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The Gazette of the Democratic Socialist Republic of Sri Lanka

EXTRAORDINARY

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Government Notifications

TELECOMMUNICATION S REGULATORY COMMISSION OF SRI LANKA

Policy and Regulatory Framework for Next-Generation Networks in Sri Lanka

Contents

1 Executive summary

The objective of this report is to provide the main guidelines for the future next-generation network (NGN) policy and regulatory framework in Sri Lanka. These objectives are based on the responses to the NGN regulatory framework consultation issued by the Telecommunications Regulatory Commission of Sri Lanka (TRCSL) on 29 September 2010and on the key issues that the TRCSL foresees in the transition to an NGN world.

1.1 Introduction to NGN

Historically, incumbent operators built and operated the public switched telephone network (PSTN), which was exclusively designed to offer voice services. The PSTN consisted of an access network*, which used copper loops to connect each enduser to a switch, and a* core network *that connected the switches to each other as well as to international routes.*

New technologies and demands have led to two significant developments. First, at the core network level, a demand for data communications services over existing access networks has emerged, mainly motivated by the introduction of the Internet and the requirement from businesses and governments to be connected. Second, new access networks emerged, such as mobile, fixed wireless, and Internet-enabled cable TV, which are able to offer voice services, while also increasingly meeting the demand for Internet access services. Both of these developments have led to significant challenges for operators, which NGNs are able to address.

NGN technology makes it possible to replace all the legacy core networks dedicated to different data services with a single scalable next-generation core network (core NGN) capable of supporting all types of services. This is illustrated in Figure 1.1. With the implementation of a core NGN, the operator will be able to significantly reduce its operational expenditure (opex), as a single operational team will be able to operate and maintain the entire network. Also, since the NGN uses a single technology – typically based on Internet Protocol (IP) – all equipment in the network will be of the same type, leading to larger economies of scale and therefore a reduction in the operator's capital expenditure (capex).

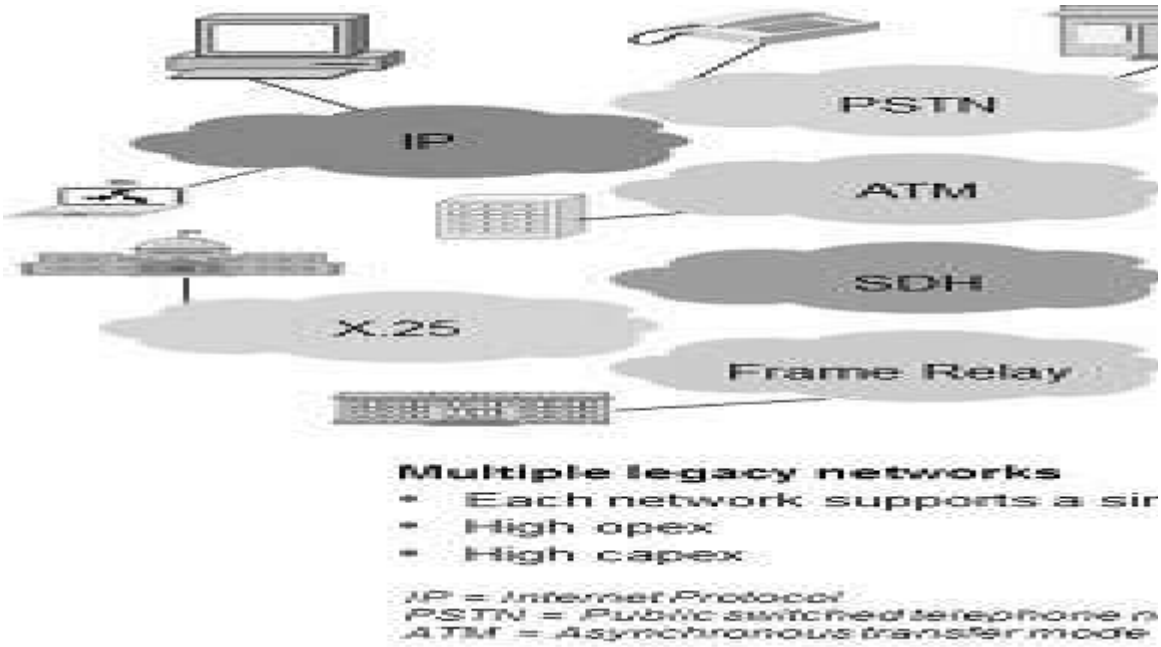

Figure 1.1: Consolidation of legacy core networks into a single core NGN [Source: Analysys Mason]

Another significant advantage is that the same NGN technology can operate over all of the different access networks, including copper wires, mobile (cellular) connections, and wireless radio networks. An access network that uses next-generation technology is called a next-generation access network (NGA network). By upgrading to NGA technology, operators that have multiple access networks will benefit from increased interoperability between these networks, and therefore lower costs. Even operators that only have a single access network will also benefit from the lower cost of purchasing and operating NGA equipment, as well as the ability to offer new services over their network.

Finally, as illustrated in Figure 1.1, one of the key benefits of NGN is that it enables a wide range of services to be provided over a single network. This means that an operator can now provide new services without having to build new, dedicated networks. In other words, NGNs enable services to be provided independently from the physical network, and in particular, independently from the access network: for example, an operator with wireless access infrastructure will be able to provide the same services as a fixed-line operator. The result is convergence of both networks, and services, as described below.

1.2 Introduction to convergence

Historically, the types of services or content delivered over a particular network have been intimately tied to the nature of the communications network being used to deliver those services or content. Each access network was served by one or more overlapping core networks and offered a different service to a dedicated user device. For example, fixed telephony services and Internet access were provided over copper lines connected to telephones, mobile telephony was delivered using cellular technologies to mobile phones, and TV signals were broadcast using radio waves or via cable to TV sets. This historical situation is illustrated in Figure 1.2 below.

Figure 1.2: Telecoms, radio communications and media industries before convergence [Source: Analysys Mason]

The introduction of NGNs means that operators will have to depart from this legacy model and align their business models in order to enjoy the full benefits of the migration to NGN. The introduction of NGN results in two types of convergence:

- **convergence of networks** – includes the ability for a single network to carry both IP-based content and legacy TDM traffic.
- **convergence of services** – refers to the fact that services including voice, video and data can all be provided using IP-based protocols, which means that it is no longer necessary to have a dedicated infrastructure to deliver each type of service.

At the same time, to support these developments, devices are beginning to converge to adapt to these networks, thereby increasing the ability to offer either multiple services over multiple networks using a single device.

Figure 1.3illustrates the structure of the communications and media industry as a result of convergence. Fixed-line, mobile and wireless NGA networks can connect to a single core NGN. Also, from a service perspective, users with any type of access infrastructure can access any services. Of particular interest is the separation of services and networks. Formerly, the network owner offered services over its own network, but under a converged network,it is now possible for another service provider to offer services, such as voice over Internet Protocol (VoIP) telephony, with little or no interaction with the owner of the network.

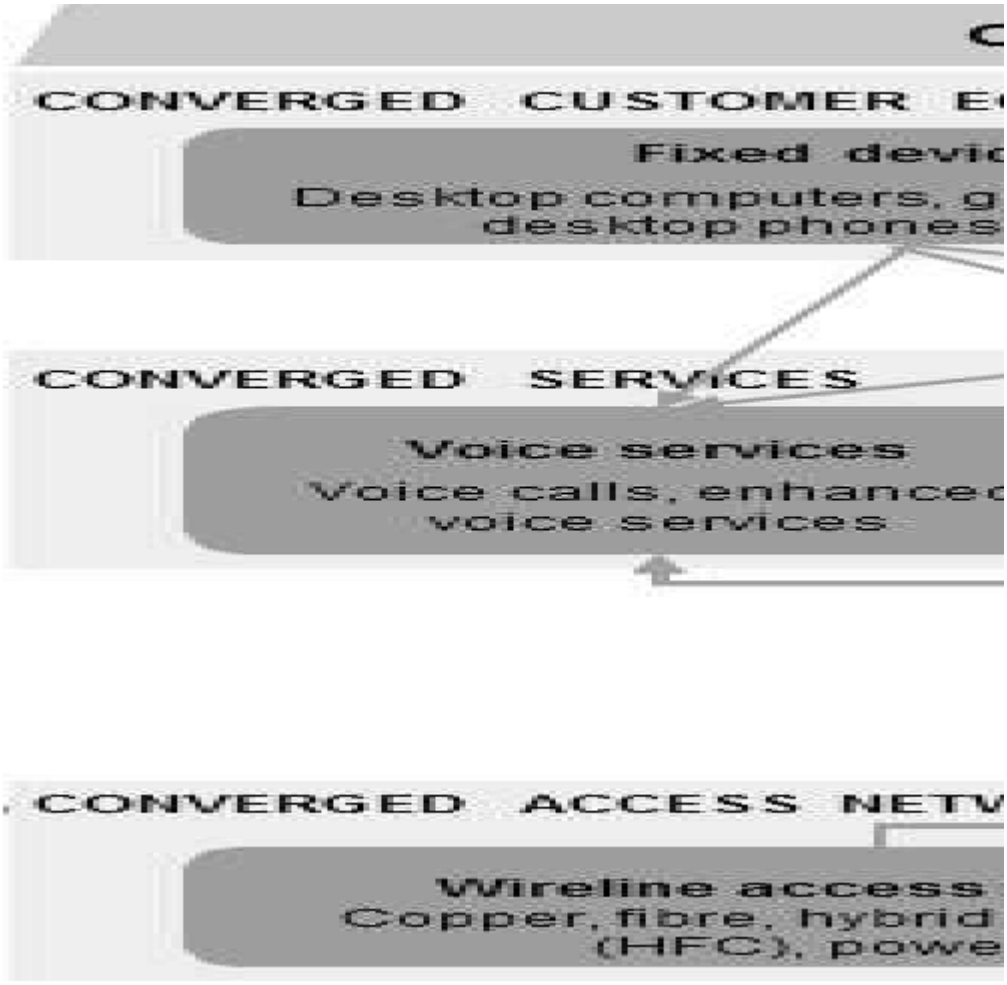

Figure 1.3: Communications and media industry after convergence [Source: Analysys Mason]

The TRCSL believes that Sri Lanka has a unique opportunity in this convergent climate to rapidly close the gap that exists with the most technologically developed countries with regard to advanced communications and media services. The very swift process of convergence means that Sri Lankan network operators and service providers do not have to follow the same developmental path as followed in more developed countries: Sri Lanka could leapfrog certain steps and rapidly deploy the most optimal advanced technologies. This would provide a means to close the gap quicker than would otherwise be possible, and give users a chance to enjoy the benefits being experienced by consumers in more technologically developed nations.

1.3 Technical issues

The recommendations with respect to the technical issues raised by NGN are summarised below.

1.3.1 Next-generation access

In general, two types of infrastructure can be used to provide broadband access:

- Wireline infrastructure – which refers to an architecture where the access network consists of physical cables (copper or fibre) to connect the end-user
- Wireless infrastructure - which refers to an access network that does not require any physical cables and which is instead implemented using wireless technology (e.g. 2G, 3G, LTE, WIMAX, etc)

Wireline infrastructure is usually significantly more expensive to deploy than wireless infrastructure, especially in areas where there is little (or no) wireline infrastructure. Also, wireless network are in general faster to deploy than wireline networks.

Therefore, Sri Lanka should focus on wireless broadband in rural areas as it provides the most cost-effective way to deliver broadband in rural areas where wire line deployment is not feasible. The TRCSL believes that a number of measures could be adopted to ensure this aim is achieved:

- ensure that enough spectrum has been allocated in the preferred bands for operators to implement mobile broadband solutions (e.g. digital dividend, sub 900MHz bands)
- assess the assignment of spectrum among operators and ensure that this creates a level playing field for all operators and potential new entrants
- encourage the sharing of mobile infrastructure (sites and towers) by mandating infrastructure access
- encourage operators to share their backhaul for remote sites.

Therefore, the TRCSL believes that undertaking a study on digital migration and general spectrum management reform would be highly beneficial to meet the above objectives. For this, the TRCSL will weigh the benefits of spectrum fees/auctions against the benefits of promoting competition and deployment.

1.3.2 Next-generation services

The TRCSL believes that over the top (OTT) applications such as Google and Skype should not be discriminated against for several reasons:

- it would be difficult to control all new applications that will be made available on the Internet
- these applications enable communications for Sri Lankans for social and business purposes
- these applications are in essence different services than those offered by operators in a closed network where quality of service (QoS) can be controlled
- discriminating against OTT applications such as Google,Skype and other similar services would send a strong negative message internationally regarding Internet policies in Sri Lanka, and may hamper innovation and investment.

However, the TRCSL is aware of the potential loss of revenues from bypassing the levy on incoming international traffic with these applications, and will partly address this issue through the formulation of the USO programme.

As a consequence, the TRCSL has now decided to permit the importation of VoIP phonesto ensure all consumers have equal access to VoIP technology, irrespective of the network they use to access it.

1.3.3 Convergence of media and telecoms

Engaging with the Ministry of Media and Information and harmonising policies to promote competition regarding the issue of accessing TV content will be key to ensuring competition. For example, in the UK, in order to ensure that service providers compete on a level playing field, the regulator Ofcom mandated BskyB to provide a wholesale product for two of its sports channels (Sky Sport 1 and 2) to all other broadband service providers in the UK.The TRCSL believes that a review of the market regarding TV content should be undertaken and appropriate measures enforced if significant market power (SMP) is found in this area.

The TRCSL believes that it should be feasible to meet the above requirements by closely co-operating with theMinistry of Media and Information.

1.3.4 Technical NGN Advisory Committee

The consultation responses revealed that different operators are planning to adopt different standards for interconnecting their NGNs, and each operator will have a different roadmap regarding how they transition from their existing legacy network to the NGN.[1] If operators were to deploy NGN networks in isolation, there could be adverse impacts on telecommunications in Sri Lanka, as potentially different networks would not be compatible for inter-connection. Therefore, the TRCSL believes that it can play a crucial role in co-ordinating these activities among operators to ensure interoperability among operators.

The consultation responses also sugges that there is a requirement to harmonise numbering and naming(including the specifications of the architectures to deploy electronic numbering (ENUM)) at a national level.

Finally, it was also identified that, since all NGNs would ultimately be interconnected to each other, co-ordination of the security strategy at a national level is also required for the successful implementation of NGN in Sri Lanka.

Therefore, in order to address the aforementioned issues, the TRCSL believes that an NGN Advisory Committee, which would comprise the key NGN stakeholders (i.e. incumbent operators, fixed and mobile operators, and data service providers), should be formed to advise the TRCSL. The NGN Advisory Committee should have three distinct working groups (or workstreams), as illustrated below in Figure 1.4.

Figure 1.4: Proposed structure of the NGN Advisory Committee [Source Analysys Mason]

[1] Some operators have already started their NGN migration and have already invested significant capex in that transformation.

The scope of each of the workstreamsis anticipated to be as follows:

- **Workstream 1: Interconnection and standards** – The core function of Workstream 1 should be to assist the TRCSL to co-ordinate the development of the technical interconnection standards and interfaces to be implemented, in order to ensure interoperability between all operators in Sri Lanka, during the transition to NGN. The TRCSL believes that the approach taken by the Network Interoperability Consultative Committee (NICC) in the UK would be appropriate to meet these objectives; that is, to start by determining end-to-end service requirements for all operators by means of a series of workshops. Once the service requirements are established, the Committee could assist the TRCSL in specifying interconnection standards and interfaces, also by organising a number of workshops between key industry stakeholders.

  The TRCSL also believes that a key role for Workstream 1 will be to specify end-to-end QoS parameters such as delay, jitter, bit error rate and packet loss for different classes of service, as well as defining a threshold for these parameters to ensure operators have a common set of objectives for the performance of their networks.As indicated in Section 3.6, the TRCSL does not intend to actively monitor QoS parameters on operators' networks during the migration to NGN, but would monitor QoS parameters when all operators have completed their transformation to NGN.

- **Workstream 2: Naming and addressing** – The core function of Workstream2should be to assist the TRCSL to co-ordinate the development of the technical specification of standards for numbering and naming, including the specification of how ENUM should be implemented. Workstream2 should also focus on how number portability may be implemented in Sri Lanka. The TRCSL is planning to launch a separate consultation on the harmonisation of numbering and naming to provide a starting point for the NGN Advisory Committee. The TRCSL anticipates that the operational model for Workstream2 should be similar to that of Workstream1 in that a series of workshops should be organised to first establish the requirements for the harmonisation in the numbering plan and naming conventions. Then, based on these requirements, the Committee will make some recommendation to the TRCSL for implementing this required numbering plan and the approach to take for implementing ENUM.

  Another key role for the NGN AdvisoryCommittee will be to study the impact of the co-existence of IPv4 and IPv6. During Phase II of the transition to NGN, some operators will implement IPv6 in their network, while other operators will still be operating a network based on IPv4.Workstream 2 will be responsible for implementing a solution that provides interoperability between vendors using different IP versions.

- **Workstream 3: Security**– The core function of Workstream 3 should be to assist the TRCSL to co-ordinate the development of the technical specification and standards relating to security issues surrounding NGN. Workstream 3 should focus on the key technical issues to establish a security strategy, and recommend a set of security standards and architectures that would be enforced by the TRCSL to ensure security at a national level.This is particularly important if an independent Internet exchange point (IXP) is created, where most or all networks will ultimately be interconnected. Again, the TRCSL anticipates that the operational model for Workstream 3 should be similar to that of Workstreams 1 and 2 (i.e. a series a workshops should be organised to first establish the requirements for a national security strategy).Finally, the TRCSL also believes that the NGN Advisory Committee should be purely technical and that commercial issues should not be in the scope of the Committee's responsibilities. In particular, the NGN Advisory Committee should not provide a forum for the participants to effectively collude by agreeing on commercial models, such as how and what to charge for NGN services (voice or data).

- **Workstream4: USO –**The core function of Workstream 4 should be to assist the TRCSL to develop the USO programme and, in particular, identify the overall objectives that the USO programme should achieve. In this workstream, key stakeholders should also provide some advice to the TRCSL regarding the possible funding model for USO, as well as defining the mechanisms to disburse the funds (how to give the money back to the industry).

1.4 Regulatory and legal issues and recommendations

A number of building blocks are needed to fully introduce competition and promote the introduction of NGN and convergence. The TRCSL's recommendations for a new regulatory framework are summarised below.

1.4.1 Market dominance and asymmetrical regulations

To ensure that Sri Lanka can smoothly transition to an NGN environment, the TRCSL considers that asymmetric regulation will be necessary and will in fact encourage more investments as operators are protected from anti-competitive behaviour by dominant operatorsfor legacy or new services.

Respondents to the consultation have demonstrated strong support in their responses for putting in place different elements of asymmetric regulation, such as requiring dominant operators to offer a reference interconnection offer (RIO) and mandating access to bottleneck elements. However, the TRCSL also notes the respondents' concerns and agrees that regulation should only be imposed to address specific competition concerns. In this regard, ex post competition regulation will be triggered when there are specific incidents of anticompetitive activities.

As for ex ante regulatory measures to be imposed on dominant operators, the TRCSL will impose those that are necessary for promoting competition and protecting consumers. The TRCSL intends to learn from international best practices in its design of the regulatory framework to avoid regulatory distortion of the market and create undesirable arbitrage opportunities.In order to determine whether an operator(s) is(are) dominant, the TRCSL will consider, amongst other factors, the level of regulatory resources and expertise available, its regulatory priorities, the demands of the different approaches and the state of development of the Sri Lankan market. As part of its forthcoming licensing review, the TRCSL will seek to incorporate the necessary elements of asymmetric regulation into the new licences.

1.4.2 NGN licensing

The TRCSL is mindful that most of the legacy PSTN licences currently issued to the present operators will come up for renewal during 2011. In renewing these licences, the TRCSL will make the necessary modifications to licence conditions in order to ensure the smooth migration to NGN. As a starting premise, the TRCSL believes that in an NGN environment, licence obligations across the same licence category must be homogeneous, except those imposed on a dominant licensee. Fewer regulatory obligations should be imposed on service-based operators compared to the facilities-based operators, reflecting their lack of control over any necessary or essential facilities, and in order to encourage the development of vibrant and innovative retail services provided via NGN.

1.4.3 Universal service obligations (USO)

The TRCSL will consider issuing a public consultation in order to seek inputs on the appropriate design of a USO programme applicable to the NGN environment. Following this consultation, the TRCSL is planning to seek advice from the NGN Advisory Committee on a number of steps to implement a robust USO programme.
The first step would be to set forth the goals of universal service funding and disbursement:

- In terms of funding, should the source of funding come from general government revenues or from specific telecoms taxes? If the latter, what levies could be imposed that would not hinder deployment, adoption and usage of the networks?
- In terms of disbursements, should universal service funding cover network deployment in underserved areas, or should it cover access for those peoplewho cannot afford it? Further, should funding decisions differentiate between mobile and fixed, or between voice and broadband?

The next step would be to determine the available funds that the current system would raise over time given changes in the networks and services, and determine what level of funding is required to meet the new goals set forth by the government. The final step will be to design a new funding mechanism that would meet the requirements set forward by the goals.

1.4.4 Wholesale obligations

The TRCSL is of the view that the imposition of wholesale obligations on dominant operators will foster and maintain competition in an NGN environment that will benefit consumers.The recommended wholesale obligations include mandating interconnection between networks and requiring dominant operators to publish a RIO setting out prices, terms and conditions on which they will provide wholesale services to a competitor. The TRCSL will seek industry opinions on the proposed terms for an NGN RIO, as part of a further consultation on the review of the licensing/asymmetric regulatory framework.

As part of the implementation of asymmetric regulation along with the corresponding RIO, the TRCSL recognises that the competitiveness of all markets must be studied and appropriate remedies be put in place where dominant operators have market power. One area where there is typically market power is in the core network for leased lines and international access, and in addition this is an area where facilitating wholesale access can significantly lower the costs of entrants and increase retail competition. This will be particularly important as broadband networks are deployed and higher-bandwidth backhaul is needed to serve customer demands.

Further, the TRCSL is in agreement with some of the consultation responsesre garding the need for wholesale access network services, and particularly bitstream service, but considers that it should be applied as part of the implementation of asymmetric regulation. The TRCSL will consider designating these services and including them in the RIO subject to a market review to identify the relevant wholesale services.

The TRCSL also notes that there appears to be general industry support for technology and net neutrality, thereby paving the way for it to adopt these principles. In terms of net neutrality, the TRCSL may allow a service provider to retain the ability to offer different levels of services at different prices as a means to manage data traffic. Essentially, the TRCSL may consider allowing operators to throttle or slow down such services to manage service-level quality across their users, but require that any operator that practices such traffic shaping/throttling make public such practices, in order to enable consumers to make educated choices.However, this ability must be subject to a non-discrimination requirement such that vertically integrated providers will not be able to unfairly disadvantage their competitors.

