. Also anti-competitive conducts such as refusal to supply, vertical price squeezes, cross-subsidization, misuse of information, customer lock-in and restrictive agreements, exclusionary and predatory pricing, tying & bundling of services should be regulated by this division.

V. Remedies for anti-competitive behaviors should be decided by local judiciary system.

6.4 View of TRCSL regarding the proposed regulatory and policy framework

Director- Networks of TRCSL is currently handling NGN regulations. It could be able to contact Director- Networks of TRCSL to get their view regarding proposed interconnection model, regulatory and policy framework. TRCSL's view was requested in below main areas.

1. What will be TRCSL preferred interconnection topology which is suitable to Sri Lanka?

   Distributed interconnection architecture is preferred.

2. What will be TRCSL preferred point of interconnection selection methodology?

   It is under discussion to select point of interconnection closer to end users.

3. Who will be TRCSL preferred party to implement and manage the interconnection hubs?

   It is under discussion to provide authority for an independent third party.

4. What is the TRCSL preferred timeline for operators to complete migration to NGN?

   It is under discussion guide operators to complete NGN migration in 2020.

5. TRCSL's opinion on mandating every operator operates in a particular region to connect in to interconnection Hub.
   It is required to mandate every operator to interconnect.

6. What is TRCSL preferred charging regime for NGN?
   It is under discussion to introduce new charging regime

7. At what layers TRCSL will allow to interconnect in NGN ?
   It is under discussion about level of interconnection.

8. What will be TRCSL preferred charging unit of NGN interconnection?
   Bits will be used as charging unit

9. What is the most suitable NGN regulatory body functional structure for TRCSL?
   Not yet decided the functional structure

TRCSL is currently working on above areas and agreed to provide complete feedback after analysis the proposed solution. TRCSL is also agreed to take input from this analysis when formulating new regulatory framework to interconnect NGN.

CHAPTER 7

CONCLUSION & RECOMENDATIONS

Regulatory instruments are best seen as “tuning” variables in a dynamic adaptive system. Specific choices not only affect the overall level of investment in regulated and unregulated market segments, they also influence the structure of investment and the amounts invested by different types of operators.

Even though Sri Lanka is a geographically small and developing country, the literacy and education level is in par with developed counties. Therefore Sri Lankan is adapting to advance technologies very fast, especially in telecommunication field. Having 100% mobile phone penetration is good example for that. Therefore national telecommunication policy should align to future trend of telecommunication networks.

The NGN interconnection model and regulatory & policy framework which I have proposed is aligned to future trends of telecommunication industry. Also it will directly affect to the development of country as a one unit, without Colombo centric development.

The most important feature of this proposed model is the quick adaptability to new service which will emerge in future. Also this interconnection model will work as a catalyst for new services which having distributed network architecture.

The proposed model can be further tuned by performing an in-depth discussion among all the telecommunication operators, media broadcasting operators and TRSCL.

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