Finally, the TRCSL notes that these principles should apply in particular to voice services, whereby vertically integrated facilities-based operators cannot discriminate against service-based operators providing competing voice services, regardless of the technology used. The TRCSL believes that it is important for consumers tobe sufficiently educated on the characteristics of the voice service in order for them to make an informed decision when they purchase a service from a given operator(e.g. whether the service meets certain QoS requirements similar to the PSTN today, or whether it is ‘bestefforts’, similar to Skype for instance).

1.4.5 Retail obligations

In general, the TRCSL believes that competitive operators should be relieved of the regulatory burden of tariff controls, and that tariff control should be focused on dominant operators.[2] Further,

[1] Only if dominance if found in a particular market.

given that NGN is still in its infancy stage, rather than imposing tariff control on the dominant operator – which requires approval for every single tariff, the TRCSL may consider retaining the power to impose tariff control (including reviewing any specific tariff offering) on a service-by-service basis at the initial stage. As such, if it is a new NGN service, even if it is offered by the dominant operator, the TRCSL is of the view that the services should not be subject to tariff control unless an operator is found to be abusing its market power to harm competition. However, if the operator is deemed to have Significant Market Power (SMP) in a relevant legacy market such as fixed voice service, the TRCSL would consider imposing tariff controls on the related IP service (namely VoIP) until the operator does not have SMP in the relevant fixed voice market so that the dominant operator cannot evade regulation by changing the underlying technology of its service offering.

1.4.6 Charging mechanism

The growing and universal trend towards the adoption of IP-based technology in fixed and mobile networks, the development of fixed–mobile convergent services and the growth of non-voice multi-media services on all networks means that the traditional distinction between fixed and mobile voice services, and between voice and data services, is likely to become less relevant in the future.As a result, there may be a movement towards having all traffic treated the same, and this may migrate to bill and keep under the Internet.Nonetheless, there is a significant impact on operators and regulators involved in migrating from a regime based on calling party's network pays (CPNP) to bill and keep.The TRCSL will conduct a study on the long-term impacts of a move to bill and keep, which it will accomplish by lowering termination rates over time in order to provide the industry with time to adapt to the new long-term regime.

1.4.7 Consumer protection

As to whether additional consumer-protection requirements should be imposed on dominant operators, the TRCSL considers that all operators should be required to treat their consumers fairly, and therefore the TRCSL does not intend to impose any consumer-protection obligations solely on dominant operators.In addition to ongoing protections, the TRCSL may prescribe measures and safeguards focused on the migration to NGN, emphasising the importance of ensuring that consumers are sufficiently informed of the differences between VoIP and PSTN voice services, especially in terms of the availability of emergency services and QoS.Additional steps will be taken to reduce any barriers to switching, in order to enable entrants to compete on a level playing field.Finally, consumer interests (such as privacy and security) will be accorded rigorous protection through regulations, codes of practices and licence conditions (where necessary).

1.4.8 Regulatory aspects to NGN migration

The TRCSL is encouraged by the fact that NGN migration is already underway for a number of operators who have already made significant investment.To ensure that consumers are adequately protected, the TRCSL will also impose some specific standards or requirements that the licensees would have to abide by, including with relation to allowing legacy networks to run concurrently with NGN.

1.5 Summary of recommendations

This section summarises the recommendations proposed by the TRCSL and indicates prioritisation and timescales for each of these recommendations. There are four categories of recommendations:

- **Higher priority, shorter timescale** – Recommendations in this category should be addressed with some urgency, and can be done using targeted policies under the current framework.
- **Higher priority, longer timescale** – Recommendations in this category should be addressed with some urgency, but will either require more time-consuming changes, or can be done in a longer time frame.

- **Lower priority, shorter timescale** – Recommendations in this category can be addressed with less urgency than the higher categories, but can also be implemented relatively quickly under the current framework and thus may be relatively straightforward to implement.
- **Lower priority, longer timescale** – Recommendations in this category do not take precedence over recommendations in any of the other categories. Their implementation, while beneficial for the process of convergence, is either not quite as critical to its progression as the other recommendations, or is not quite as effort-effective as the other recommendations.

The order of implementation or specific timescales for each of these recommendations is a function of the capacity and time available to the TRCSL. If sufficient resources are available, it is possible to implement the majority of these recommendations in parallel or in rapid succession. However, this situation is unlikely, and as such the diagram below intends to provide a relative indication of the implementation times for each recommendation. Shorter timescales indicate potential implementation timeframes within a year or two (although the actual times will vary as the specific issues are investigated and addressed in detail).

Figure 1.5: Priorities and timescales of recommendations [Source: Analysys Mason]

In summary, in order to prepare for the transition to NGN, the TRCSL is planning to issue public consultations on the following topics:

- wholesale market and dominance
- USO
- addressing and numbering (including ENUM and IPv6)
- mobile number portability (MNP).

Also, the TRCSL is considering to undertake the following studies:

- implementation of a not-for-profit IXP
- spectrum management reform, consider Long Term Evolution (LTE) spectrum requirements and digital dividend

- USO programme, in collaboration with consumer associations and with the NGN Advisory Committee
- consumer-protection framework, in collaboration with consumer associations

Finally, in order to renew licences of operators that are expiring, the TRCSL will:

- validate the recommendations to be included in the new licences
- decide what framework would be feasible to implement these new licences in relation to the conditions included in the licences or regulations
- implement this framework in a relatively short timescale (six months), which will be challenging and will required significant legal support.

2 Introduction

The introduction of NGNs has significant impacts on network architecture, enabling multiple core networks to converge into a single core network that can be used by a variety of access networks. The result of this convergence is that the new NGN is able to offer multiple services, including traditional voice and data services, along with video and other advanced services.

This section is structured as follows:

- Section 2.1 provides an introduction to NGN technologies
- Section 2.2discusses the general implications NGN on convergence
- Section 2.3 describes the potential benefits associated with NGNs.

2.1 Introduction to NGN technologies

Historically, incumbent operators built and operated the PSTN, which was exclusively designed to offer voice services. The PSTN consisted of an access network, which used copper loops to connect each end user to a switch, and a core network,which connected the switches to each other as well as to international routes.

New technologies and increasing end-user demand for broadband serviceshave led to two significant developments. First, at the core network level, demand for data communications services over existing access networks has emerged, mainly motivated by the introduction of the Internet and the requirement from businesses and governments to be connected. Second, new access networks have emerged, such as mobile, fixed wireless, and Internet-enabled cable TV, which are able to offer voice services, while also increasingly meeting the higher demand for Internet access services. Both of these developments have led to significant challenges for operators, which NGNs are able to address:

- First, the response of incumbents to the increasingdemand for data communications services was to build different physical core networks, each customised for particular types of new services. As a result, many operators today have at least a voice and a data network, while large incumbent operators around the world operate in excess of ten different network platforms (e.g. ATM, IP, Frame Relay, ISDN, PSTN, X.25).[3] This multitude of networks has created a number of inefficiencies: for example, an operator has to deploy multiple operation and maintenance teams, significantly increasing the company's opex. Another inefficiency stems from the fact that legacy telecoms equipment is network-specific, so that equipment performing similar functions (e.g. switching the signals) has to be installed in each of the networks being operated, leading to an unnecessary duplication of capex for the operator.
- Second, operators increasingly face the challenge of having to manage the services that they are offering across multiple access networks. Some operators, including typically the incumbent, may offer a variety of fixed and mobile services, and face the challenge of operating a core network that serves each of these access networks. Other operators may only operate a single access network (such as a mobile network),

but confront similar challenges in offering multiple services across that network while interconnecting with a variety of other core networks owned by other operators, to exchange traffic.

The inefficiencies described above are no longer sustainable in many countries: the revenues associated with traditional services are beginning to fall, and operators find it increasingly difficult to maintain their profit margin due to fierce competition. NGNs assist operators by reducing costs, and also provide opportunities to increase their revenues by offering new services. These benefits are described below.

2.1.1 Cost-savings opportunities

NGN technology makes it possible to replace all the legacy core networks run by an operator with a single scalable next-generation core network (core NGN) capable of supporting all types of services. This is illustrated below in Figure 2.1.

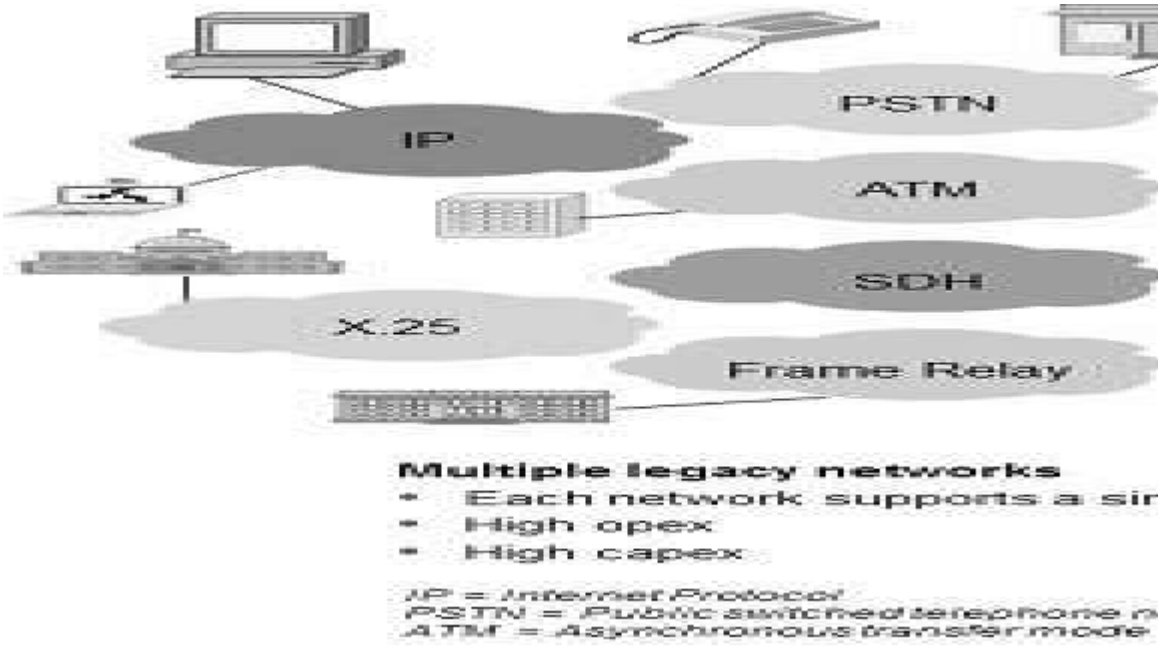

Figure 2.1: Consolidation of legacy core networks into a single core NGN [Source: Analysys Mason]

One of the major benefits of NGN is associated with the significant capex and opex savings to the operator. The sources of cost savings are:

- **Consolidation of the different networks to maintain into a single network** – Often, depending on the technology, different skills are required for field staff (expert in TDM transmission, expert in ATM switching, expert in PSTN and expert in IP networking). The collapse of all these independent networks into a single IP network means that less specialised skills are required.

- **Reduction in the number of network elements to maintain** – The second source of cost savings is associated with the reduction in the number of network elements. For example, dedicated ATM switches were required in legacy networks to provide ATM switching functionality, and dedicated SDH/Sonet add-drop multiplexers were required to provide leased-line services. This is no longer the case with new network architectures. The cost savings stemming from this are significantbecause the maintenance contract between operators and equipment vendors is a function of the number of network elements.

- **Reduction in the overall number of sites** – As show nabove in Figure 2.1, an operator may have dedicated sites for each of its networks. However, because NGN will consolidate all these networks into a single network, fewer sites may be required. Also, for the PSTN, the advent of soft-switches means that fewer switching sites will be needed,and therefore fewer exchange buildings. To illustrate this point, in the Netherlands, KPN's sale of redundant exchanges (after the NGN transformation) raisedan estimated EUR1.5 billion, which was used to fund KPN'sNGA FTTx deployment.
- **IP network elements such as routers are cheaper than their TDM and ATM counterparts** – The last source of savings is associated with the cost of purchasing IP equipment compared to legacy TDM/ATM equipment. For example, a study performed by the Ethernet Forum shows that the cost of TDM equipment per Mbit can be as much as double the price of Ethernet/IP equipment. This gap is likely to grow with the increasing adoption of IP as the protocol of choice for both wireless and wirelineinfrastructure, realising economies of scale for equipment vendors.

Therefore, operators have a significant incentive to move to NGN as they will be able to benefit from savings in both opex and capex.

2.1.2 Integration of access networks

The same NGN technology can operate over all of the different access networks, including copper wires, mobile (cellular) connections, and wireless radio networks. An access network that uses next-generation technology is known as an NGA network. By upgrading to NGA technology, operators that have multiple access networks will benefit from increased interoperability between these networks, and therefore lower costs. Even operators that only have a single access network will also benefit from the lower cost of purchasing and operating NGA equipment, as well as the ability to offer new services over their network.

2.1.3 Separation of transport and service

As illustrated in Figure 2.3, one of the key benefits of NGN is that it enables a wide range of services to be provided over a single network, effectively separating the transport network from the services. This means that an NGN will allow an operator to provide new services without having to build new, dedicated networks. In other words, NGNs enable services to be provided independently from the physical network, and in particular, independently from the access network: for example, an operator with wireless access infrastructure will be able to provide the same services as a fixed-line operator.

In summary, NGN enables the decoupling of the service (provision) from the network (transport) and allows:

- any service to be transported over any network
- multiple services to be simultaneously carried over any networks.

The result is convergence of both networks, and services, as described below.

2.2 Impact of NGN on convergence

Historically, the types of services or content delivered over a particular network have been intimately tied to the nature of the communications network being used to deliver those services or content. Each access network was served by one or more overlapping core networks and offered a different service to a dedicated user device. For example, fixed telephony services and Internet access were provided over copper lines connected to telephones; mobile telephony was delivered using cellular technologies to mobile phones; and TV signals were broadcast using radio waves or via cable to TV sets. This historical situation is illustrated in Figure 2.2 below.

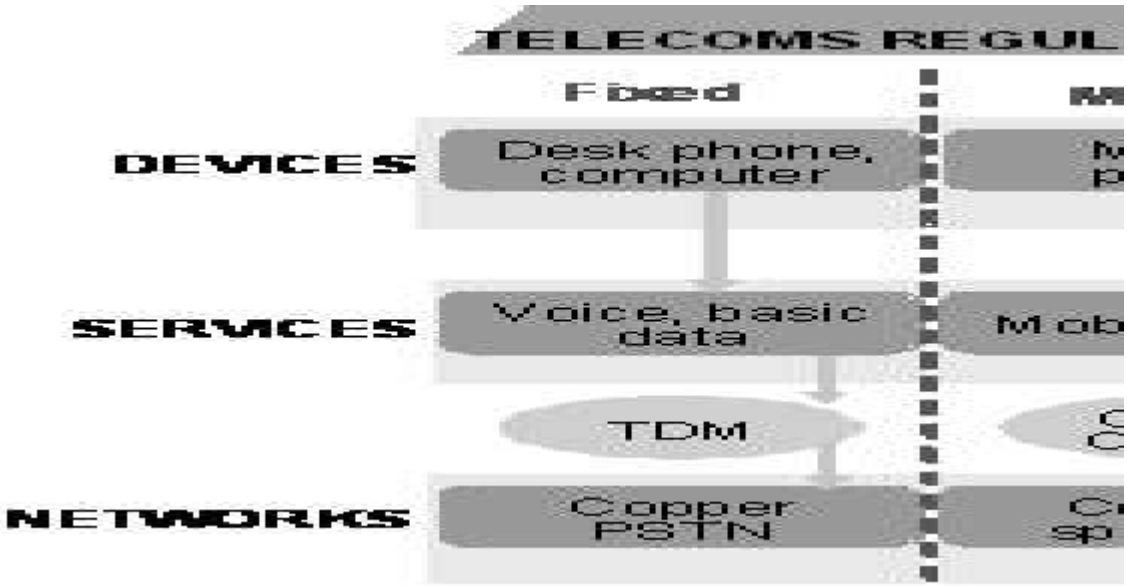

Figure 2.2: Telecoms, radio communications and media industries before convergence [Source: Analysys Mason]

The introduction of NGNs means that operators will have to depart from this legacy model and align their business models in order to enjoy the full benefits of the migration to NGN. The introduction of NGNs results in two types of convergence:

- **convergence of networks** – includes the ability for a single network to carry both IP-based content and legacy TDM traffic.
- **convergence of services** – refers to the fact that services including voice, video and data can all be provided using IP-based protocols, which means that it is no longer necessary to have a dedicated infrastructure to deliver each type of service.

At the same time, to support these developments, devices are beginning to converge to adapt to these networks, thereby increasing the ability to offer either multiple services over multiple networks using a single device.

Figure 2.3 below illustrates the structure of the communications and media industry as a result of convergence. Fixed-line, mobile and wireless NGA networks can connect to a single core NGN. Also, from a service perspective, users with any type of access infrastructure can access any service. Of particular interest is the separation of services and networks. Where formerly the network owner offered services over its own network, now under convergence it is possible for a service provider to offer services, such as VoIP telephony, having little or no interaction with the owner of the network.

Figure 2.3: Communications and media industry after convergence [Source: Analysys Mason]

The TRCSL believes that there is a unique opportunity in this convergent climate to rapidly close the existing gap between Sri Lanka and the most technologically developed countries with regard to advanced communications and media services. The very swift process of convergence means that network operators and service providers in Sri Lanka do not have to follow the same developmental path as followed in more developed countries: Sri Lanka could leapfrog certain steps and rapidly deploy the optimal advanced technologies. This would provide a means to close the gap quicker than would otherwise be possible, and give users a chance to enjoy the benefits being experienced by consumers in more technologically developed nations. As discussed below, this provides significant opportunities for benefits to a wide range of stakeholders.

2.3 Potential benefits of NGN in Sri Lanka

All stakeholders in Sri Lanka will benefit from the introduction of NGNs, including the operators deploying NGN technology and the broader society using services provided over NGNs.Each of these is addressed in turn below.

2.3.1 Benefits to telecoms operators

As mentioned above, one of the main reasons for operators to migrate to an NGN is to optimise both opex and capex, enabling them to maintain their profit margins in a telecoms market that is becoming increasingly competitive. Also, in Sri Lanka as in many other countries, the PSTN is reaching the end of its life and needs to be replaced. It is increasingly difficult and expensive to find equipment

vendors that can support and maintain legacy telephone switches, and it is even more difficult (and very expensive) to replace these switches as all the equipment vendors have now refocused their portfolio on NGN equipment. Therefore, there is a strong incentive for operators to migrate their voice services from the legacy PSTN onto an NGN.

In addition to these cost savings, an NGN provides opportunities for operators to generate new lines of revenue – which are much needed, given the competition in traditional voice services. For example, NGN allows operators to offer TV services such as video on demand (VoD). Because NGNs can support all types of services, there is no requirement to build service-specific networks and therefore the time and cost to market for new services is significantly lower than that associated with legacy networks. Also, it should be noted that service providers with no infrastructure can start competing with more traditional operators by offering services over the internet (e.g. Internet telephony provider Skype is a good example). Such service providers could be located abroad.However, it is difficult to provide a mass market service completely from abroad, given the latency and network costs; many of the services offered from abroad, such as Skype, are expressly not marketed as phone replacement services, and thus should not be subject to the same regulation (e.g. Emergency service) as more traditional services.

2.3.2 Benefits to the wider society

In an era where many countries have embarked on a fundamental transformation catalysed by the progress in telecoms technology, it is important that Sri Lanka is not left behind, and even 'leapfrogs' other countries whose larger base of legacy equipment makes the migration to NGN more costly. In order to better understand the impact of NGN on Sri Lanka, the potential benefits in three key areas are examined: social benefits, economic benefits and environmental benefits.

Figure 2.4: Benefits of NGN in Sri Lanka [Source: Analysys Mason]

Social benefits

Many of the benefits of NGN result from lowering the cost of transactions between parties, such as the cost of conveying information or the cost of travelling to receive or provide services, while also transforming the delivery of these services with new applications. Below, the social benefits of NGN in terms of e-learning, e-health, e-business, e government and social cohesion and e-homes are described.

* *E-learning*

Education is an area where arguably NGNs could have the most significant impact in Sri Lanka. Students of both primary and secondary education are currently facing the problem that they have to take private tution in addition to their state education in order to develop the full set of skills that employers desire. As for tertiary level education, the availability of university places is decreasing alarmingly and as a consequence not all students wanting to access tertiary education are offered the opportunity to do so.

NGN could alleviate these problems by making available virtual classrooms and virtual universities. In such an e-learning environment, school teachers or college professors can deliver a full lecture through a multi-party video conferencing facility, supported by appropriate material such as tutorials sent via email to the students. The key to virtual classrooms is that qualified teachers and professors can reach out to many more pupils and students, without requiring either party to travel to a school or university. This will have the advantages that, as more and more people are able to benefit from primary/secondary and university education, the average level of skills will increase, ultimately resulting in job creation. On the other hand, significant public-sector savings can be achieved through the implementation of a leaner education system (e.g. fewer classrooms needed).

* *E-health*

The development of NGNs, and in particular the wide availability of broadband services, will also benefit health care services in terms of primary medical requirements. People with access to broadband facilities will be able to have a virtual medical consultation with a doctor by means of a video conference, and the resulting prescription or treatment can be recorded in an online system, providing access to the medical history of all patients. Also, the availability of NGNs will enable the remote monitoring of patients, removing the need to hospitalise some of these patients, and therefore making significant savings.In Japan, the health authorities have implemented sensors in elderly patients' homes to detect unusual behaviours. For example, sensors are connected to a kettle to check that the person drinks tea or coffee several times a day. If the sensor detects that that person has not used the kettle for a full day, then, the health authorities send a representative to the patient's home to check that the patientis well. This advance in technology will help alleviate the efficiency issues that the healthcare sector faces in Sri Lanka.

* *E-business*

As an example of e-business applications facilitated through the deployment of NGNs, e-trading and online auctions are gathering significant momentum in Sri Lanka. For example, Alibaba[4] provides an online facility for citizens and businesses to advertise items for sale. At the same time, e-commerce websites will enable Sri Lankans to easily access foreign markets in order to buy and sell products and services.

* *E-government and social cohesion*

Governments the world over are increasingly viewing information and communication technology (ICT) as a key enabler for accelerating economic and social development in their countries, while also transforming the delivery of government and public services, as described above.

The deployment of NGNs throughout Sri Lanka will provide a solid platform for e-government initiatives in the future, and make a significant impact on the social cohesion of the country as

[1] Alibaba.lk is a full-service Internet marketing and advertising agency.

these initiatives will provide connectivity to underserved areas, giving people in these areas the opportunity to take part in the ICT revolution currently underway in Sri Lanka. This is commonly referred to as bridging the digital divide. As a result, individuals will have increased opportunities to network with one another, using voice, video and other innovative applications, as well as being able to access and develop new content.

* *E-homes*

The implementation of NGNs will enable new applications in the home. For example, broadband connectivity will enable users to have access to electronic security systems at commercial and domestic levels. State-of-the-art services such as burglar and fire alarms, and surveillance cameras are all applications that can be developed to be accessed remotely (e.g. from a portable device while away from home) to help improve many security-related issues in Sri Lanka. Also, it will be important to ensure that the benefits of NGN are also brought to elderly Sri Lankans, with remote monitoring that makes it possible to extend the duration for which older people are able to remain living in their homes, bringing significant reductions in public health spending.

Economic benefits

Several studies have shown that there is a correlation between the increase in broadband penetration within a country and the growth of its economy. For instance, the report *The Economic Impact of Stimulating Broadband Nationally,* published in February 2008 by Connected Nations (USA)[5] estimates that by increasing broadband penetration by 7%, the USA could gain the following economic benefits:

· USD92 billion through 2.4 million jobs created or saved annually

· USD662 million savings per annum in healthcare costs

· USD6.4 billion savings per annum from reduced driving

· USD35.2 billion savings from 3.8 billion hours saved per annum from accessing broadband at home

· USD134 billion per annum in the total direct economic impact of accelerating broadband across the USA.

Also, on a smaller scale, the Australian report *True Broadband: Exploring the economic impact*[6] estimates that the availability of broadband in the region of Brisbane and Moreton (in Queensland, Australia) would result in an output increase of more than AUD4 billion within 15 years, with more than two-thirds of the output increase coming from industries other than telecoms. This report also estimates that the availability of broadband in that region would lead to the creation of 1500 new jobs.

In the case of Sri Lanka, the deployment of NGNs and the wider availability of broadband services are likely to bring even bigger economic benefits than those for the developed countries mentioned above. In general, emerging nations do not have extensive legacy ICT systems and networks, and therefore if they migrate to new systems the costs of maintaining and transitioning from these existing systems is not great, while the benefits of delivering services to those who did not previously have connectivity are larger.[7]Although the economic benefits in developing countries are

[5] Available at http://connectednation.org/_documents/Connected_Nation_EIS_Study_Executive_Summary_02212008.pdf.

[6] The Allen Consulting Group (Australia, September 2003), *True Broadband: Exploring the economic impacts*. Available athttp://www.citynet.nl/upload/ERN01_Final_Report_2_Broadbandproductivity_1.pdf.

[7] World Bank (2009), *Information and Communications for Development 2009: Extending Reach and Increasing Impact*. Available athttp://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTINFORMATIONANDCOMMUNICATIONANDTECHNOLOGIES/EXTIC4D/0,,contentMDK:22229759~menuPK:5870649~pagePK:64168445~piPK:64168309~theSitePK:5870636,00.html

likely to be larger, they are more difficult to measure given the relatively recent deployment and the low penetration to date. A recent World Bank paper estimates that in emerging markets a 1.38% increase in per-capita GDP will result from each 10% increase in broadband penetration[8] – a higher rate than in developed countries (but less statistically significant).

In Sri Lanka, the Business Process Outsourcing (BPO) sector provides an example of the economic benefits that could accrue from NGN. In BPO, an organisation outsources the operation and responsibilities of specific business functions or processes (e.g. customer care services) to a third-party service provider. Countries such as Sri Lanka are prime targets for such investment by multinational companies due to the relatively low cost of labour. However, one of the key factors in deciding where to invest is the access to telecoms services and connectivity, as data centres have to be linked to other parts of the businesses they serve, which are usually located in a different country. Therefore, the early adoption of NGN in Sri Lanka would give the Sri Lankan BPO sector a competitive advantage over neighbouring countries such as India, and could attract significant investment from foreign companies.

Environmental benefits

NGN networks can have both direct and indirect environmental benefits. In terms of direct benefits, as explained in Section 2.3.1, one of the key drivers for the adoption of NGN is the possibility of consolidating a number of different networks into one. This means that, as a whole, operators will need significantly less equipment to run their networks. Also, NGN equipment is more energy-efficient compared to legacy equipment, as it uses the latest technology. The combination of fewer items of equipment and decreased power consumption means that NGNs will be ecology-friendly, contributing to a decrease in CO_2 emissions.

In terms of indirect benefits, the services provided over NGNs can reduce the energy consumption of the people using them. For instance, travelling requirements can be significantly reduced through teleworking, e-learning applications or even e-health applications, which will significantly reduce CO_2 emissions from the vehicles used for this transportation. For example, in Europe the FTTH Council has estimated that the deployment of NGA networks could save the CO_2 equivalent of driving 4600km by car per annum for every household in the country.[9]

2.3.3 Benefits to the telecoms industry

Finally, NGN implementation and the resulting convergence would help to meet a number of goals for the telecoms sector in Sri Lanka. The lower cost of NGNs will help to promote the deployment of, and access to, networks and will result in increased Internet access and usage. At the same time, the convergence of services can facilitate increased entry of new service providers to compete with existing ones, and improve the delivery of existing services as well as allowing for new innovative services to emerge.

2.3.4 Summary

The migration to NGN technology in Sri Lanka promises significant benefits for operators, businesses, society, the environment and the telecoms sector. This migration also represents a significant shift from traditional business models, which is a cause of concern for both operators and regulators around the world. For operators, the migration to NGN represents a complex network transformation, and they will need to understand the benefits as well as the risks involved in order to plan appropriately.

[8] Ibid., page 45.

[9] FTTH Council, FTTx Summit 2009, Munich (8–11 June 2009).

3 Technical issues and recommendations

As explained in the previous section, NGNs essentially involve the replacement of all the legacy networks run by an operator with a single unified network, based on IP technology, capable of supporting all types of services. The International Telecommunications Union (ITU) provides the following more formal definition of NGN in its Y.2001 Recommendation:

"A Next Generation Network (NGN) is a packet-based network able to provide Telecommunication Services to users and able to make use of multiple broadband, QoS-enabled transport technologies and in which service-related functions are independent of the underlying transport-related technologies. It enables unfettered access for users to networks and to competing service providers and services of their choice. It supports generalised mobility which will allow consistent and ubiquitous provision of services to users.[10]

This report follows this definition by the ITU.The remainder of this section discusses the main technical issues that should be understood by stakeholders in this consultation. It is structured as follows:

- Section 3.1describes the general architecture and topology principles of NGN, covering both core and access networks
- Section 3.2 describes next-generation services including VoIP and video over IP
- Section 3.3summarises the operational issues associated with migrating legacy networks to NGN
- Section 3.4 describes interconnection models for voice and data in both legacy networks and NGNs
- Section 3.5 summarises interoperability issues regarding interconnection between different networks
- Section 3.6 defines the QoS issues associated with NGNs
- Section 3.7 summarises the security issues associated with NGNs
- Section 3.8describes the numbering and addressing issues that stem from a migration to NGN, with particular emphasis on ENUM
- Section 3.9 describes the scope and governance model for the proposed NGN Advisory Committee to assist the TRCSL with all the technical issues associated with NGNs.

3.1 NGN architectures and topologies

In order to understand the architecture of an NGN, it is important to differentiate between two parts of the network:

- **core network**– which provides a unified packet-based network based on IP technology
- **access network**– which connects end users to the core NGN by means of fixed, mobile or wireless infrastructure.[11]

Figure 3.1illustrates the two components of an NGN. A core NGN can support a multitude of access infrastructures, including wireline and wireless networks such as WiMAX, accessed by end users using a variety of devices. This means that the services can be provided irrespective of how users access the network.

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[10]ITU-T Recommendation Y.2001 (December 2004),*General overview of NGN.SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS.*

[11]New access networks, replacing legacy copper or mobile networks and delivering Internet access to a core NGN, are also known as NGA networks.

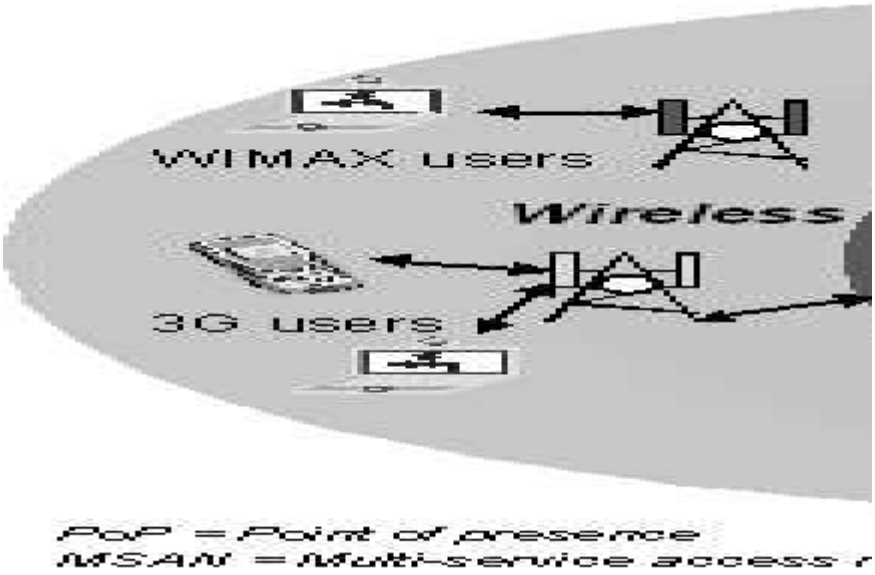

Figure 3.1: Illustration of an NGN [Source: Analysys Mason]

The architecture of an NGN includes the principle of separating, from a physical point of view, the transport and routing of traffic and the definition and creation of the service. As a result, third-party operators can offer services based on standardised and open interfaces to the transport network. With reference to the open systems interconnection (OSI) reference model, there is some discussion about where the demarcation point of the transport and service layer is. However,the NGN service layer and the NGN transport layer are mapped againstthe OSI reference model in Figure 3.2.

Figure 3.2: Mapping between the NGN service and transport layers and the OSI reference model [Source: ITU, NGNuk]

However, the host transport network must be able to support the specific characteristics of the service, in particular, bandwidth and QoS. The aim of this architecture is to build a converged network where any service (e.g. voice and data) shares the same transport infrastructure. This architecture applies to both mobile and fixed networks. One other aim of this architecture is that it opens the way for a new breed of services, for example, converged multimedia services and converged fixed–mobile services.

It is not yet clear to what extent features such as the separation of the service and transport layer will remain possible in the network architectures finally implemented. A number of operators intend to implement their NGNs using centralised platforms for service provision, affecting the ability of independent service providers to integrate their services into the NGN platform. Whether independent service providers will be able to do so also depends on the availability of open and standardised interfaces. Furthermore, such a configuration of services and the centralisation of the control function have implications for the locations at which traffic can be exchanged between networks.

In most NGNs planned by incumbents, services tend to be provided using centralised platforms. Operators with SMP may not have an incentive to open their networks to competition at the service level, and may instead want to limit use of these capabilities. This aspect has an impact on the ability of independent service providers to integrate their services into the NGN platform.The architecture of both core NGNs and NGA networks is reviewed below, focusing on NGN-enabled services.

3.1.1 Core NGN

Legacy PSTNs are based on *circuit-switched* technology, which allocates a dedicated physical path to each voice call and reserves an associated amount of dedicated bandwidth (usually a PSTN voice channel has a bandwidth of 64kbit/s) across the network. This bandwidth is dedicated to the call connection for the duration of the call whether or not any audio voice is being exchanged between the callers.

In contrast, NGNs are based on *packet-switched* technology, whereby voice is sent in 'packets' of digitised data using VoIP. Without any special network features being applied,i.e. QoS mechanisms, each voice data packet competes equally with any other data packets (voice or other types of data on the converged NGN) on the network for the available network resources, i.e. bandwidth. No dedicated bandwidth is reserved for voice data packets for the duration of the call. QoS mechanisms can prioritise voice data packets over other types of data packets, helping to ensure that the voice data packets pass through the network unhindered and within strict timing rules associated with the voice service.[12]

Since voice streams are transported in the same NGN network as data, voice packets can be delayed in some routers in the network, having to 'queue' before being processed. This may lead to a degradation in the quality of the service provided to the customer because voice services are real time services, and any delay in the network will negatively impact the quality of the communication between end-users. Therefore, as mentioned in the ITU definition, a QoS mechanism has to be implemented in NGNs to ensure voice packets are prioritised over other data streams that may be less sensitive to delay, to provide the same quality for the voice service as in PSTN networks (see Section 3.2.1 for more details on VoIP).

[12] An abundance of bandwidth can also improve call quality without QoS mechanisms, if there is sufficient bandwidth for all services/calls. However, the lack of QoS mechanisms and constrained bandwidth can lead to unacceptable call quality at peak times, while requiring an inefficient investment in bandwidth.

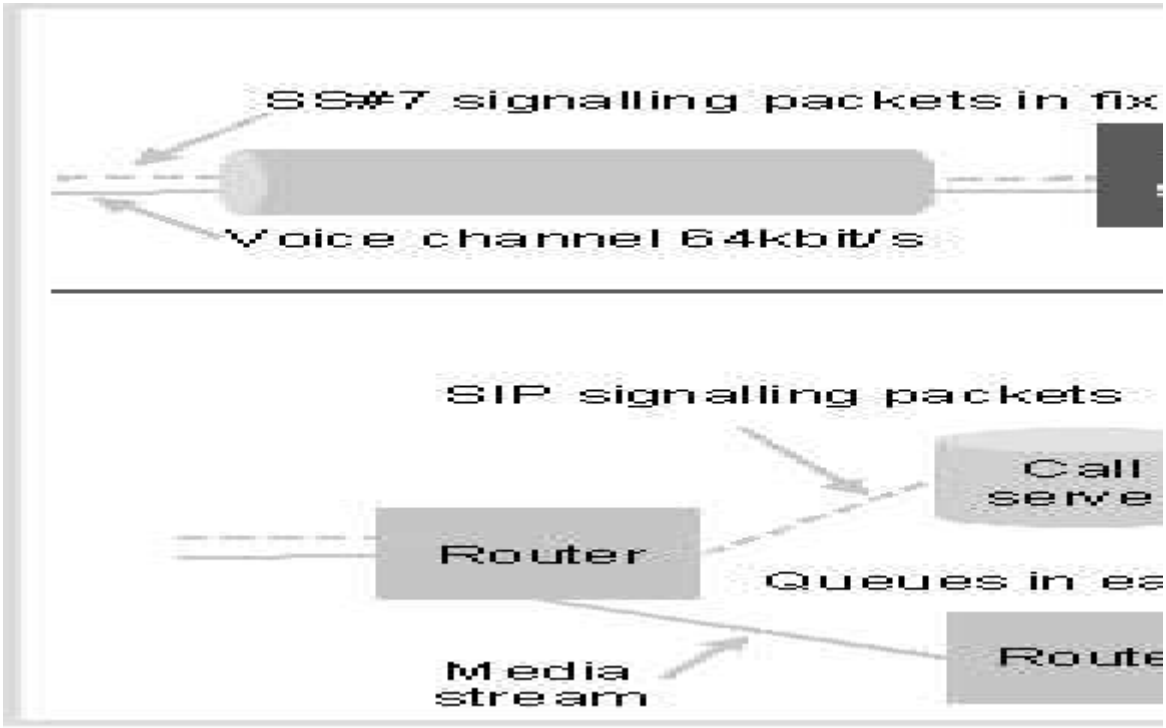

Figure 3.3: Comparison between circuit-switched and packet-switched networks [Source: Analysys Mason]

Figure 3.4below compares the architecture of a legacy PSTN with that of an NGN. It can be seen that the separate layers of local and transit switches are replaced by call servers in a single-layer structure. Typically, a PSTN of 100 local and 10 transit switches might be replaced by a few (less than five) call servers in an NGN. This implies that fewer network nodes are required, yielding the significant opex and capex savings as mentioned earlier (Section 2.1.1).

Interconnection with other operators' networks is implemented by border gateways that control access to the network. If the network interconnects with an older circuit-based network, media gateways may be needed to convert the signals from a packet-switched basis. Interconnection architecture is further discussed in Section 3.4 below.

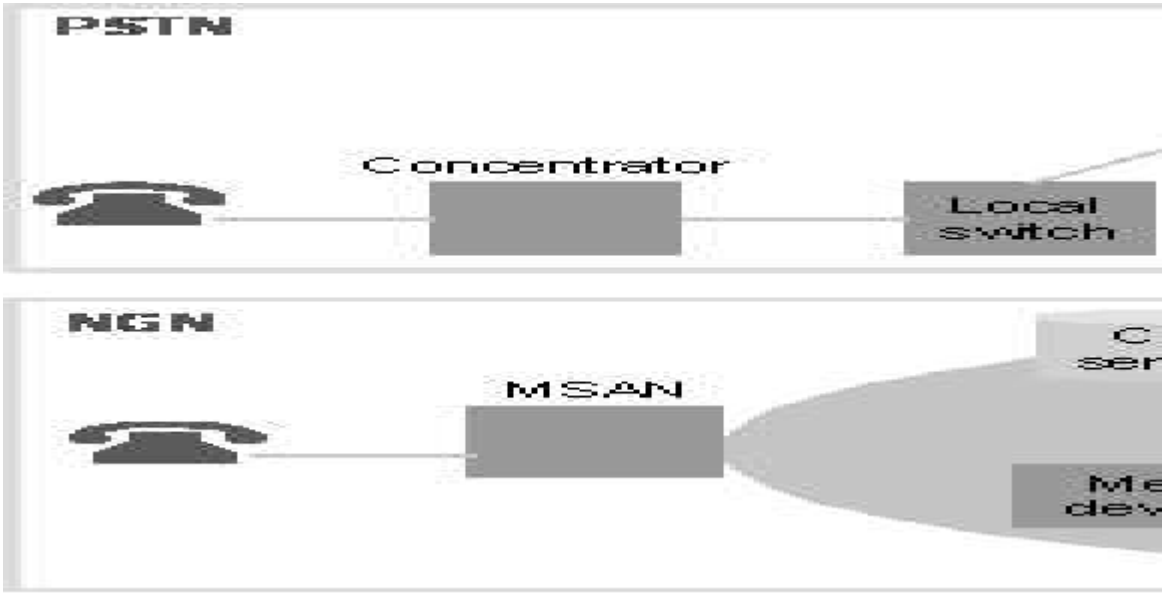

Figure 3.4: Comparison of the traditional PSTN and voice services on an NGN [Source: Analysys Mason]

It is also worth noting that Sri Lanka has embarked on the construction of a National Backbone Network, which will further facilitate the migration to NGN for existing operators, especially in areas where they do not have any infrastructure. The deployment of a fibre-based backbone means that the network will be future-proof in terms of capacity, as fibre can support virtually unlimited bandwidth (in contrast with, for example, microwave technology). For example, fibre systems used in submarine cables can support bandwidths in excess of 3 terabits per second, which is 10 000 times the bandwidth supported by a typical microwave system.[13]

3.1.2 NGA network

A core NGN has little benefit if end users cannot obtain a connection to it with a reasonable bandwidth. This is precisely the role of NGA networks. It is important to note that core NGNs will interoperate with legacy access networks (both wireline and wireless) as well as NGA networks, which will enable operators to make the transition to NGN more smoothly.

This report differentiates between two types of NGA networks: wireline and wireless. In order to explain wireline NGA networks, one must first consider the legacy local-loop access architecture. In turn, wireline NGA networks can be divided into two sub-types depending on the legacy local-loop access architecture: wireline NGA networks using the existing local loop, and wireline NGA networks using fibre to the home (FTTH).

Legacy local-loop wireline access

Figure 3.5illustrates the legacy local-loop access network, which is based on twisted copper pairs. The technology commonly used to access broadband services is known as Digital Subscriber Line (or DSL), which consists in connecting amodem at the user's premiseto the telephone line. A splitter is used at the main distribution frame (MDF) in the local exchangeto separate the voice signal from the DSL-based Internet data stream. Telephony is handled by a remote concentrator unit, and Internet access by a digital subscriber line access module (DSLAM) and an associated network access server (NAS). The network termination equipment (NTE) represents the demarcation between the operator and the end-user environment.

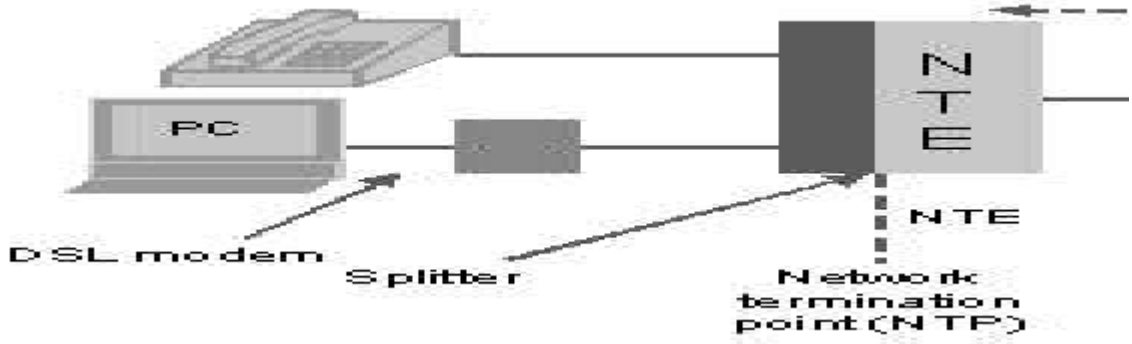

Figure 3.5: Legacy local-loop access network [Source: Analysys Mason]

[13] Assuming a microwave system based on 28MHz of spectrum in the 2.5GHz band.

Wireline NGA network using the existing local loop

Figure 3.6 illustrates how the current local access network can evolve to an NGA network, while keeping the copper-based local loop. In an NGA network, new equipment is provided to the enduser, normally by the service provider, to communicate with the new network. The main function of this equipment is to separate the different types of traffic. In the network, the DSLAM and telephone concentrator are both replaced by a single piece of equipment in the local exchange known as a multi-service access node (MSAN). The MSAN can handle traditional services such as telephony and Internet access, but it can also support new services such as Internet Protocol television (IPTV) and video on demand (VoD).

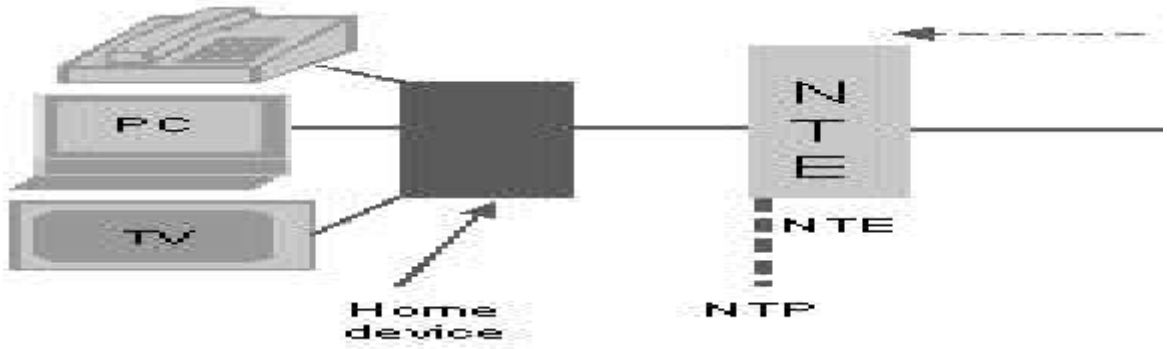

Figure 3.6: Architecture of a wireline NGA network using the existing local loop[Source: Analysys Mason]

In such an NGA network, the access speeds are limited by the length of the copper loop;thus, shortening the copper loop yields higher speeds. One way for operators to achieve this is to replace the link between the exchange and the street cabinet near the customer with a fibre connection, while leaving the existing copper wires between the cabinet and the end user (the sub-loop). Since the copper sub-loop starts from the cabinet, in this configuration the MSAN needs to be sited in the street cabinet instead of in the local exchange. This architecture is known as fibre to the cabinet (FTTC). Typically, existing street cabinets cannot be used to house a 'mini-MSAN' as there is not enough space available, and therefore new street cabinets need to be installed. A typical FTTC architecture is shown below in Figure 3.7.

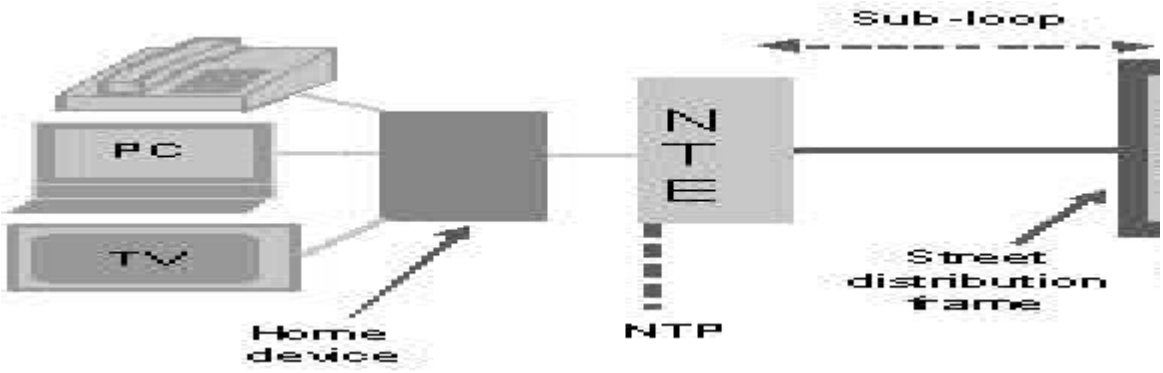

Figure 3.7: Illustration of an NGA network using an FTTC architecture [Source: Analysys Mason]

Wireline NGA network using FTTH

In order to achieve even greater speeds and support a wider range of applications, it is possible to remove the copper from the network completely and replace it with fibre all the way to the end user's premises. This solution is commonly referred to as fibre to the home (FTTH). There are two types of FTTH architectures:

· **Passive optical networks (PON)** – A PON has a point-to-multipoint, FTTH-based architecture, in which unpowered optical splitters are used to enable a single shared optical fibre to serve 16 to 1024 premises. The other PON components include the optical line termination (OLT) at the service provider's central office, and the optical network termination (ONT) located at the end user's premises. This is illustrated in Figure 3.8.

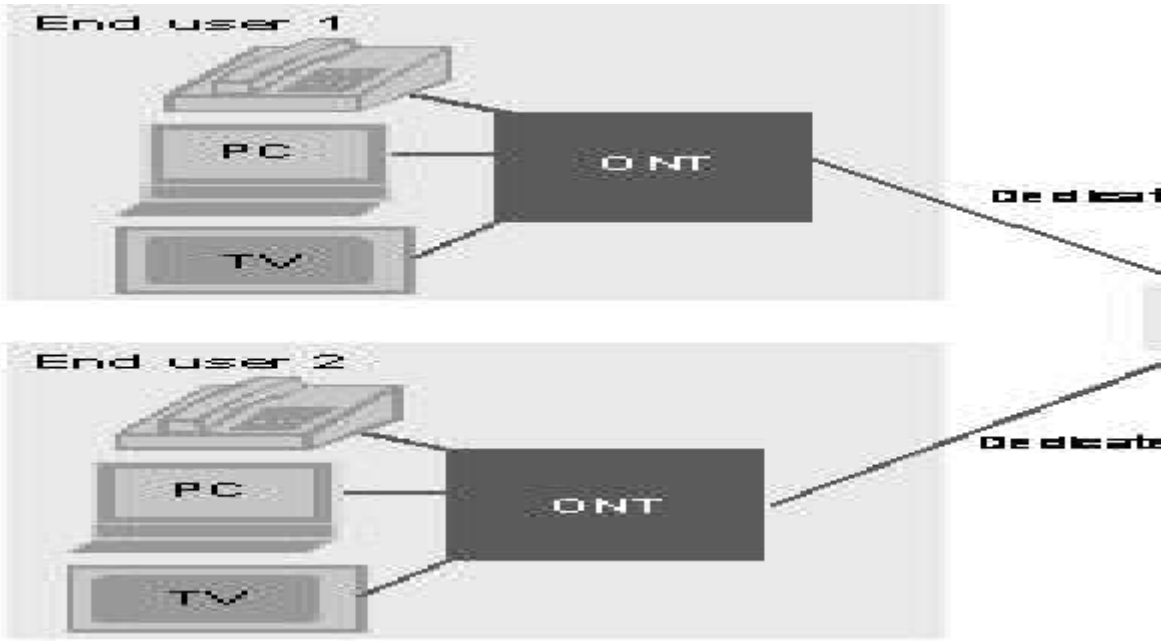

Figure 3.8: Illustration of an NGA network using FTTH: PON architecture [Source: Analysys Mason]

· **Point-to-point (P2P) networks** – A P2P architecture is based on Ethernet technology and uses a dedicated fibre for each individual user. This is illustrated below in Figure 3.9.

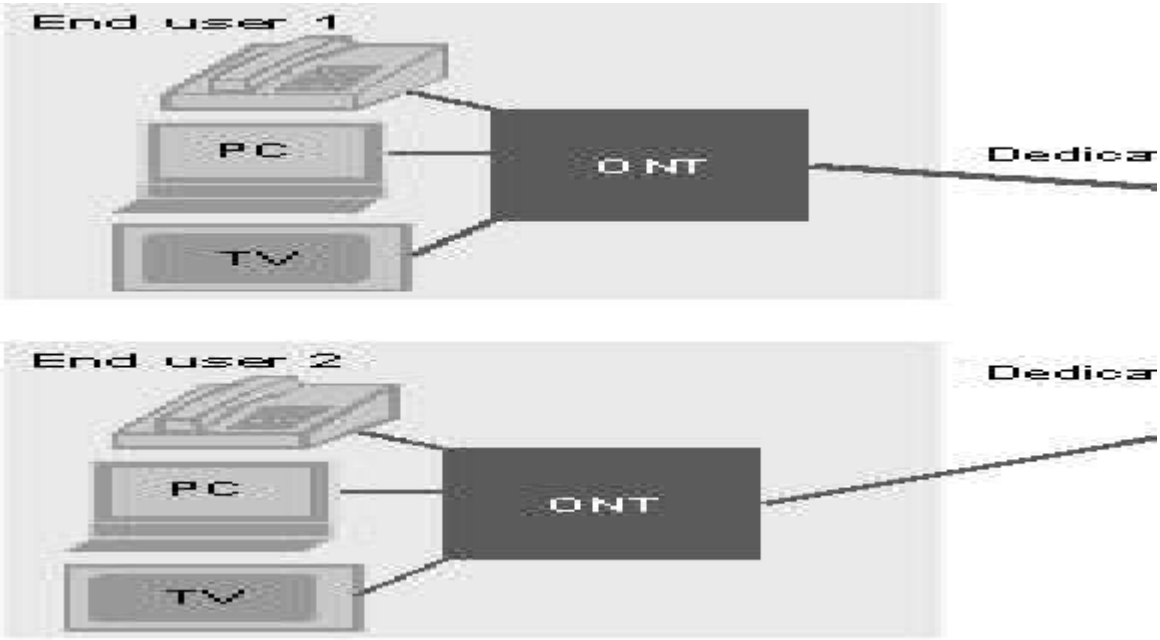

Figure 3.9: Illustration of an NGA network using FTTH: P2P architecture [Source: Analysys Mason]

The difference between a PON and P2P architecture is that in the latter each home has its own dedicated fibre from the exchange; this means higher speeds, but also greater costs.

Wireless NGA networks

* Wireless standards and evolution

Wireless access networks are becoming increasingly popular to connect end users, especially in emerging economies where the wireline access infrastructure is not well developed. There are currently three families of mobile access technologies: Global System for Mobile communications (GSM), Code Division Multiple Access (CDMA) and Worldwide Interoperability for Microwave Access (WiMAX). The evolution of these technologies is illustrated in Figure 3.10below.

Figure 3.10: Wireless access technology roadmap [Source: Analysys Mason]

These mobile access technologies are discussed in turn below:

- **GSM**and its associated family of standards are the most popular standards for mobile telephone access in the world; according to the GSM Association, as of mid-2009 there were over 3.5 billion mobile GSM subscribers in over 200 countries, representing a global market share of 89.5%. The development of these standards is supported by the Third-Generation Partnership Project (3GPP) which emerged from the collaboration of different groups of telecoms associations throughout the world.

- **CDMA** and its family of standards originated from the Interim Standard 95 (IS-95), which was developed by Qualcomm. CDMA2000 was the first CDMA-based digital cellular system, and is therefore a second-generation (2G) mobile system. Supporting the development of these standards is the 3GPP2, which emerged from the collaboration of associations in Japan, China, North America and South Korea.

- **WiMAX** is a wireless broadband standard based on the 802.16 family of standards developed by the Institute of Electrical and Electronics Engineers (IEEE). There are two versions of WiMAX technology, fixed and mobile, and these have separate standards, namely 802.16d and 802.16e, respectively.

As shown in Figure 3.10, the 3GPP and WiMAX standards are still both evolving and will both provide a fourth generation of devices and networks. However, the CDMA family of standards is not future-proof as its development has been stopped in favour of LTE, a technology belonging to the 3GPP family. This is of concern in Sri Lanka as many operators use CDMA technology to provide fixed voice services.

In this context, the TRCSL believes that it is particularly important to understand the current stage of development of LTE technology. At the beginning of 2011, there were only 16 worldwide operational LTE networks; the vast majority of these have been deployed in Scandinavian countries, home to equipment manufacturers Nokia and Ericsson, which use these networks as testbeds. It is also interesting to note that, according to Analysys Mason, only two LTE networks were operational in Asia in the first quarter of 2011 (one in Hong Kong and one in Japan).

TeleGeography anticipates that the take-up of LTE services will remain very low for at least the next couple of years, mainly due to the fact that there are still no affordable and compelling LTE devices available on the market. The take-up levels of LTE are expected to follow a similar profile to the initial take-up level of UMTS, when it was first introduced. The TRCSL believes that it will take several years before end-user devices become affordable for mobile operators to expect reasonable take-up of LTE services in Sri Lanka.

* Spectrum requirements

In wireless access systems, efficient use of the spectrum is crucial as spectrum is a finite resource that is highly valuable for both operators and regulators. The increase in bandwidth that can be provided using wireless technologies has mainly been achieved by maximising the spectrum efficiency of the technologies (i.e. increasing the number of Mbit/s that can be carried in each MHz of spectrum).

Spectrum requirements for each wireless access technology are different, and the regulator has to take this into account when managing its spectrum. Figure 3.11 provides an indication of the spectrum requirements for each of the three wireless technology standards mentioned in the previous section (i.e. 3GPP, 3GPP2 and WiMAX).

Wireless broad band technology	*Download peak rate*	*Upload peak rate*	*Channel width*	*Frequency duplex*	*Commercial availability*
3GPP 2 (CDMA2000)					
EV-DO (Rev 0)	2.4Mbit/s	153kbit/s	1.25MHz	FDD	Available
EV-DO (Rev A)	3.1Mbit/s	1.8Mbit/s	1.25MHz	FDD	Available
EV-DO (Rev B)	4.9Mbit/s	1.8Mbit/s	1.25MHz	FDD	Available
3 GPP (GSM/UMTS)					
W-CDMA (R99)	384kbit/s	128kbit/s	5MHz	FDD	Available
HSDPA+	28Mbit/s	N/A*	5MHz	FDD	Available
HSUPA (cat 6)	N/A	5.7Mbit/s	5MHz	FDD	Available
LTE	>300Mbit/s	>80Mbit/s	20MHz	FDD/TDD	Available
IEEE 802.16 (WiMAX)					
IEEE 802.16d	6.55Mbit/s	2.5Mbit/s	1.75MHz	FDD/TDD	Available
IEEE 802.16e	46/32Mbit/s	8/14Mbit/s	10MHz	TDD	Available
IEEE 802.16m	100/1000Mbit/s	TBD	20MHz	TDD	Not standardised

Figure 3.11:Wireless technology bandwidth and spectrum requirements [Source: Analysys Mason] *Note: N/A = Not available

In terms of regulation, the adoption of a particular technology by operators has a significant impact on spectrum management since:

- technologies can only be deployed in discrete bands of the spectrumas specified by the 3GPP, IMT and other standards
- technologies dictate the duplexing and therefore how spectrum should be allocated (i.e. TDD vs. FDD).

In order to harmonise end-user equipment around the world, increase volumes and therefor optimise costs, ITU and IMT have specified a number of discrete spectrum bands for both WiMAX and LTE, respectively.Figure 3.12illustrates the LTE-advanced band allocation, whereas Figure 3.13provides the profile bands forWiMAX.

	Uplink		*Downlink*		
E-UTRAN band	$F_{ul\,Low}$*(MHz)*	$F_{ul\,High}$*(MHz)*	$F_{dl\,Low}$*(MHz)*	$F_{dl\,High}$*(MHz)*	*Duplex mode (MHz)*
1	1920	1980	2110	2170	FDD
2	1850	1910	1930	1990	FDD
3	1710	1785	1805	1880	FDD
4	1710	1785	1805	1880	FDD
5	824	849	869	894	FDD
6	830	840	875	885	FDD
7	2500	2570	2620	2690	FDD
8	880	915	925	960	FDD
9	1749.9	1784.9	1844.9	1879.9	FDD
10	1710	1770	2110	2170	FDD
11	1427.9	1447.9	1475.9	1495.9	FDD

Schedule (*Contd.*)

	Uplink		*Downlink*		
E-UTRAN band	$F_{ul\ Low}$*(MHz)*	$F_{ul\ High}$*(MHz)*	$F_{dl\ Low}$*(MHz)*	$F_{dl\ High}$*(MHz)*	*Duplex mode (MHz)*
12	698	716	728	746	FDD
13	777	787	746	756	FDD
14	788	798	758	768	FDD
15	Reserved	-	-	-	FDD
16	Reserved				FDD
17	704	716	734	746	FDD
18	815	830	860	875	FDD
19	830	845	875	890	FDD
20	832	862	791	821	FDD
21	1447.9	1462.9	1495.9	1510.9	FDD
….	…	…	…	…	…
33	1900	1920	1900	1920	TDD
34	2010	2025	2010	2025	TDD
35	1850	1910	1850	1910	TDD
36	1930	1990	1930	1990	TDD
37	1910	1930	1910	1930	TDD
38	2570	2620	2570	2620	TDD
39	1880	1920	1880	1920	TDD
40	2300	2400	2300	2400	TDD

Figure 3.12: LTE-advanced operating band [Source: 3GPP]

Profile name	*Frequency(GHz)*	*Channel bandwidth (MHz)*	*Technology*	*Duplexing*
ET01	3.4–3.6	3.5	Fixed WiMAX	TDD
ET02	3.4–3.6	3.5	Fixed WiMAX	FDD
MP01	2.3–2.4	8.75	Mobile WiMAX	TDD
MP02	2.3–2.4	5.1	Mobile WiMAX	TDD
MP05	2.493–2.69	5 and 10	Mobile WiMAX	TDD
MP09	3.4–3.6	5	Mobile WiMAX	TDD
MP10	3.4–3.6	10	Mobile WiMAX	TDD

Figure 3.13: WiMAx profile bands [Source: WiMAX Forum]

As well as spectrum bands, the choice of technology dictates the frequency duplexing access to be used. Frequency duplexing relates to how the downlink and the uplink of a full duplex communication are separated in frequency.Two main full-duplex access schemes exist:

- **Frequency division duplexing (FDD) –** uses different spectrum bands for the uplink and downlink, separating them in frequency.

- **Time division duplexing (TDD)** – separates uplink and downlink signals in time, using the same spectrum band.

TDD has a strong advantage over FDD in cases where there is asymmetry of the uplink and downlink data traffic. As the amount of uplink data increases, more communication capacity can dynamically be allocated to that, and as the demand shrinks capacity can be taken away. The same is true for the

downlink traffic.In the case of FDD, high utilisation in any of the separated bands cannot be compensated for by dynamically allocating more spectrum from the lower utilisation band, so FDD is more suited for symmetric traffic flows such as those associated with voice traffic, which by nature is balanced in both directions.

As illustrated in Figure 3.11, 3GPP- and 3GPP2-based standards were traditionally based on FDD, whereas WiMAX 802.16e and 802.16muse both FDD and TDD.[14] One of the most important developments in 3GPP standards is that LTE is standardised for both FDD and TDD, which significantly simplifies spectrum management, as TDD spectrumcan be the duplex methodology for both WiMAX and 3GPP.

In any case, it is expected that new spectrum will be required for LTE.The preferred spectrum band for LTE in Sri Lanka at the moment is 2100MHz, where 2Í20MHz of FDD spectrum is available. Since 20MHz is required per operator, the TRCSL believes that this spectrum will be sufficient for two LTE licences using FDD.The LTE licences will be allocated using a similar principle to that used for the allocation of the UMTS spectrum (i.e. on a first-come first-serve basis and charging a base price per MHz).At present, the TRCSL considers that 220MHz of spectrum for LTE will be sufficient to meet the short-term demand for LTE.This observation is based on experience of allocating the UMTS spectruma few years ago.

At present, other potential spectrum bands suitable for LTE are not available in Sri Lanka:

- **800MHz band**– is occupied by broadcast operators, CDMA operators, GSM operators and is also used for Trunk Radio services
- **2300MHz band** – has already been allocated to WIMAX operators
- **2600MHz band –** is used by operators to operate their microwave link.

The TRCSL is considering migrating some of the 2600MHz spectrum to accommodate more LTE licences when demand is sufficient.The TRCSL expects that spectrum clearance in the 2600MHz band will take at least three years.

It is also worth noting that the current 3G licences have been issued to Sri Lankan mobile operators with 3G coverage targets.However, the licence does not include any specific obligations regarding the deployment of HSPA and HSPA+ services, which will be key in the near future to provide NGA to endusers.Since the licences are renewable every year, the TRCSL is considering reviewing the terms of these licences to include specific HSPA/HSPA+ coverage targets to ensure that a wider proportion of the population can benefit from true NGA broadband speeds.Also, the TRCSL believes that operators investing in HSPA and HSPA+ technology to meet these new coverage targets should be rewarded with the allocation of LTE spectrum when it becomes available.

* *Digital dividend*

Historically, analogue terrestrial TV signals have been broadcast mainly in the 470MHz to 806MHz spectrum band in Sri Lanka.The advent of digital terrestrial television (DTT) means that less spectrum is required per channel.This means that, if there is a switch-over from analogue TV to DTT, spectrum can be freed up and made available to non-broadcast operators such as telecoms operators.The result of this switch-over is usually referred to as the digital dividend, and the process has already begun, or even been finalised, in a number of countries eager for access to

[14] 802.16d was specified with both TDD and FDD, but was mostly deployed in spectrum blocks characterised as FDD allocations. This is one of the reasons why it is so difficult to upgrade a fixed WiMAX (802.16d) network into a mobile WiMAX network (802.16e).

additional spectrum.The relevant frequencies are of particular interest to mobile operators as they typically have good propagation properties, and therefore require fewer base stations to cover the same area compared to higher spectrum bands currently used in the telecoms industry.This leads to less capex required by the mobile operator to obtain the same coverage, and can result in greater coverage in unserved or underserved areas.

Currently, the TRCSL has identified spectrum for digital migration and is planning to start introducing DTT in the Western and Northern regions by the end of this year.A digital broadcast network operator (DBNO) will be introduced to deploy and operate the infrastructure required for DTT, including transmission towers and multiplexes. The exact governance model of the DBNO is still under study.However, the key objective of introducing the DBNO is to separate services from infrastructure, a concept that is aligned with NGN technology, as explained in Section 2.1.3.

Licences for digital broadcasters providing the content will be issued by the Ministry of Media and Information.Full implementation of DTT is expected to be completed by the end of 2013 and the full digital switch-over (DSO) is expected to be completed by 2017.At that time, new spectrum resulting from the DSO will be available for NGA networks.

Policy makers and regulators must ensure that spectrum allocation, and indeed re-allocation of spectrum through, for example, the digital dividend, does not hamper competition between established mobile operators and potential new entrant service providers and the deployment of new NGA networks and services. In many countries, established operators have delayed the entry of new operators in the market by not providing access to last-mile connectivity, therefore hampering competition. NGA networks, however, allow new entrants and other service providers to deploy alternative technologies such as WiMAX that facilitate high-speed broadband Internet access over wireless connections.The TRCSL has already allocated a number of WiMAX licences to ensure that competition is maintained in broadbandaccess and will continue to monitor spectrum allocations to ensure it creates a level-playing field for all operators.

Comparison between wireline and wireless NGA

In order to compare the bandwidth provided by both wireline and wireless NGA, Figure 3.14 illustrates the peak bandwidth for each access technology, and indicates whether this bandwidth is shared between different users or is dedicated to a single user.

First, in Figure 3.14, it should be noted that peak bandwidth advertised for wireless broadband technology by mobile operators is different from what end users usually experience.This is due to two main reasons:

- the peak bandwidth advertised is usually the peak bandwidth made available to an entire sector, which in practice has to be shared by all mobile broadband subscribers in that sector

- the peak bandwidth is measured at a point close to the mobile basestation, but the bandwidth a user will receive in practice decreases with distances from the base station due to a deterioratingsignal-to-noise ratio.

As the realised bandwidth can differ from the theoretical bandwidth available (and often advertised), it is important for the regulator to ensure that the end users fully understand the service they pay for, which requires transparency from the operators.

Technology	*Media*	*Shared/dedicated*	*Peak bandwidth*
Dial-up	Wireline copper	Dedicated[1]	64kbit/s
ADSL	Wireline copper	Dedicated[15]	8Mbit/s
ADSL2	Wireline copper	Dedicated[15]	24Mbit/s
VDSL2+	FTTC	Dedicated[15]	50Mbit/s[2]
PON/Ethernet	FTTH	Shared/dedicated	10Mbit/s–1Gbit/s
3G	Wireless	Shared	384kit/s[3]
HSPA	Wireless	Shared	7.2 Mbit/s– 14.4Mbit/s[17]
HSPA+	Wireless	Shared	28.8Mbit/s–42Mbit/s[17]
LTE	Wireless	Shared	100Mit/s[17]

Figure 3.14: Comparison of fixed and wireless peak bandwidths [Source: Analysys Mason, 3GPP, Ericsson]

In Figure 3.14, it can be seen that the typical peak bandwidth available using mobile broadband (wireless) technology provides less bandwidth than wireline technology, in particular when one considers that the above-stated bandwidth must be shared between all active mobile users in the same cell sector, as described above.This is a significant issue in dense urban areas where the high population density means that there can be many simultaneous active users. This is why the TRCSL is trying to promote fixed access infrastructure (FTTC) through its NBN initiative.

However, the use of wireless technology should not be under-estimated, as it provides a very cost effective means of providing NGA bandwidth and services to end-users, especially in rural areas, where deploying fixed access infrastructure would be very costly.

3.1.3 National Backbone Network in Sri Lanka

In an NGN, the first step is the deployment of the core network, which is usually based on fibre to ensure it is scalable in capacity and can accommodate future traffic growth.The primary function of the core network is to transport data and voice services between different regions of the country.Once the core network is deployed, theaccess network has to be built to enableendusers to connect to the NGN.As illustrated in Section 3.1.2,NGA networks can be based on a number of different technologies including copper, fibre or wireless.Usually, the cost of the access network represents the vast majority of the NGN (around 60–80% of the total investment depending on penetration).

In Sri Lanka, only SLT currently has a core fibre network that spans a significant part of the country, but still uses microwave to reach the most remote regions.Other operators have fibre in core networks for only certain parts of the country, and still rely heavily on microwave technology or on leased lines to interconnect different regions of their core network. It should be noted that microwave technology is quite limited in terms of capacity, especially when considering the bandwidth required by NGN applications.Also, leased lines are expensive to upgrade as the cost is a function of the bandwidth required.

In Sri Lanka, the vast majority (c. 75%) of PSTN lines useswireless local loop[18] (WLL) (based on CDMA technology), which cannot be directly upgraded to NGA. Therefore, significant investment would be required to provide wireline broadband speeds of 10Mbit/s and above.Given the expected return on investments, TRCSL believes it would not be commercial variable for operator to deploy their own wire line NGA network in Sri Lanka, specially in rural areas.

[15] Dedicated bandwidth in the access network but contended bandwidth in the backhaul.
[16] Peak bandwidth depends upon the length of copper sub-loop.
[17] Peak bandwidth per sector for the downlink.
[18] Telegeography, Globalcomms database, Sri Lanka, 2010

Based on the above observation, the TRCSL considers that without any government intervention, operators are unlikely to invest in fibre infrastructure in both the core and access network to offer high-speed broadband services to the vast majority of Sri Lankans in order for them to enjoy the full benefits associated with NGN mentioned in Section 2.3.2.

In order to realise this vision, the TRCSL launched a consultation in April 2008 to explore the possible options onhow to build and operate anNBN that would serve as a fibre infrastructure for all operators, and therefore remove any potential barriers to entry for operators with little existing national infrastructure to provide NGN services.

One of the key objectives of the NBN is to facilitate competition through non-discriminatory open-access arrangements that ensure equivalence of price and non-price terms and conditions for all operators, providing scope for the operators to differentiate their product offerings.In its specification, the NBN shall support high-quality voice, data, video and audio services, as well as symmetrical applications such as high-definition video-conferencing.

The idea of a national broadband infrastructure has/is being implemented in a number of countries. Examples include New Zealand and Australia, where NGA networks are being deployed partly or fully subsidised by the government.In these countries, the entity responsible for operating the NGA network is solely a wholesale service provider and is not allowed to provide retail services to endusers.This ensures that there is a level-playing field between retail service providers purchasing wholesale services on an equal basis.For these countries, the network deployment is limited to the access network (and not to the core network) as operators already have their own national fibre backbone network, which is different from the Sri Lankan market.

Also, it is interesting to note that for both Australia and New Zealand, the access technology considered for the NBN includes a mix of fibre, wireless and satellite technologies, to address the requirement of different areas (i.e. in urban and suburban areas, wireline access is cost effective to deploy, but wireless and satellite technologies are more cost effective to deploy in more rural areas).

3.1.4 Recommendations

Wireless access and spectrum

During the transition period to NGN, the TRCSL believes that the most effective way to provide access to endusers is through wireless broadband technologies (i.e. 3GPP HSPA and IEEE 802.16d/e WIMAX), especially in areas with low population density. According to the TRCSL, a number of measures could be adopted to ensure this aim:

· undertake a study programme on spectrum management including the following aspects:

  — assess the assignment of spectrum among operators and ensure that this creates a level playing field for all operators and potential new entrants

  — assess whether sufficient spectrum has been allocated in the preferred bands for operators to implement mobile broadband solution

  — assess the impact of the digital dividend, including how spectrum could be freed up and re-allocated to mobile operator.

· review the terms of current 3G licences and investigate options to introduce specific HSPA/HSPA+ coverage obligations, including incentives for the future allocation of LTE spectrum

· encourage the sharing of mobile infrastructure (sites and towers) by mandating infrastructure access

· encourage operators to share their backhaul for remote sites.

Regarding the first issue above (i.e. ensure that enough spectrum is allocated), many countries are already in the process of freeing up the digital dividend spectrum and re-allocating it to broadcasters and telecoms operators depending on the government's overall objectives. For example, in 2008 the French regulator ARCEP commissioned a report entitled *Valuation of the digital dividend in France*[19] to better understand how the digital dividend should be re-allocated to the broadcast and telecoms market. The report argues that the digital dividend in France should be shared between telecoms operators and broadcasters to meet both the social and financial objectives of the country. This outcome is specific to France and to the objectives of the French government.A similar study for meeting the specific objectives of the Sri Lankan government would have to be undertaken.

In making this decision, the TRCSL will weigh the benefits of spectrum fees/auctions against the benefits of promoting competition and deployment.

National Backbone Network

The TRCSL believes that, considering the lack of fixed infrastructure in Sri Lanka, the NBN will provide a criticalnational infrastructure that operators will be able to access to provide NGN services. In order to ensure that the NBN provides an environment that will foster fair competition, the TRSCL is studying the following issues:

- define the optimum mix of wireline and wireless technologies in the access network
- assess the competition impact of allowing the successful tenderer to offer both wholesale and retail services
- define wholesale services in both the access network and the core network.

3.2 Next-generation services

The two most relevant converged services are explained below– VoIP and IPTV services – being provisioned today by various converged operators around the world, and which are of interest to Sri Lanka.

3.2.1 VoIP

NGNs no longer support the circuit-switched technology that was used in legacy PSTNs; instead, voice is sent in data packets over the IP-based network. This report loosely defines VoIP as the set of protocols required to transport voice services over an NGN. There are several types of VoIP implementation that are found in various markets worldwide: enterprise VoIP, mass-market retail VoIP, and carrier-internal VoIP (see Figure 3.15 below).

[19]Analysys Mason for ARCEP (May 2008),Valuation of the digital dividend in FranceAvailable at http://www.analysysmason.com/PageFiles/4324/Valuation%20of%20the%20digital%20dividend%20in%20France%20(English%20Version).pdf.

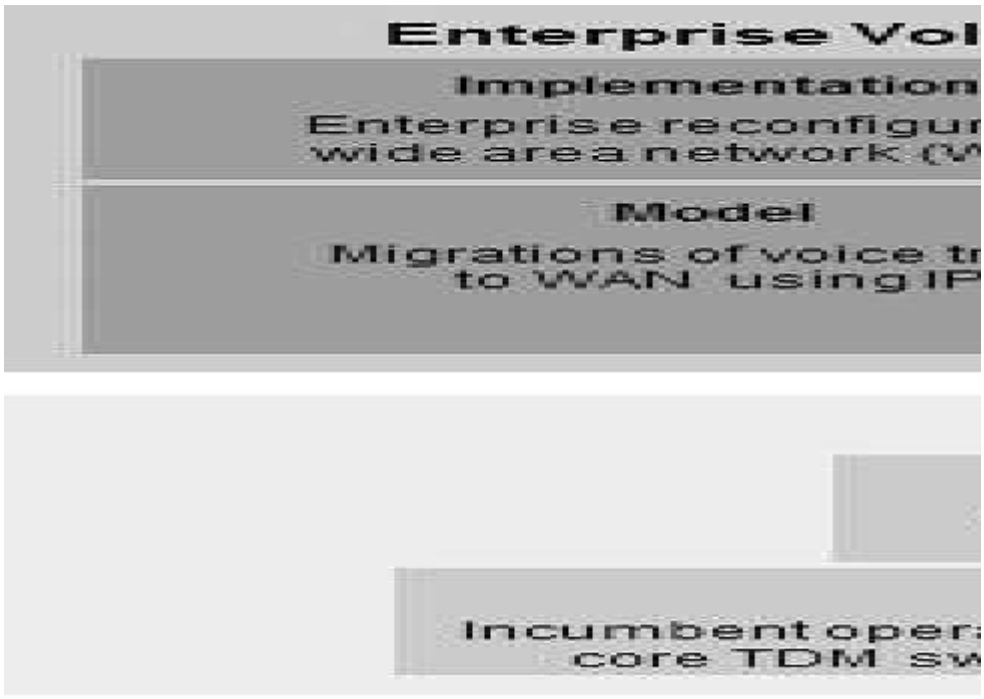

Figure 3.15: Type of VoIP implementations [Source: Analysys Mason]

- **Carrier-internal VoIP**– Of these different types of VoIP implementation, carrier-internal VoIP is the result of operators (carriers) moving to NGN and carrying voice traffic using IP. This will become the norm as over time the majority of (or all) voice networks upgrade to NGN. Carrier internal VoIP will be a significant focus of the NGN regulatory framework being put in place in Sri Lanka.

- **Enterprise VoIP** – On the other hand, enterprise VoIP is a private service that businesses may deploy over their own internal WANs. Companies already using a WAN for data services to connect branches can utilise the WAN to also offer voice services between those offices, thus saving costs. Currently, calls to numbers outside the company would exit the WAN and be delivered to the PSTN where they are terminated. As the PSTN is migrated to NGN, it is expected that private WANs will interconnect with the NGN directly using IP. From the perspective of the regulatory framework, enterprise VoIP services are typically not regulated since they are used only internally within the organisation and not sold as a commercial service outside the company.

- **Mass-market retail VoIP**– During the migration to NGN (resulting in carrier internal VoIP), the most significant impact on operators' business models – and therefore the most significant regulatory challenges – is likely to arise from three forms of mass-market retail VoIP:

  — **Direct access** – This is the most common type of mass-market retail VoIP. In this model, the broadband access connection is sold by the same operator as the voice calls, for instance when a cable operator that can provide broadband services also offers voice services and interconnects with the PSTN. The provider usually offers a bundle of Internet access and voice services, but the broadband connection can be used for voice only. Full triple-play bundles (including IPTV as well as Internet access and voice) are increasingly common in many markets, including Sri Lanka.

  — **Indirect access** – Another form of mass-market retail VoIP service is based on the indirect access model, in which a provider offers voice services over another operator's broadband network. An example of such a service, which is not available in Sri Lanka, is Vonage in the USA. Indirect

access VoIP services can use traditional telephone handsets connected to an adaptor, which in turn is connected to the broadband modem. As the adaptor can be moved while keeping the original phone number and service plan, these services are sometimes referred to as 'nomadic' and can provide great flexibility for users.

— **Do-It-Yourself (DIY)** – The last type of mass-market retail VoIP is the DIY model popularised by services such as Skype. In the original model, the supplier provides software that enables free voice calls between end users with the same software. Calls generally can be made over any type of broadband connection, unless this is restricted by the broadband access provider. For example, Google recently launched a Skype-like service which allows broadband users to phone US landlines for free. This service is currently available worldwide, including Sri Lanka.

Note that mobile VoIP taking any of these three forms (particularly DIY) is also technically feasible.

Such services embody the possibilities of NGN by allowing entrants to provide voice services at relatively low cost, but also create significant challenges to the underlying network providers' business models.

In Sri Lanka, VoIP phones have not been allowed until recently by the TRCSL.Without a VoIP phone, the benefits of new services such as Skype and Google,voice services can only be enjoyed by endusers that have access to a computer, which may be seen as unfair to users who do not have such facilities.Therefore, the TRCSL has decided to permit the importation of VoIP phones to ensure all consumers have equal access to VoIP technology, irrespective of the device they use to access it.

3.2.1 Video over IP

There are two broad ways in which video and TV services can be delivered to consumers over NGNs:

- OTTvideo – the video content is streamed or downloaded by the user over a general Internet connection

- dedicated delivery – the content is delivered using a dedicated system such as a satellite broadcasting system or a broadband telecoms network.

Both of these delivery paradigms can be used to offer broadcast video (sometimes referred to as linear video) as well as VoD.

IPTV is defined as TV and video services delivered to a TV set over a closed, managed IP network (fitting into the dedicated delivery paradigm). This definition *excludes* video services such as YouTube and iPlayer that are usually (though not always) delivered to the PC, rather than the TV, over the public Internet. While these services may not technically constitute IPTV, their usage can be significant and, thus, such services should be included in a consideration of the impact of NGN services.

In many developed markets, a package of digital TV channels, supplemented by VoD and personal video recorders (PVR), is no longer sufficient to attract and retain subscribers, no matter how competently this service is delivered. IPTV operators need to clearly differentiate their services from those of their competitors. This is where the availability of content plays a key role in establishing fair competition. For example, Ofcom, the UK regulator, recently required Sky to provide two of its sports channels (Sky Sports 1 and Sky Sports 2) on a wholesale basis to other operators, to enable them to compete with this premium content effectively. This has vast implication in terms of regulation as it means that media content can no longer be treated in isolation from telecoms, and therefore implies a merging of the media content regulator and the telecoms regulator, as has already been done in the UK.

1.1.2 Recommendations

VoIP

The TRCSL believes that OTT applications such as Google and Skype should not be discriminated against for several reasons:

- it would be difficult to control all new applications that will be made available on the Internet
- these applications enable communications for Sri Lankans for social and business purposes
- these applications are in essence different services than those offered by operators in a closed network where QoS can be controlled
- discriminating against OTT applications such as Google and Skype would send a strong negative message internationally regarding Internet policies in Sri Lanka, and may hamper innovation and investment.

However, the TRCSL is aware of the potential loss of revenues from bypassing the levy on incoming international traffic with these applications. Also, the TRCSL believes that the recent levy imposed by the government on outgoing international calls will further encourage users to use applications such as Skype and Google to bypass the PSTN and therefore avoid paying the levy. This means that a different mechanism may be required to raise funds for universal service access. This recommendation is further detailed in Section 4.1.3.

However, the TRCSL has decided to permit the importation of VoIP phones to ensure all consumers have equal access to VoIP technology, irrespective of the device they use to access it.

Video over IP

Engaging with the Ministry of Media and Information and harmonisingpolicies to promote competition regarding the issue of accessing TV content will be key to ensuring competition in Sri Lanka. For example, in the UK, in order to ensure that service providers compete on a level-playing field, the regulator Ofcom mandated BskyB to provide a wholesale product for two of its sports channels (Sky Sport 1 and Sky Sport 2) to all other broadband service providers in the UK. The TRCSL believes that a review of the market regarding TV content in Sri Lanka should be undertaken and appropriate measures enforced if SMPis found in this area.

Likewise, there is now a strong overlap between media and telecoms as cable operators can provide the triple play including broadband and voice services;also, harmonisation between the regulators can ensure that there is a level-playing field between the different platforms and avoid onerous restrictions on any type of operator. In particular, the licensing conditions should be identical for the same services, regardless of the underlying platform.

The TRCSL believes that it should be feasible to meet the above requirements by closely co-operating with the Ministry of Media and Information.

3.3 Migration issues

The TRCSL consultation on the NGN regulatory framework shows that most operators in Sri Lanka have already started migrating their legacy networks to NGN. This represents a significant cost for operators, which they must consider closely. Regulation has a fundamental impact on the process to follow and its timing: if regulation is introduced too early in the process, operators may be discouraged from investing in NGNs; if, on the other hand, regulation is introduced too late into the process, this may result in the continued dominance of the incumbent operator.

Therefore, the TRCSL considers that it is important to develop the NGN migration roadmap for each operator in Sri Lanka. This will ultimately lead to the development of a suitable migration roadmap. In addition, given the interconnection and interoperability issues that will arise for operators (described below), it is also important for them to understand the general migration roadmap as well as the regulatory roadmap, in order to guide their own investments.

For the core NGN, the migration options for operators include:

- retain the current legacy circuit-switched network
- introduce an overlay of soft switches for use where additional capacity is needed, or for business customers that need additional features
- replace the current circuit-switching equipment in a programme planned over several years.

For wireline NGA networks, the options are:

- upgrade DSL modems for faster Internet access (e.g. by introducing ADSL2+), and optionally offer IPTV/ VoD over the broadband component
- replace DSLAMs with MSANs and offer triple-play services
- introduce FTTC or FTTH to offer an even wider range of services and higher bandwidths to customers.

For wireless operators, the options are:

- upgrade the access network to the latest standard, such as 4G
- upgrade the core packet network, including enabling QoS
- introduce packet switching in the backhaul network.

In order to illustrate what is happening in other countries, a number of case studies have been developed to identify international best practice regarding migration to NGN. These are described in Annex A. The results are mixed: the incumbent in the UK is replacing the whole of its network(both core and access) with NGN, while Singapore and Australiaarefinancing the deployment of a national broadband network.

Based on the above observations, the TRCSL defines three different phases for the transition to NGN, where different policies and regulations will be put in place to encourage investment and at the same time foster competition:

- Phase 1: Legacy network – where operators still have legacy network assets.From the consultation responses, there is evidence that the majority of operators in Sri Lanka have already started their migration to NGN networks, and therefore the legacy network period will terminate when all licences are renewed.
- Phase 2: Transition to NGN –where some operators will have deployed a full NGN,and other operators will be in different stages of transition from their legacy network to an NGN.The TRCSL believes that this will be the most critical phase in the success of NGN in Sri Lanka.To remove some of the investment risks and uncertainty associated with a new platform, in this phase the TRCSL will consider the interoperability issues raised in Section 3.5. This is to address the situation where potential new entrants may be reluctant to invest in any particular technical specification, out of concern that their technical specifications may not be supported by the incumbent operator(s).During this period, new licences will be issued to ensure there is appropriate regulation in place to both encourage investment and a timely migration. (Phase 2 licence obligations and conditionsare further explored in Section4.6.) The duration of this period depends in part on the future actions of the operators, butis expected to be between five and seven years.

- Phase 3: Full migration to NGN –where all operators will have migrated to an operational NGN, and no legacy networks will be in operation. In this phase, the TRCSL expects sufficient infrastructure to be in place to introduce a separate category of service-based licences (possibly an NGN Class Licence) that will be created to allow operators (particularly new entrants) to offer retail telecoms services through the lease of telecoms network elements (on a wholesale basis) from the NGN Individual Licensee.

Figure 3.16summarises the indicative timeline for each of the above-defined phase.

Figure 3.16:Indicative timelime of NGN migration phases [Source: TRCSL]

It should be noted that it is not the TRCSL's intention to force operators to migrate to NGN as it is a decision that should be left for the market. Therefore, Figure 3.16 is only indicative.

3.3.1 Recommendations

The TRCSL considers that it has a crucial role to play in the migration to NGN in Sri Lanka, especially in ensuring there is appropriate technical co-ordination among all operators.Industry-led technical advisory bodies (or equivalent) have been implemented in the UK (NICC) and in India (Telecommunication Engineering Centres (TEC)) in order to ensure there is suitable co-ordination between operators during the migration of their legacy networks to NGN.According to the TRCSL,an industry-led NGN Advisory Committee should be created in Sri Lanka to assist the TRCSL in implementing a migration roadmap. The exact governance model, as well as the key focus areas for the Committee, are detailed in Section 3.9.

Also, in order to facilitate the creation of a flexible framework that takes into account the different nature of operators' requirements at different phases of their migration to NGN networks,the TRCSL defines three phases:

- Phase 1: Legacy network
- Phase 2: Transition to NGN
- Phase 3: Full migration to NGN.

These phases will be used as a reference to help prioritise the definition of technical standards for NGN interconnection made by the NGN Advisory Committee.The different phases will also serve as a reference for the implementation of different licence obligations to ensure, at any time, that operators are encouraged to invest and that competition is maintained.

3.4 Interconnection

Interconnection between NGNs run by different operators is a fundamental issue, especially during the migration phase when operators may have a mix of legacy networks and NGNs. This section concentrates on the *technical* implications of interconnection, whereas the different models for the *governance* of interconnection are discussed in Section 4.2.1.

Fundamentally, one should distinguish between PSNT interconnection and data interconnection. For each of these, one has to consider both legacy networks and NGNs. These are described below. It should be noted that both scenarios can support interconnection based on TDM (legacy) protocols, or based on IP.

3.4.1 PSTN interconnection

Fundamental principles

In order to understand how PSTN interconnection works, let us consider a typical call as illustrated inFigure 3.17.

Figure 3.17: Typical interconnection between PSTN operators [Source:Analysys Mason]

Figure 3.17 assumes a legacy PSTN network where a call originates from Network 1 and terminates in Network 3. In this case, 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.

In such configurations, the key network element is the TDM switches which perform both the signalling and transport functionalities. TDM switches of operators connecting clients are usually referred to as Class 5 switches.[20] In marked contrast, if the call had to go through a transit operator, then a Class 4 switch would typically be used as the transit switch does not need to retain any information regarding the calling party. However, as explained elsewhere in this report, legacy TDM switches are now being phased out. It is important to note that for PSTN interconnection, it is always possible to identify the origin and destination of a call, which is not the case in data interconnection (see Section 3.4.2)

In terms of charging mechanisms, the most common wholesale billing regime in the PSTN is calling party's network pays (CPNP), under which the network of the party who places the call (the originating network) makes a payment to the network of the party that receives the call (terminating network). Thus, at the wholesale level, the entire call is paid by the caller's network. The rationale of CPNP is based on the assumption that the costs are caused solely by the calling party's network. (Charging mechanisms are discussed in more detail in Section 4.4of this document.

* Interconnection of an NGN with a legacy PSTN network
Figure 3.18 and Figure 3.19 illustrate, respectively, TDM and IP interconnection between an NGN and a PSTN.

Figure 3.18: TDM-based interconnection between an NGN and a PSTN [Source: Analysys Mason]

[20]A class 5 switch is a TDM siwtch used in PASNs that can host subscriber infomation as well as performing the standard function of a PSTN switch (singalling and transport of voice calls).

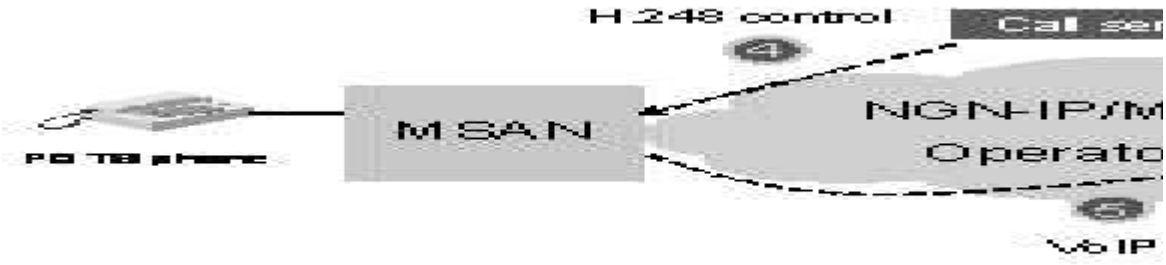

Figure 3.19: IP-based interconnection between an NGN and a PSTN [Source: Analysys Mason]

As illustrated in Figure 3.18, the interconnection between an NGN and a PSTN can be TDM-based. In this case, the PSTN does not need any additional network nodes as the translation from TDM protocol to IP for both the signalling and media planes are carried out in the NGN at little extra cost. In marked contrast, if the interconnection between an NGN and a PSTN is IP-based (Figure 3.19), 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 signalling gateway, controlled by a call server,is also required to convert the legacy SS7 signalling message (such as ISUP) to signal initiation protocol (SIP) or H.323 signalling messages. Finally, as for every IP interconnection, asession border controller(SBC)must also be added[1]. Therefore, a significant amount of new equipment is required in order to enable IP interconnection with NGNs: this is both time-consuming and expensive to implement.

Therefore, given the differences in network costs, the choice of TDM or IP interconnection during the migration of legacy networks to NGN has strong implications in terms of regulation. This is further discussed in Section4.6.

* 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, as gateways are not required. Figure 3.20 illustrates IP-based interconnection between NGNs.

Figure 3.20: IP-based interconnection between two NGNs [Source: Analysys Mason]

There are three different versions of SIP that could be used for signalling within NGNs:

- Generation 1 – SIP-I, which encapsulates the legacy circuit-switched ISUP signalling protocol within the SIP protocol.
- Generation 2 – pure SIP, where SIP is used without encapsulating ISUP.
- Generation 3 – the IMSversion 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.

In practice, most current implementations in fixed networks use pure SIP or SIP-I.

The migration to NGN will not change the fact that it will always be possible to identify the origin and destination of a call for PSTN voice services.

3.4.2 Data interconnection

Fundamental principles

In order to understand data interconnection, it is important to first define the concepts of peering, transit and Internet exchanges (IX):

- Peering – is defined as a bilateral arrangement between two operators to exchange traffic originating from, and terminating with, their own customers, typically (but not always) with no fee settlement between them.
- Transit – is an agreement whereby an ISP agrees to carry traffic on behalf of another ISP or end user. Transit is usually a bilateral business and technical arrangement, where one provider (the transit provider) agrees to carry traffic to third parties on behalf of another provider or end user (the customer). In most cases, the transit provider carries traffic to and from its other customers, and to and from every destination on the Internet, as part of the transit arrangement.[22]
- Internet exchange points (IXP) – sometimes called network access points (NAP), constitute an institutional setting for the exchange of traffic, where ISPs can voluntarily participate and where they agree to interconnect at a multilateral peering point. IXs enable ISPs to interconnect their networks and to exchange traffic directly between them without having to deliver traffic via an upstream provider, hence, reducing costs as there are, usually, no payments for the exchange of traffic. Moreover, they may also improve network resilience. The Internet 'world' has historically adopted this interconnection model where many ISPs meet to exchange their traffic.[23]

The relationship between peering, transit and the IXP is illustrated below in Figure 3.21.

[21] It should be noted that the term "Softswitch" is usually used to describe Call Server, Signalling Gateway and Session border controller functionalities.

[22] NRIC V Interoperability Focus Group, Service Provider Interconnection for Internet Protocol Best Effort Service, page 7.

[23] ERG (2008), ERG Consultation Document on Regulatory Principles of IP-IC/NGN Core. Available at http://www.erg.eu.int/doc/publications/consult_ngn_2008/erg_08_26rev1_consul_ip_ngn_080604.pdf

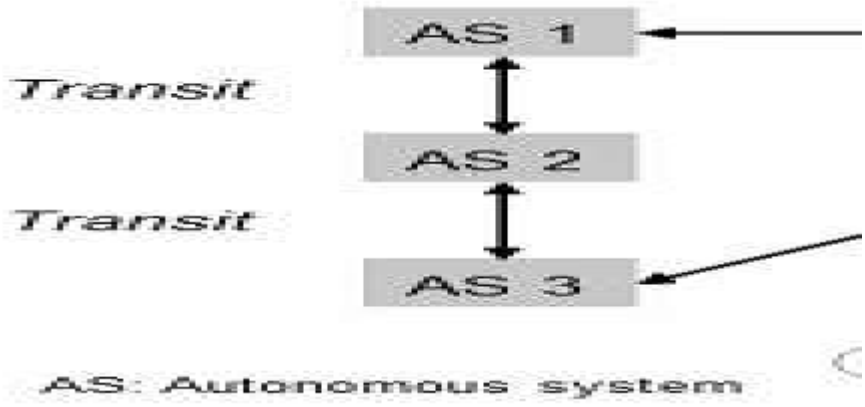

Figure 3.21: Data flow in IP data networks [Source: ERG Consultation Document on Regulatory Principles of IP-IC/NGN Core, 2008]

As shown in Figure 3.21, IP networks are related to one another in a hierarchy of different tiers according to whether they only buy transit, buy transit and peer with some IP networks, or peer with some IP networks only.

Usually, ISPs operating on the same tier peer with one another (e.g. between two Tier 1 ISPs). At the highest tier, all operators peer with every other operator, and as such the definition of a Tier1 ISP is that it does not need to purchase transit to provide Internet access – all its connectivity is via peering. The other tiers are not fully meshed. If there is a peering agreement between the Autonomous System 1 (AS 1) and AS 2, then traffic is not only conveyed between these AS involved, but also conveyed to networks such as AS 3 or AS 4 that have transit agreements with AS 1 and AS 2, respectively.

A Tier 2 ISP has to buy transit from a Tier 1 ISP, paying for both upstream and downstream traffic. As there is no peering agreement between AS 3 and AS 4, they have to buy transit from AS 1 and AS 2, respectively, if they want to route traffic between each other.

Also, it is worth noting that for peering and transit, there is usually no possibility to determine at the interconnection point the network of origination or termination of a session.It is therefore not possible to make use of the concepts of origination and termination for billing purposes.Normally, there are no payment flows in peering agreements, as long as traffic imbalances do not exceed a certain specified limit. The precise requirements for the applicability of peering are laid out in the peering policies of the interconnected ISPs. Transit agreements involve payments, covering both outgoing and incoming traffic.

In terms of charging mechanism, as discussed above, peering is typically without settlements, also known as bill and keep. Under this regime, each operator does not charge the other operator for interconnection – all costs are recovered by the operator from its own customers. In other words, an operator will peer with other operators in order to ensure access to the entire Internet, which it sells to its end users and transit customers. (Charging mechanisms are discussed in more detail in Section 4.4.)

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 services, including voice, migrate to NGNs, this

interconnection model may become increasingly obsolete[24]as Internet interconnection is based on commercial negotiation and may involve unpaid exchange of traffic.

NGN interconnection results in the exchange of higher levels of Internet traffic, which may increase the significance of IXPs. The primary benefit of an IXP is to reduce the cost of interconnection: rather than using a separate leased line (transit) to connect to each interconnecting network, operators can use a single leased line to reach a single location at which a number of networks can all interconnect. To the extent that an IXP promotes peering, it may also have a secondary benefit of more localised routeing of traffic, with fewer hops, leading to lower latency. This is becoming increasingly relevant – not just for new delay-sensitive applications like VoIP, but also for other Internet services such as distance learning and e-commerce.

The benefits of an IXP can extend to the NGN when calls begin to be exchanged using IP interconnection. Given the importance of Internet traffic exchange, a number of such exchanges have arisen around the world. In Sri Lanka, a number of operators have created exchange points for commercial reasons, but international best practice is to establish an independent IXP, operated commercially by a third party or on a non-profit basis by a consortium of users of that exchange.In order to spread the benefits of an IXP geographically, a 'virtual IXP' can be established that distributes nodes of the IXP in a number of data centres, allowing the customers of each data centre to interconnect with members of other data centres.This is preferred to having multiple IXPs, which cannot enjoy network effects because customers must then connect to each one in order to reach full connectivity.The issue of establishing a virtual IXPis under study by the TRCSL and will be a topic of discussion for the NGN Advisory Committee.

3.4.3 Recommendations

The TRCSL believes that an industry-led Technical NGN Advisory Committee would be best placed to advise the TRCSL on technical standards and interfaces required for interconnection between the different operators in Sri Lanka, as operators have already started the migration to NGN and have a deep understanding of the technical issues arising from this transformation. As argued in previous recommendations within this document, different operators in Sri Lanka are currently planning to use different standards, and co-ordination at the national level is required to ensure interoperability between these operators.

In relation to interconnection, one of the core functions of the NGN Advisory Committee should be to assist the TRCSL in co-ordinating the development of the technical interconnection standards to be implemented in order to ensure interoperability among all operators in Sri Lanka. According to the TRCSL, the approach taken by NICC in the UK would be appropriate to meet these objectives; that is, start by determining end-to-end service requirements for all operators by means of a series of workshops. Once the service requirements are established, the NGN Advisory Committee could assist the TRCSL in specifying interconnection standards and interfaces, also by organising a number of workshops with key industry stakeholders.

In more general terms, the TRCSL believes that the NGN Advisory Committee, which would comprise the key NGN stakeholders (i.e. incumbent operators, fixed and mobile operators, service providers and relevant equipment vendors), should be formed to advise the TRCSL on technical aspects of interconnection (please refer to Section 3.9 for a full description of the scope and governance model **of** the NGN Advisory Committee).

[24] For the case of PSTN

Finally, the TRCSL recommends the adoption of an independent not-for-profit IXP for the exchange of local data Internet traffic. Since this would be a 'meet-me point', the TRCSL believes that the same sites should be used for both NGN voice (PSTN) and data interconnection, with appropriate licence modifications to allow VoIP traffic to be exchanged in the IXP in addition to data.

In line with the industry's consultation response, the TRCSL considers that, initially, peer-to-peer (peering) interconnections should still be permitted during the NGN transition period (Phase 2), especially if two operators agree on the technical standards and commercial terms to be used. The TRCSL further believes that it should be mandated for the incumbent dominant operator to interconnect at the IXP to provide connectivity for the other operators. However, as more and more operators implement their NGNs, the TRCSL would expect all interconnection to be migrated to an IXP as it will provide the most cost-effective arrangement for operators.

The TRCSL considers that the NGN Advisory Committee should advise the TRCSL regarding the optimum configuration of an IXP to be deployed in Sri Lanka to allow effective competition.

3.5 Interoperability issues

In order to ensure interoperability between NGNs, a certain amount of collaboration between operators must take place to ensure that each NGN supports a minimum set of features. For example, in the UK two standardisation bodies have been set up to ensure interoperability between operators:

- NICC is a standards body that acts as a technical forum for the communications sector, and develops interoperability standards for public communications networks and services in the UK.

- NGNukisa co-ordination forum in which key investors in NGN infrastructure and services can discuss research, consider and, where possible, agree the direction for NGN in the UK.

This form of collaboration is key to providing true interoperability between different NGN operators. Taking the example of voice services, a vast number of features are available, but not all are implemented in different networks, for a variety of reasons. NGNuk suggests a number of mandatory, recommended and optional features to be supported by all operators, as set out in Figure 3.22(note that this list is not exhaustive and is only intended as an illustrative example).

Mandatory	*Recommended*	*Optional*
Originating Identification Presentation (OIP)	Communication Diversion CCDIV)	Conference (CONF)
Originating Identification Restriction (OIR)	Communication Waiting (CW)	Advice of Charge (AOC)
Terminating Identification Presentation (TIP)	Communication HOLD (HOLD)	Reverse charging
Terminating Identification Restriction (TIR)	Communication Barring (CB)	
Malicious Communication Identification (MCID)	Completion of Communications to Busy Subscriber (CCBS)	
Anonymous Communication Rejection (ACR)	Message Waiting Indication (MWI)	
Relay Services for the Disabled	Support for SIP protocols	

Figure 3.22: Example of voice features to be supported by NGN operators [Source: NGNuk]

The TRCSL believes that it may be beneficial to implement a similar initiative in Sri Lanka in order to ensure interoperability of voice services, and of all other multi-media services when practically possible. Section 4.2 explores whether it may be necessary to impose wholesale obligations on one or more operators to ensure that the agreed standards are adopted to promote entry.

3.5.1 Recommendations

Based on the responses from the NGN consultation, there is clear evidence that all operators in Sri Lanka do not consider the same standards for interconnection. Therefore, the TRCSL believes that it has a crucial role to play in the migration of legacy networks to NGN in Sri Lanka, especially in ensuring there is appropriate co-ordination among all operators. As mentioned in the previous section of this report, industry-led national standardisation bodies (or Advisory Committees) have been implemented in the UK (NICC) and in India (TEC) in order to ensure there is suitable co-ordination among operators during the migration to NGN. The TRCSLconsiders that the NGN Advisory Committee should include the standardisation of interconnections.(The exact governance model, as well as the key focus areas regarding the Committee, are providedin Section 3.9.)

The TRCSL also considers that it can play a role in the migration to NGN by providing regulatory clarity with this NGN regulatory framework.

1.2 Qo Sissues

As mentioned in the ITU definition of NGN, QoS mechanisms have to be implemented in NGNs in order to ensure that time-sensitive services such as voice are prioritised over other applications such as web browsing. Unlike the circuit-switched PSTN, many parameters of the services requested by a user could be under the user's control, either directly or in association with the end-to-end service required. In particular, the need for QoS will vary from the performance required to support interactive, real-time communication (voice and multimedia) to the variable performance of the current public Internet.

In order to meet the need for QoS, the ITU-T standard Y.1541 defines five classes of service, each corresponding to a family of applications with different characteristics. Figure 3.23 illustrates the different classes of service.

Class of service	*Description*
0	Real-time, jitter-sensitive, high interaction (VoIP, VTC)
1	Real-time, jitter-sensitive, interactive (VoIP, VTC)
2	Transaction data, highly interactive (signalling)
3	Transaction data, interactive
4	Low loss only (short transaction, bulk data, video streaming)

Figure 3.23: Classes of service defined in the ITU-T standard Y.1541 [Source: ITU]

Since each class of service has different requirements in terms of delay, delay variation (also called jitter), packet loss and bit error rate, the ITU formally defines the performance targets for each class of service as shown in Figure 3.24.

Classes of service	*Delay*	*Delay variation*	*Packet loss rate*	*Bit error rate*
Class 0	100ms	50ms	10^-3	10^-4
Class 1	400ms	50ms	10^-3	10^-4
Class 2	100ms	U	10^-3	10^-4
Class 3	400m	U	10^-3	10^-4
Class 4	1s	U	10^-3	10^-4

Figure 3.24: Performance target of each class of service as defined by the ITU [Source: ITU]

This means that if an operator wants to support Class 0 services such as conversational voice, its network must ensure that:

- the end-to-end delay between source and destination is no more than 100ms
- the delay variation is less than 50ms
- the number of packets lost in the network is less than 1 for every 1000 transported
- the number of errored bits (within packets) is less than 1 for every 10 000 transported.

If these performance indicators are met by the network, the user should have a reasonable experience of the service. It is also important to be able to measure these parameters in all networks under different loads, to ensure that all NGNs perform similarly, especially if interconnection is required between different networks to provide a given service.

A number of practical steps can be taken by operators in order to meet these performance indicator thresholds:

- Design their networks to minimise routing hops, providing sufficient redundancy including call servers, gateways and network capacity, to deal with any throughput issues during re-routing or congestion.
- Proactively manage any customer premises equipment (CPE) to dynamically alter the properties, such as packet and/or window size, to maximise throughput for voice traffic in response to observed network performance.
- Implement monitoring policies to identify and prioritise voice traffic in those parts of the network over which the operator has control.

3.6.1 Recommendations

The TRCSL is encouraged that some respondents to the consultation process have already implemented a strategy to monitor the performance of their network. As mentioned in the previous section, ITU-T standard Y.1541 (QoSstandards for IP networks and services) recommends a threshold for the following parameters:

- delay
- jitter
- packet loss rate
- bit error rate.

In the UK, NICC makes some recommendations regarding the threshold of these parameters, providingbest-practice guidelines for operators to implement in their network. However, in the UK, there is no enforcement of these thresholds and operators implement the best-possible QoSto meet their business objectives, an approach that seems to be adequate at this early stage of the NGN implementation.

In Sri Lanka, the TRCSL recommends a similar approach whereby the NGN Advisory Committee should assist the TRCSL in specifying best-practice thresholds for the above parameters for every interconnection model.

During Phase 1 and Phase 2 of the NGN migration, the TRCSL does not recommend any active monitoring of these parameters, nor their enforcement by a third party as it may introduce some complexity in the migration process and delay the transition to NGN. The TRCSL also recommends that service transparency be introduced for the incumbent (e.g. how the service will be provisioned and what to expect in terms of quality for a service such as Skype). However, once the transition to NGN is completed, the TRCSL believes that active monitoring shouldbe enforced in Phase 3 (full NGN migration).

Finally,the TRCSL considers that competition will provide a natural incentive to all operators to comply with the standards set by the TRCSL through the NGN Advisory Committee, which will reduce the requirements for active monitoring in the short term. However, depending on how the competition evolves, the TRCSL may review this position at a later stage of the NGN migration.

3.7 Security issues

Legacy PSTNs were essentially closed networks, which could not be accessed without physical access to the network.However, in an NGN world, both voice and data services are carried on an IP network that is connected to the Internet. This means that, without the necessary security policy in place, malicious users connected to the Internet can gain access to the network remotely and disrupt services.Additionally, the NGNs of different operators will be interconnected to each other, which could result in customers connected to one operator gaining access to another operator's network.

Both issues highlighted above mean that security policies must be enforced, not only at the operator level but also at the national level to minimise the risk of malicious activities on any networks that could lead to a service outage or a degradation in service quality for end users.

Since NGNs are based on IP, NGN applications (including VoIP) inherit the known and unknown security weaknesses that are traditionally associated with IP.The resulting security problem domain is considerably larger compared to legacy PSTNs.Examples of a few potential security breaches that result in various degradation levels of network performance or in the theft of identity are provided below.

Eavesdropping

In general, the majority of IP network communications occur in an unsecured or 'cleartext' format, which allows an attacker who has gained access to data paths in a network to 'listen in' or interpret (read) the traffic. When an attacker is eavesdropping on communications, it is referred to as sniffing or snooping. The ability of an eavesdropper to monitor the network is a significant security problem. Therefore, without strong encryption services, the data can be read by others as it traverses the network.

Data modification

Attackers can not only read data, they can also alter it. An attacker can modify the data in the packet without the knowledge of the sender or receiver. Even if communications are not strictly confidential, such modifications can be costly. For example, enterprises would not want items, amounts or billing information to be modified in their purchase requisitions.

Identity spoofing (IP address spoofing)

Most networks and operating systems use the IP address of a computer to identify a valid entity. In certain cases, it is possible for an IP address to be falsely assumed – identity spoofing. An attacker might also use special programs to construct IP packets that appear to originate from valid addresses inside the corporate intranet.After gaining access to the network with a spoofed valid IP address, the attacker can modify, reroute or delete data. The attacker can also conduct other types of attacks, as described below.

Password-based attacks

A common denominator of most operating system and network security plans is password-based access control. This means access rights to a computer and network resources are determined by a user name and password.

Older applications do not always protect identity information as it is passed through the network for validation. This might allow an eavesdropper to gain access to the network by posing as a valid user.When an attacker

enters a valid user account, the attacker has the same rights as the real user. Therefore, if the user has administrator-level rights, the attacker can also create accounts for subsequent access at a later time.As a result of such access, an attacker can do any of the following:

- obtain lists of valid user and computer names and network information
- modify server and network configurations, including access controls and routing tables
- modify, reroute or delete data.

Denial-of-service attack

Unlike a password-based attack, the denial-of-service attack prevents normal use of a computer or network by valid users.After gaining access to the network, the attacker can do any of the following:

- randomise the attention of internal information systems staff so that they do not see the intrusion immediately, which allows the attacker to make more attacks during the diversion
- send invalid data to applications or network services, which causes abnormal termination or behaviour of the applications or services
- flood a computer or the entire network with traffic until a shutdown occurs because of the overload
- block traffic, which results in a loss of access to network resources by authorised users.

Man-in-the-middle attack

As the name indicates, a man-in-the-middle attack occurs when someone is actively monitoring, capturing and controlling communications. For example, the attacker can re-route a data exchange. When computers are communicating at low levels of the network layer, they may not be able to validatethe identity of the other party.As a result, valuable information may be exchanged with the attacker.This attack is capable of the same damage as an application-layer attack, described later in this section.

Compromised-key attack

A key is a secret code or number necessary to interpret secured/encrypted information. Although obtaining a key is a difficult and resource-intensive process for an attacker, it is possible. After an attacker obtains a key, that key is referred to as a compromised key.An attacker uses the compromised key to gain access to a secured communication without the sender or receiver being aware of the attack.With the compromised key, the attacker can decrypt or modify data, and try to use the compromised key to compute additional keys, which might allow the attacker access to other secured communications.Such communications, believed to be protected by encryptions, may be particularly valuable and sensitive if compromised in this fashion.

Sniffer attack

A sniffer is an application or device that can read, monitor and capture network data exchanges and read network packets. If the packets are not encrypted, a sniffer provides a full view of the data inside the packet. Even encapsulated (tunneled) packets can be broken open and read unless they are encrypted and the attacker does not have access to the key.Using a sniffer, an attacker can do any of the following:

- analyse the network and gain information to eventually cause the network to crash or to become corrupted
- read communications.

Application-layer attack

An application-layer attack targets application servers by deliberately causing a fault in a server's operating system or applications. This results in the attacker gaining the ability to bypass normal access controls. The attacker takes advantage of this situation, gaining control of the application, system or network, and can do any of the following:

· read, add, delete or modify data or operating system

· introduce a virus program that uses computers and software applications to copy viruses throughout the network

· introduce a sniffer program to analyse thenetwork and gain information that can eventually be used to crash or to corrupt thesystems and network

· abnormally terminate thedata applications or operating systems

· disable other security controls to enable future attacks.

Summary

In summary, many of these attacks are related to one another, and all have one of two outcomes: communications are compromised allowing access to sensitive information; or the breach is purely malicious and meant to harm the network *per se*.

3.7.2 Recommendations

The TRCSL believes that security is a very important issue in NGNs and, since all NGNs will ultimately be interconnected, a co-ordinated approach to security at the national level is required.

The NGN Advisory Committee should assist the TRCSL in supporting the development of national NGN security policies and standards. Therefore, as discussed in Section 3.9, the TRCSL considers that the NGN Advisory Committee should include a 'security working stream' to understand the security issues faced by each of the operators in Sri Lanka, and recommend a set of security standards and architectures to be enforced by the TRCSL to ensure security at a national level, especially if an independent IXP is created.

3.8 Numbering and addressing

The migration to NGN will initiate a corresponding change in the numbering and addressing schemes used by end users and operators to provide services. The Internet uses the domain name system (DNS), in which a domainname identifies a source or destination with a textual name that is easy to use and remember, while an address is a network identifier that enables the network to route data to its destination. Thus,www.trcsl.gov.lk is the domain name of the TRCSL's website, while 202.124.180.5 is the underlying IP address associated with the server that runs that website. On the other hand, legacy telephone numbers are based on the E.164 standard and can be viewed as functioning as both a name and an address, especially for fixed-line numbers.[25]

[25] With number portability, this is no longer true – a telephone number serves primarily as a key to a database look-up rather than itself being the basis for the physical routing of a call to the customer's telephone.

The migration from PSTN to NGN means that the telephone network will now run over IP-based facilities similar to those used for the Internet. Therefore, like websites, telephone lines will be identified by an IP address. This does not imply fundamental changes to IP addressing or the DNS: these naming and addressing systems are already nearly as mature as those used by the PSTN. ENUM, a standard system that trans lates E.164 to IP addresses (see below), bridges the legacy PSTN and VoIP numbering domains.

Numbering, naming and/or addressing schemes will need to encompass legacy, transitional and NGN services and associated directory services. The existing numbering and addressing schemes include some that are nationally based (e.g. telephone numbers and country domain names such as .lk), some that are global (e.g. IP addresses and generic domain names such as .com), and some that are proprietary (e.g. instant messaging). Further, certain NGN services such as VoIP can be nomadic, allowing formerly national telephone numbers to be used internationally, which may pose tariff transparency issues.

In an NGN world, where the networks of all operators will be interconnected, there may be a requirement to harmonise naming and addressing conventions on at least a national basis. The inter-relationship of these number and addressing schemes, and their management during the transition to NGN, will be a major task.

1.2.1 ENUM

In order to achieve the transition to NGN while enabling consumers to keep their telephone numbers, operators will need a mechanism that maps telephone numbers to Internet services. The ENUM protocol was created for this specific purpose, using the underlying mechanisms of the DNS to provide look-up services. With ENUM, the telephone number truly becomes a name rather than an address, serving primarily as a key to identify the best way to reach a subscriber, based on their IP.

1.2.2 IPv6

The current IP addressing system, based on IPv4, can accommodate, at most, approximately four billion addresses. At one time, this was felt to be hugely in excess of demand; however, today there are credible forecasts that this address space may be exhausted within five years. The Internet Engineering Task Force (IETF) defined a successor protocol (IPv6) many years ago; however, IPv6 has seen little deployment to date. The migration to NGN may create additional pressure for migration to IPv6. In particular, while the use of IPv6 is generally optional in NGN, it is mandatory in IMS.Therefore, until all operators migrate to IPv6, there will be a transitional period where interoperability between IPv6 and IPv4 will be required. One solution is to implement a network address translation (NAT) service which maps IPv6 addresses into IPv4 addresses (and vice versa).

3.8.3 Recommendations

Numbering

The introduction of NGN may have a significant impact on numbering plans for new services. First, in an NGN environment, there will be an explosion of devices that will require a new number. Also, NGN will introduce nomadic services that may require their own number range. The current numbering plan will not be able to address the aforementioned issues.For this, the TRCSL anticipates that a new numbering block specifically for VoIP services will be required during the transition period to NGN (Phase 2).However, once all operators have migrated to NGN (Phase 3), the TRCSL believes that VoIP blocks and legacy PSTN numbers will be merged to enable full number portability.

However, in order to ensure that the new numbering plan addresses all issues raised by the industry, the TRCSL intends toconsult with key stakeholders on this issue toformulate a new numbering plan that will be compatible with the NGN environmentand with both Phase 2 and Phase 3 of the NGN migration.In particular, the consultation willaim to better understand from key stakeholders in Sri Lanka what will be the demand for non-geographical numbers.

The TRCSL also considers that the harmonisation of naming and numbering is an important issue in an NGN environment, but that there is no immediate urgency to address this issue in Sri Lanka as it can be addressed when all networks have to be migrated to all-IP architectures. Therefore, the harmonisation of naming and numbering should be one of the topics addressed by the NGN Advisory Committee, which will be able to assist the TRCSL in identifying the requirements of the Sri Lankan telecoms industry.Should there be a disagreement by the parties over the need for, or means of, harmonisation, the Committee can provide a report that will present the issues to the TRCSL for a final decision.

ENUM

The TRCSL agrees with the consultation responses that the ENUM protocol has to be considered when devising the regulatory policy for NGN as it will provide essential translation between legacy E.164 numbers and IP/SIP addresses. The implementation of ENUM requires a significant amount of collaboration among operators, as elements of the technical solutions are owned by operators themselves, and other elements (located in the IXP domain) of the solution could be owned by a third party, the same way as DNS domains.

Therefore, the TRCSL believes that one of the key roles of the NGN Advisory Committee will be to identify the requirements of the telecoms industry in Sri Lanka in terms of ENUM and advise the TRCSL accordingly.

Finally, the TRCSL notes that number portability is consistent with regulatory best practice. In particular, it is a key factor in promoting competition, as a significant number of consumers, often the most financially attractive business customers, are reluctant to take the expense and risk of changing their telephone numbers. There are, however, several ways to implement number portability, both technically and in terms of who bears the costs. Therefore, the TRCSL is planning to undertake a consultation process regarding mobile number portability.

3.9 Scope and governance model for the NGN Advisory Committee

A discussed in the previous sections, the consultation responses indicate that different operators are planning to adopt different standards for interconnecting their NGNs, and each operator will have a different roadmap regarding how it transitions from its existing legacy networks to the NGN.[1] Therefore, the TRCSL considers that it can play a crucial role in co-ordinating these activities between operators to ensure interoperability between operators.

[26] Some operators have already started their NGN migration and have already invested significant capex in that transformation.

The consultation responses also suggest that there is a requirement to harmonise numbering and naming (including the specifications of the architectures to deploy ENUM) at a national level.

Finally, it was also identified that, since all NGNs would ultimately be interconnected to each other, co-ordination of the security strategy at a national level is also required for the successful implementation of NGN in Sri Lanka.

In addition, as explained in Section 4.1.3, there is a requirement to define a USO programme, starting with defining a set of objectives for the said programme. The NGN Advisory Committee could assist the TRCSL in defining this programme.

Therefore, in order to address the aforementioned issues, the TRCSL believes that the NGN Advisory Committee, which would comprise the key NGN stakeholders (i.e. incumbent operators, fixed and mobile operators, and data service providers), should be formed to advise the TRCSL. The Committee should have fourdistinct working groups (or workstreams), as illustrated in Figure 3.25.

Figure 3.25: Proposed structure of the NGN Advisory Committee[Source: Analysys Mason]

As illustrated in Figure 3.25, it is anticipated that the TRCSL would Chair the NGN Advisory Committee and that the Executive Board should comprise the key stakeholders in the industry.

The anticipated scope of responsibility for each of the workstreams is detailed below.

- **Workstream 1: Interconnection and standards** – The core function of Workstream 1 should be to assist the TRCSL to co-ordinate the development of the technical interconnection standards and interfaces to be implemented, in order to ensure interoperability between all operators in Sri Lanka, during the transition to NGN. The TRCSL believes that the approach taken by NICC in the UK would be appropriate

to meet these objectives; that is, to start by determining end-to-end service requirements for all operators by means of a series of workshops. Once the service requirements are established, the Committee could assist the TRCSL in specifying interconnection standards and interfaces, also by organising a number of workshops between key industry stakeholders.

The TRCSL also believes that a key role for Workstream 1 will be to specify end-to-end QoS parameters such as delay, jitter, bit error rate and packet loss for different classes of service, as well as defining a threshold for these parameters to ensure operators have a common set of objectives for the performance of their networks. As indicated in Section 3.6, the TRCSL does not intend to actively monitor QoS parameters on operators' networks during the migration to NGN, but would monitor QoS parameters when all operators have completed their transformation to NGN.

- **Workstream 2: Naming and addressing** – The core function of Workstream 2 should be to assist the TRCSL to co-ordinate the development of the technical specification of standards for numbering and naming, including the specification of how ENUM should be implemented. Workstream 2 should also focus on how number portability may be implemented in Sri Lanka. The TRCSL is planning to launch a separate consultation on the harmonisation of numbering and naming to provide a starting point for the NGN Advisory Committee. The TRCSL anticipates that the operational model for Workstream 2 should be similar to that of Workstream 1 in that a series of workshops should be organised to first establish the requirements for the harmonisation in the numbering plan and naming conventions. Then, based on these requirements, the Committee will make some recommendation to the TRCSL for implementing this required numbering plan and the approach to take for implementing ENUM.

  Another key role for the NGN Advisory Committee will be to study the impact of the co-existence of IPv4 and IPv6. It should be noted that NGNs do not require IPv6 to be implemented, but the implementation of IPv6 is mandatory for operators willing to implement IP multi-media sub-system (IMS). During Phase II of the transition to NGN, some operators will implement IPv6 in their network, while other operators will still be operating a network based on IPv4.Workstream 2 will be responsible for implementing a solution that provides interoperability between vendors using different IP versions.

- **Workstream 3: Security** – The core function of Workstream 3 should be to assist the TRCSL to co-ordinate the development of the technicalspecification and standards relating to security issues surrounding NGN. Workstream 3 should focus on the key technical issues to establish a security strategy, and recommend a set of security standards and architectures that would be enforced by the TRCSL to ensure security at a national level. This is particularly important if an independent Internet exchange point (IXP) is created, where most or all networks will ultimately be interconnected. Again, the TRCSL anticipates that the operational model for Workstream 3 should be similar to that of Workstreams 1 and 2 (i.e. a series a workshops should be organised to first establish the requirements for a national security strategy).Finally, the TRCSL also believes that the NGN Advisory Committee should be purely technical and that commercial issues should not be in the scope of the Committee's responsibilities. In particular, the NGN Advisory Committee should not provide a forum for the participants to effectively collude by agreeing on commercial models, such as how and what to charge for NGN services (voice or data).

- **Workstream4: USO** – The core function of Workstream 4 should be to assist the TRCSL to develop the USO programme and, in particular, identify the overall objectives that the USO programme should achieve. In this workstream, key stakeholders should also provide some advice to the TRCSL regarding the possible funding model for USO, as well as defining the mechanisms to disburse the funds (how to give the money back to the industry).

4. Regulatory and legal issues and recommendations

In order to understand the changes that the TRCSL is envisaging for the NGN policy and regulatory framework in Sri Lanka, it is helpful to consider how telecoms regulation typically evolves. One can distinguish three phases:

* **Monopoly phase –** During this phase, telecoms was considered to be a natural monopoly. The telecoms operator was typically owned and operated by the government (as was the case in Sri Lanka), and tariffs were set to provide low prices and encourage universal access.

* **Competition phase –** As new technologies were introduced, relevant markets were liberalised and competition was introduced where feasible. Many new technologies – wireless technologies in particular – were conducive to *facilities-based competition*, in which entrants built their own networks and competed on the basis of coverage, service quality and prices. At the same time, other technologies – such as ADSL – were conducive to *service-based competition*, in which entrants were given wholesale access to key parts of the incumbent's network in order to increase competition. Finally, the incumbent was typically corporatised and privatised so that it would compete on an equal basis with the entrants.

* **NGN and Convergence phase –**The introduction of NGN may facilitate competition at several levels. As discussed above, next-generation core network equipment is less costly than that in traditional networks, thus fostering facilities-based competition, while at the same time on NGNs it is easier for providers to engage in service-based competition.

During the Competition phase, the international best practice is to differentiate between facilities-based and service-based competition (as is the case in Sri Lanka). Under such a regime, more stringent regulatory control is asserted over facilities-based operators, while service-based operators are subject to comparatively 'light-touch' regulation. For example, service-based operations would have a simplified and more expedient licence application process, lower licence fees and fewer regulatory requirements than a facilities-based licence. In the long term, facilities-based competition may provide the most significant consumer benefits, while allowing for a significant reduction in regulatory intervention. In the short to medium term, however, service-based competition can play an important role in facilitating the launch of new innovative services. While this differentiation was aimed to promote the introduction of competition under traditional networks in the Competition phase of regulation, such policies may be even more relevant for a regulatory framework in theNGN and Convergence phase, given how NGNs favour service-based entry for VoIP and other advanced services.

A main building block for introducing a distinction between facilities-based and service-based competition is asymmetric regulation. Under asymmetric regulation, one or more operators are designated to be 'dominant', based on having SMP in one or more telecoms services. A number of regulations are then imposed on the dominant operator as a means of increasing competition through wholesale access, which can enable service-based competitors to enter the market and compete. The other aspect of asymmetric regulation is that competitors face only minimal regulations, in order to reduce the regulatory burden and promote entry and innovation. Again, just as asymmetric regulation is considered important for promoting entry during the Competition phaseof regulation, it is critical to maintain (and strengthen) an asymmetric regulatory framework under the NGN in order to enable providers to take advantage of the ease of entry under convergence.

Finally, in many countries, USO has been an important consideration during all phases of regulation.The important considerations for USO are how to raise the USO funds, and in turn how to disburse them.In the Monopoly phase, USO was essentially implicit, as the monopoly provider charged above-cost rates on certain services used mainly by businesses and high-income families in urban areas, such as international calls, in order to subsidise access and local calls targeted to low-income users or in high-cost areas.Under the Competition phase, USO became more explicit, as competitors targeted services with the high rates such as international calls and business services, causing those prices to fall and thereby creating a need to raise funds to continue to subsidise necessary services offered by the incumbent and competitors alike.Regulators around the world are considering how the model changes under the new Phase III of regulation.

A number of building blocks are needed to realise an NGN regulatory framework going forward:

* policies for NGN (market dominance and asymmetric regulation, NGN licensing and USO)
* wholesale obligations
* retail obligations
* charging mechanisms
* consumer protection.

Each of these issues is discussed in turn below.

4.1 Policies for NGN

The current regulatory framework is no longer suitable for an NGN world, for a number of reasons.First, current regulations are suitable for services that are closely tied to a corresponding network (as shown in Figure 2.2, Section 2.2), whereas no such correspondence is necessary under NGN (as shown in Figure 2.3, Section 2.2).As a result, for instance, voice regulations cannot be applied only to the owners of fixed and mobile networks, but also potentially to cable networks as well as service providers that offer VoIP solutions with no infrastructure.The same is true for video applications, which can be offered over a variety of networks.As a result, a new regulatory framework must recognise these changes in order to apply relevant regulations to services regardless of the network, but also to promote entry and competition that is enabled by the NGN technologies.

The general policies that the TRCSL is considering for its NGN regulatory framework are discussed here. While these policies are important for the NGN framework, they include regulations that many countries adopted under the Competition phase of regulation, but which may not have been fully implemented in Sri Lanka.The concept of asymmetric regulation is discussed, followed by a consideration of the distinction between facilities-based and service-based competition, which is typically embodied in the relevant licences.Finally, the impact of NGN on USO is discussed.

4.1.1 Market dominance and asymmetric regulation

Asymmetric regulation is a principle underlying the policies of many developed and developing countries worldwide. This principle may be particularly relevant and beneficial in promoting growth of the telecoms industry in Sri Lanka, including the adoption of NGN and corresponding services. Under such a model, greater regulatory controls would be imposed on carriers that have SMP in the relevant telecoms market. Such a framework can be used to constrain anti-competitive market behaviour by adominant player, while minimising the regulatory burdens on both new entrants and regulators.

In determining whether an operator is dominant, there are two possible approaches:

* **Market-by-market approach –** Conduct a market definition exercise and expressly set an objective criterion for defining a 'dominant' operator in the relevant market, often defined as an operator with the ability to exercise SMP in a particular market in which it provides telecoms services. In turn, SMP can refer to the ability to unilaterally restrict output, raise prices, reduce quality or otherwise act, to a significant extent, independently of competitive market forces (i.e. independently of the operator's competitors, suppliers and customers). The effect of this approach is that the onus is on the regulator to demonstrate that an operator is dominant and thereby impose appropriate regulations. An example of this approach can be seen in the EU, under the European Regulatory Framework.

* **Entity-based approach** – Designate as 'dominant' an operator that operates infrastructure/facilities that are sufficiently costly or difficult to replicate, presenting a significant barrier to timely entry by an efficient new entrant. This is known as an entity-based approach such that the operator is dominant in respect of all the services it provides, and the onus is on the operator to provide evidence to remove the dominance classification on a market-by-market basis. The advantage of such an approach is that the regulator can dispense with the

need to undertake complex (and costly) market analysis, especially in the situation where SMP can be assumed because of the entrenched position of the incumbent in a newly liberalised environment. Examples of countries where this approach has been taken include the USA and Singapore.

The first approach (i.e., market-by-market approach) places significant regulatory burden on the regulator as it requires detailed and sophisticated market analysis, including determining the different relevant markets within the telecoms industry and assessing whether one or more operators have SMPwithin each respective market. Such an exercise is time consuming and requires significant resources and expertise on the part of the regulator. The entity-based approach is easier to implement, as it can be applied to all services provided by one entity that is determined to be dominant.However, it does not accommodate two related aspects of the market in Sri Lanka. First, it does not reflect areas where competition has already developed, such as in mobile markets, where notably the fixed incumbent is not the largest mobile operator.Second, it does not reflect that all retail competitors may have market power in wholesale termination services, as has been the finding in European countries using the market-by-market approach.[27]

To the extent that a market is competitive, a regulator could rely primarily on market forces and industry self-regulation, subject to minimum regulatory requirements designed to protect consumers and to prevent anti-competitive conduct. However, to the extent that a market is not yet competitive, *ex ante*regulatory measures may be necessary. By adopting asymmetric regulation such that special obligations are placed on the dominant operator, the regulator is seeking to establish a balance between the incumbent and new entrants that facilitates the growth of competition. In particular, many *ex ante* regulatory interventions typically provide for wholesale access to those parts of the network that would allow entrants to compete in retail markets; additional regulatory interventions such as tariff control would regulate retail services where wholesale access may not quickly lead to competition. These regulatory interventions are discussed below in Sections 4.1.3 and 4.3.

4.1.2 NGN licensing

A licence is a unilateral grant of permission to provide a telecoms service or operate a telecoms network, and should not be regarded as a contract or bilateral agreement.

The NGN licensing framework will be developed to cater for integrated network platforms that deploy efficient and advanced technologies; in future, it will carry all forms of communication originating from various service providers. This includes fixed and mobile voice, data and multimedia applications. Due to the uncertainty of the evolution path for NGN, the new licensing structure should avoid reliance on any singular view of future market structures, whilst also avoiding unnecessarily complex licensing structures.

Present licensing framework

The mission of the TRCSL includes the creation of *"the optimum conditions for the telecoms industry in Sri Lanka by serving the public interest in terms of quality, choice, and value for money"*. To this end, the TRCSL has issued licences to a number of operators providing fixed and mobile telephony and data communication services, and to ISPs. As presently provided for under the Telecommunications Act, No. 25 of 1991 (as amended by the Telecommunications (Amendment) Act, No. 27 of 1996), any person who wishes to operate a telecoms system or to provide a telecoms service in Sri Lanka must be licensed by the TRCSL. The current licences issued by the TRCSL seek to be technology-neutral but service-specific, as operators are licensed to provide either mobile or fixed telephony. Presently, the TRCSL has adopted a licensing approach that differentiates between the provision of facilities-based operations and non-facilities-based operations:

[27]In Europe, retail markets for mobile services are competitive in most, if not all, countries, but the market-by-market approach still allows regulators to impose remedies on all mobile operators for mobile termination services, to control the rates that operators would charge one another for terminating calls. In Singapore, for instance, which uses an entity-based approach focusing asymmetric regulation on the incumbent, this issue is avoided by the fact that mobile termination rates are not charged, using a system known as bill and keep or sender keeps all.

* **Facilities-based operations** –It typically requires usage of scarce resources (frequency spectrum and/or rights of way, numbering) and refers to the establishment and operation of any form of public telecoms network infrastructure systems and/or facilities for the purpose of providing public telecoms services to third parties, which may include other licensed telecoms operators, business customers or the general public. An Individual Licencies issued for this purpose.

* **Non facilities-based operations (*i.e.* service-based operations)** –It refers to operators that intend to lease telecoms network elements (including transmission capacity, switching services, ducts and fibre) from a facilities-based operator in order to offer their own telecoms services to third parties, or to resell the telecoms services of the facilities-based operators. The TRCSL presently issues a Class Licence for this purpose.

A key objective of allowing service-based competition is to prevent the inefficient duplication of networks. The entry of a facilities-based competitor in a market with large economies of scale would result in significant duplication of facilities, which could be productively inefficient. Therefore, service-based competition may play an important role in ensuring that existing infrastructure is used efficiently. On the other hand, it is important to ensure that the regulatory regime does not undermine incentives for efficient network investment.This report seeks to address this issue below in developing the NGN policy and regulatory framework for Sri Lanka.

NGN licensing framework

It is likely that integrated network platforms using NGN technology will carry all forms of communication, including fixed and mobile voice, data and video, originating from many different providers. In this regard, it is increasingly recognised that imposing a service-specific or technology-specific licensing regime may severely restrict the way in which technology is used and prevent operators from extracting the full benefits and flexibility afforded by the NGN infrastructure. For regulating service offerings in NGNs, it is observed that there is a shift away from service-specific and technology-specific vertically integrated licensing regimes towards horizontal licensing regimes that better reflect the technical and logical separation of the core, access and service layers of NGNs. For example, the Indian regulator TRAI has implementeda single unified licence that currently enables operators to provide both fixed and mobile services.This policy ensures a smoother migration to an NGN environment.

As stated above, service-based competition will play an especially important role in facilitating the launch of new innovative services in the NGN environment, given how NGNs favour service-based entry for VoIP and other advanced services.

Accordingly, the TRCSL had earlier sought industry feedback on maintaining service-based competition in an NGN environment. To this end, the TRCSL had intended to strengthen the present two-tier approach to differentiate between licences based on the nature of licensed operations, i.e. whether the licence relates to a facilities-based type of operation or a service-based type of operation.The TRCSL is encouraged that most of the respondents were generally supportive of a two-tier licensing structure.

With the introduction of NGNs, the TRCSL is of the view that an Individual Licence will still be relevant for operators who establish and operate any form of telecoms network infrastructure systems and/or facilities. To this end, the TRCSL might impose varied conditions relating to, without limitation: service quality, wholesale access, interconnection, interoperability, number portability, security, and some other relevant conditions specifically applicable to NGNs. The extent to which the TRCSL would impose such conditions could depend on whether or not the operator is dominant.

Separately, Class Licences could become the primary means of regulating the provision of innovative services in an NGN environment. At present, the TRCSL has issued licensing guidelines and procedures for the granting of licences for legacy networks.These guidelines will be revised in line with the recommendations made in this framework document, listing the specific types of services that qualify for this ‘lighter’ form of

licensing (*e.g.* for the provision of IP telephony, Internet access services, and other value-added network services).
In addition to licence conditions, the TRCSL is also empowered to give directions, issue codes of practice and standards of performance to its licensees where necessary. The intention is to ensure the provision of communications in a multi-network, multi-operator competitive environment in which end users will be able to access any service from any service provider, regardless of the network to which the end users are directly connected.

A service-based licence could be sub-divided into at least two further categories:

- **Standard Class licensing** – It applies to stipulated types of operation and service that may require closer regulatory scrutiny (such as the provision of IP telephony services or re-sale of fixed telephony).

- **Simplified Class licensing –** It can be issued for basic telecoms services that raise fewer regulatory concerns, such as possibly ISP services, which do not require licences in a number of countries.

In the forthcoming renewal of telecoms licences in Sri Lanka (beginning in 2011), the TRCSL intends to maintain the two-tier licensing framework, and to further explore sub-dividing the service-based licences into the Standard Class and Simplified Class licence divisions.Additionally, the new licences will include different conditions for the different phases of the NGN migration, as defined in Section 3.3.

4.1.3 Universal Service Obligations

The original goals of USO – affordability and accessibility – are key policy goals that should not be abandoned or altered in an NGN environment. During the migration to NGN, there is ongoing relevance to the existing structure of USO, with additional concern that the levies do not stifle investment and innovation in services that might otherwise undermine the source of these revenues.

At the same time, under NGN the challenge remains to preserve the objectives of USO, while fostering innovation in new networks and services. There are two parallel questions to be raised relating to the implications of NGN on universal access funding, and on the distribution of universal access funds under NGN.

Implications of NGN on universal access funding

There are two related issues with respect to the implications of NGN on universal access funding:first, whether NGN services will undermine current funding sources, and second, how best to raise funds with NGN.

The implementation of NGN will allow, amongst other services, the delivery of managed and unmanaged VoIP services. VoIP could impact universal access funding, which is now based on a per-minute levy on international calls.While the levy has been falling in recent years, as calls migrate to VoIP services, the levy will be harder to impose and revenues will start to fall.Further, the source of these revenues may create resistance to change that would further undermine universal access funding, making it harder to migrate to NGN.

The related issue is how to supplement or replace the current source of funding, and, in particular, whether NGN service providers should contribute to a USO fund, and on what basis.A key consideration is to minimise distortions to competition and usage of the relevant services.One idea that has been raised is to attach the USO to the issuance of numbers, as these would be paid by all subscribers;these chargeswould be a one-off levy that would be independent of the number of calls made by the subscriber. This fund-raising mechanism has not been implemented yet in any country.However, the TRCSL anticipates that it will be broadly considered, in order to avoid the distortion, and difficulty, of levying per-minute charges on calls as they migrate to the internet.

Implications of NGN on the distribution of universal access funding

The other question to be addressed relates to the disbursement of funds.In particular, should the funds go to operators to build networks and/or provide services, or should the funds go to users to increase their ability to pay for services?In addition, questions relate to whether the funds should promote basic voice services or broadband, and further whether they should differentiate between fixed or mobile networks and services.

4.1.4 Recommendations

Market dominance and asymmetric regulations

Currently, the TRCSL already practices a form of asymmetric regulation as part of its licensing framework in which facilities-based operators (such as fixed telephony and mobile telephony providers) are subject to more extensive licensing conditions. Moving forward, the TRCSL believes that asymmetric regulation based just on the ownership of facilities is no longer sufficient to enable effective regulation of the industry, given that there are other sources of market power.Nonetheless, to ensure that Sri Lanka can smoothly transition to an NGN environment, the TRCSL considers that asymmetric regulation will be necessary and will in fact encourage more investment as operators are protected from anti-competitive behaviour (for instance, on the part of the NGA network operator(s).

Despite the lack of direct support for asymmetric regulation from the consultation responses, it is noted that respondents have in fact demonstrated strong support in other parts of their responses for putting in place different elements of asymmetric regulation, such as requiring the dominant operator to offer a RIO and mandating access to bottleneck elements. However, the TRCSL also notes the respondents' concerns and agrees that regulation should only be imposed to address specific competition concerns. In this regard, *ex post* competition regulation will be triggered whenthere are specific incidents of anticompetitive activities.

As for *ex ante* regulatory measures to be imposed on dominant operators, the TRCSL will impose those that are necessary for promoting competition and protecting consumers. The TRCSL intends to learn from international best practices in its design of the regulatory framework to avoid regulatory distortion of the market and create undesirable arbitrage opportunities.In deciding which approach the TRCSL will adopt to determine whether an operator is dominant, the TRCSL will consider, amongst other factors, the level of regulatory resources and expertise available, its regulatory priorities, the demands of the different approaches and the state of development of the Sri Lankan market. As part of its licensing review, the TRCSL will seek to incorporate the necessary elements of asymmetric regulation into the new licences.

The TRCSL considers that an entity-based approach is more appropriate for the migration phase to NGN (Phase II), but given that some markets already have competitors today, in applying the entity-based approach, the TRCSL will seek to incorporate aspects of a market-by-market approach, by exempting retail markets that are shown to already be competitive, such as perhaps mobile markets, while at the same time retaining the ability to impose wholesale termination regulations on all competitors where appropriate.In addition, the TRCSL foresees to issue a consultation on the specific issue of dominance within three years of implementing the entity-based approach.Based on the result of the consultation, the TRSCL will define the optimum approach to asymmetric regulation for Phase III of the migration to NGN (full NGN migration), which could entail a move to a market-by-market approach based on how wholesale and retail competition develop.

NGN licensing

Respondents were generally supportive of maintaining a two-tier licence structure, *i.e.* Individual and Class Licences, but respondents also highlighted the need for the licensing regime to be technology-neutral. Given the general support for the two-tier licence structure, the TRCSL plans to adopt this licensing model moving forward. As a matter of principle, the licensing regime should be technology-neutral and flexible to minimise

administrative burden, as well as preventing any unfair regulatory burden on any licensee using specific technology. The relevant competition rules, investigation and enforcement powers should also be considered concurrently with the review of the licensing structure so that the TRCSL can decide which regulatory instruments to use for specific purposes.

The TRCSL is mindful that most of the legacy PSTN licences currently issued to the present operators will come up for renewal beginning in 2011. In renewing these licences, the TRCSL will introduce new licence conditions in order to ensure a smooth migration to NGN. As a starting premise, the TRCSL believes that in an NGN environment, licence obligations across the same licence category must be homogeneous, except those imposed on dominant operators. Fewer regulatory obligations should be imposed on service-based operators compared to the facilities-based operators, reflecting their lack of control over any necessary or essential facilities, and in order to encourage the development of vibrant and innovative retail services provided via NGN.

Given the complexity of the issues involved and the substantial impact on the licensees (as reflected in the responses received), the TRCSL is likely to conduct a further and separate industry consultation focusing on the specific obligations for each category of licence required in an NGN environment, prior to the renewal of licences. This is a preferred approach compared to an *ad hoc* approach when each licence comes up for renewal because:

* the TRCSL will be in a better position to formulate a consistent framework applicable to all similarly situated licensees – i.e. fairness and certainty to industry with a 'one-size-fits-many' regime.
* the TRCSL can avoid having to grapple with multiple versions of licences (each with specific and differing licence conditions) – *i.e.* the benefits of administrative simplicity
* the TRCSL can ensure a level-playing field to ensure that operators whose licences expire first will not be at an advantage or disadvantage against those whose licences expire later
* licensees would be given ample opportunities and, possibly, an open forum to consider all relevant issues.

In addition to the above issues, the TRCSL considers that data-only operators should also be allowed to provide voice services to take advantage of the possibilities afforded by NGN, and the TRCSL will review the current data-only licence accordingly.

Universal Service Obligations

The TRCSL will consider issuing a public consultation in order to seek inputs on the appropriate design of a USO programme applicable to the NGN environment. Following this consultation, the TRCSL is planning to seek advice from the NGN Advisory Committee on a number of steps to implement a robust USO programme.

The approach recommended by the TRCSL to undertake this study is summarised in Figure 4.1

Figure: 4.1: Approach to universal service access [Source: TRCSL]

The first step would be to setforth the goals of universal service in terms of coverage, services and QoS required for each of the regions in Sri Lanka.The TRCSL anticipates to closely collaborate with telecomsconsumerassociationsto ensure that the desire of Sri Lankans in terms of coverage, services and QoS they require is accounted for when defining the overall objectives.Also, the TRCSL will consider whether universal service funding should cover network deployment in underserved areas, or should it cover access for those peoplewho cannot afford it.Further, should funding decisions differentiate between mobile and fixed, or between voice and broadband?

The second step will be to evaluate the levels of funding required to implement the USO objectives defined in the previous step.When estimating the amount, the TRCSL will consider the investment from industry in commercially viable areas and define the additional subsidies that are required in order to help the industry deploy targeted services.

The third step will be to design the mechanism to raise the USO funds.Sources of funds could be one or more of the following:

* levy on end users
* levy on operators
* contribution from central government
* contribution from third-party organisations (World Bank, European Union, etc.)

In designing the fund raising mechanism, the TRCSL believes that any levy imposed on end users should be kept reasonable, not to hinder adoption and usage of the service.

The final step would be to define the mechanisms to disburse the funds to operators and ISPs.This process need to be transparent, where operators/ISPs would have to produce justification of their expenditure (as currently performed in the current system).

As explained in section3.9, the TRCSL recommends the implementation of an independent workstream (e.g. Workstream 4)to assist the TRCSL to develop the USO programme and, in particular, identify the overall objectives that the USO programme should achieve. In this workstream, key stakeholders should also provide advice to the TRCSL regarding the possible funding model for USO, as well as defining the mechanisms to disburse the funds (how to use the money to serve the goals of the programme).

4.2 Wholesale obligations

For legacy networks, in order to promote competition by reducing the cost of entry, it is common for regulators to impose wholesale obligations on operators. According to international best practice, many wholesale obligations are imposed only on dominant operators in order to ensure competition in those areas where the operator would otherwise be dominant. Such wholesale obligations include interconnection requirements as well as targeted wholesale access.At the same time, as discussed above, NGNs provide opportunities for service-based competition with less wholesale regulation, such as the ability of Skype or Google to facilitate VoIP calls over broadband connections.While such services do not require wholesale regulation *per se*, regulatory conditions will help facilitate service-based competition.

Regulators recognise that the key issue in creating competition in an NGN environment is to take advantage of the new opportunities of NGN to enable service-based competition, without reducing incentives to invest in the new networks.In particular, the ability of providers to enter and compete vigorously with network owners in services such as voice can leave network operators providing only connectivity.The resulting reduction in NGN service revenues earned by the network operator can correspondingly reduce the incentive to invest in NGNs.On the other hand, allowing the network operator an advantage in providing retail services may provide incentives for operators to invest and compete at the network level, but at the expense of service-based competition.

The result is a certain balance for regulators between promoting facilities-based competition versus service-based competition.As competition in NGN services is still nascent, there is an additional balance between imposing regulations that provide certainty to those seeking to invest in networks and service provision,

while allowing markets to operate and determine successful business strategies.Thus, the TRCSL seeks to identify the minimum obligations that are necessary to promote investment in NGNs and services today, versus those obligations that may become necessary as market forces determine the development of network and service-based competition over time.

4.2.1 Interconnection

Interconnection requirements area key part of the regulatory framework aimed at facilitating new entry. Interconnection between networks is essential, to ensure that subscribers on different networks are able to communicate with one another. It is recognised that dominant operators may lack the economic and commercial incentives to voluntarily enter into interconnection agreements (or do so in a timely manner) with competing operators or new entrants. This is particularly true since subscribers would be unlikely to migrate to a new network if they are unable to communicate with the bulk of subscribers who remain on dominant operators' network.

Regulators typically impose a requirement for all operators to interconnect with one another, to prevent dominant operators from blocking entry through a refusal to interconnect. Many regulators go further than this, and require dominant operators to publish a RIO that sets out the prices, terms and conditions on which dominant operators will provide designated wholesale services to any competitor. These wholesale services can include interconnection for the transit or termination of voice calls, as well as wholesale access to network elements, as described in the next section.

The purpose of the RIO is to make dominant operators the point of interconnection 'of last resort'. If the new entrants are able to commercially negotiate better terms for interconnection between themselves and/or the dominant operators, they have the flexibility to do so. However, they can fall back on dominant operators and interconnect on the basis of the RIO offering if they are unable to do so. The RIO must thus be sufficiently detailed to enable a competing operator to accept dominant operators' prices, terms and conditions *as is*, without having to engage in protracted negotiations with dominant operators.

Under this model, a regulator would issue guidelines regarding the services and pricing methodology that would need to be incorporated into the RIO to ensure fairness, and would have to give its approval to the resulting RIO.

With respect to interconnection between non-dominant operators, the regulator could play a more limited role and instead rely on market forces and commercial negotiations to foster agreements. The regulator could further act as adjudicator to resolve disputes over the terms of an agreement or in situations where no agreement can be reached. However, it should be noted that a number of regulators have determined that certain interconnection rates, such as mobile termination rates, should not be left to market forces even when the retail market is competitive.

As discussed above in Section 3.1, the technologies and architecture of NGNs differ from the PSTN and result in new network topologies, associated costs and interconnection models. This presents challenges to the current interconnection regime in many countries where the value paradigms in NGN architectures mean that new models may be needed for settlement of interconnection services.

This is likely to lead to the development of new IP-based interconnection arrangements that are service-based and capacity based, rather than based on minutes and miles, particularly for certain types of traffic. Regulatory and policy considerations include the impact of IP-based networks on current interconnection arrangements; ensuring no discriminatory access behaviour; defining the parameters of interconnection in a multi-service environment; and whether there will still be a need for mandated wholesale interconnection regimes, as well as a revision of the charging principles.

IP traffic does not lend itself easily to per minute charging, and it is technically complex to separate one kind of traffic (e.g. voice) from another (e.g. World Wide Web traffic) where many different types of traffic may be carried simultaneously across the same interconnection link. Also, as explained in Section 3.1, in the IP network, it is difficult to identify the source and destination of a particular session, unlike in the PSTN environment. This raises issues about how service providers should charge for interconnection, and the issues are particularly complex when traffic has to be passed from a circuit-switched to an IP environment, or vice versa, during the migration to NGN.

In addition to charging issues, NGN interoperability may be critical to ensure that there are no delays in the introduction of new services and providers in retail markets, as discussed above. Regulations may be needed to ensure the interface between legacy networks and NGN, to enable entrants that have invested in NGNs to interconnect with legacy networks. While the TRCSL prefers that standards should be market driven to every possible extent, it is also realistic that the NGN Advisory Committee would be best placed to make recommendations on interconnection standards, interfaces (and other such technical issues), akin to the work of NICC in the UK (as discussed in Sections 3.4 and 3.5), which was established to address NGN standardisation matters.

As discussed above in Section 3.4.3, there is a stark contrast today between voice and data interconnection, as the latter is not regulated and often traffic is exchanged without settlements in a peering arrangement.Further, IP traffic is often exchanged in an IXP where a number of providers can meet and exchange traffic under peering or transit arrangements.As voice migrates to IP in the NGN, it is likely that increasingly it will also be exchanged at an IXP under existing or new interconnection arrangements, and the TRCSL has proposed some conditions to facilitate this process in Sri Lanka.

4.2.2 Wholesale access

Wholesale access to key network elements is important in promoting entry and expansion by service-based providers; facilities-based providers can also benefit from such access as a means of reducing their costs of providing service and/or extending their services into new markets.For these reasons, wholesale access is mandated by regulators around the world, as a means of facilitating entry and competition in relevant retail markets.An understanding of the experience in Europe, which has one of the most developed wholesale access frameworks in the world, is useful to understand potential wholesale access issues.

Wholesale access in access networks is mandated across all EU countries, with significant success in creating competition. The European New Regulatory Framework (NRF) is composed of six Directives that address the convergence of telecoms, media and information technology, but does not specifically address any content regulation**.** This framework is built on the following principles:[28]

- technology- and provider-neutrality
- focus on services, not technology
- informed by legal principles drawn from general competition law
- focus on enduring bottlenecks
- light-touch regulation
- foster innovation and investment
- provide legal and investment certainty
- avoid fragmentation of markets
- balance harmonisation and innovation
- address the question of cross-border services.

Of particular interest is the fourth principle, namely ‘focus on enduring bottlenecks’. This reflects the general *ex ante* approach taken to regulation. The NRF states that *ex ante* regulatory obligations (notably wholesale access) should only be imposed where there is not effective competition, i.e. in markets where there are one or more providers with SMP. As soon as wholesale competition creates significant retail competition, then any retail obligations are removed, and to the extent that wholesale competition becomes sustainable without regulatory obligations, then those obligations are removed as well.

In many countries, including in Europe, wholesale access is applied to both core and access networks, which are reviewed here in turn.

28 Source: European Telecommunication Platform. (06) 01, 17 January 2006.

Wholesale services in the core network

As is the case in many countries, including those in Europe, the TRCSL recognises that local leased circuits (LLC) are important elements in the telecoms market that are commonly used by telecoms service providers to provide services to wholesale and retail customers, and by business users to communicate between their local and international offices. For instance, mobile operators can use leased lines to connect their base stations, and also to provide backhaul to submarine cable landing stations. Internet access service providers also rely heavily on LLCs for connecting customers to their points of presence (PoP) for provision of Internet access services. For these reasons, effective competition in the LLC market can make a positive contribution to the competitiveness of telecoms markets, and extend to the overall economy (e.g. through growth of the business process outsourcing industry). The same is true for international core network access and infrastructure.

The TRCSL has considered the need to adopt additional regulatory measures to facilitate further competition in the core network, while at the same time being careful not to diminish the economic incentive for telecoms operators to deploy their own network infrastructure to serve their customers over the longer term. One possible regulatory measure is to designate the dominant operator's core network assets (such as LLC) as a wholesale service that will be provided at a pre-approved wholesale price for a pre-determined number of years (subject to regular regulatory review).This could be included in the RIO, covering a variety of LLC bandwidths that would enable competitors to match all retail leased-line services provided by the dominant operator, at the same QoS.

With increased competition in the core network, the TRCSL hopes to further reduce business costs and, ultimately, promote the economic growth of Sri Lanka and its attractiveness as a business location. The planned NBN, creating competition in backhaul services, would be expected to reduce or eliminate relevant wholesale obligations on any dominant operator in the relevant markets.

Wholesale services in the access network

As part of the wholesale regulatory regime for broadband access, regulators in Europe generally have tried to establish a ladder of investment for new entrants offering data services, as illustrated in Figure 4.2

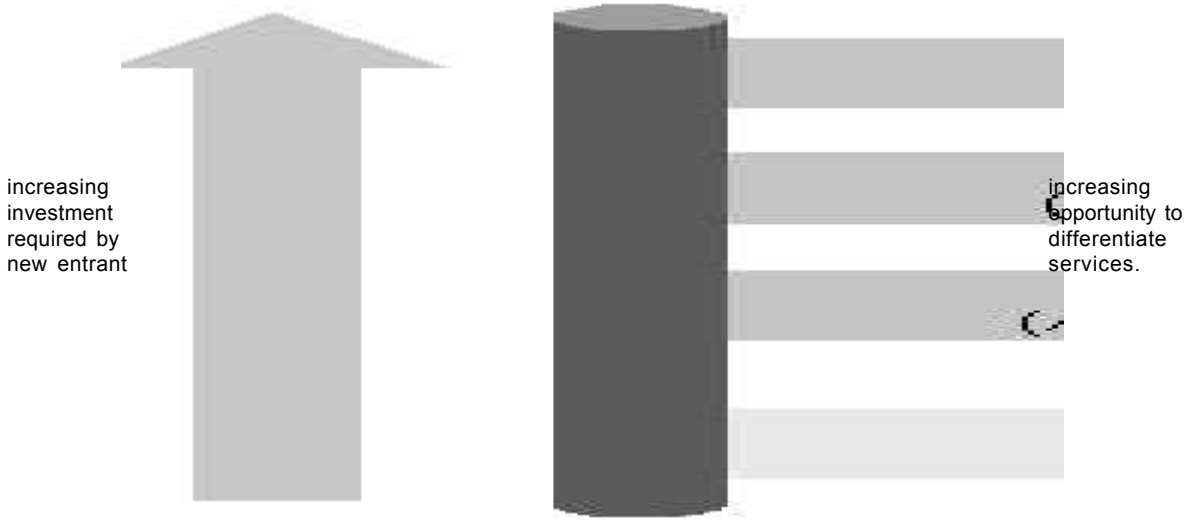

Figure 4.2: Ladder of investment for wireline new entrants [Source: Analysys Mason]

The investment ladder starts with resale, which requires the least investment by the entrant while providing the lowest wholesale discount, which in turn provides the least means for the entrant to differentiate its retail service, as it is essentially selling the service of the incumbent. In other words, it is meant as a means for an entrant to begin selling service under its own brand name and build up a customer base, with the least fixed investment needed.

As soon as the entrant has enough customers, it has an incentive to move up the ladder, to a form of bitstream access (differentiated by where in the network the entrant picks up traffic); this requires more investment by the entrant, but in return has a larger discount and provides more means for the entrant to differentiate its service, being able to offer both data and voice services.

Again, when the entrant builds up a customer base, it has an incentive to take LLU, which requires yet more investment in return for more flexibility.With LLU, entrants are able to offer the entire triple play.

The culmination of the ladder is infrastructure investment, which can be characterised by the purchase of dark fibre or by the purchase of duct space by the new entrant to deploy its own fibres for providing FTTH services to its customers.This obviously requires the most investment from the entrant and is only feasible in areas where the new entrant is likely to make sufficient return (typically in dense urban areas).In Europe, countries like Portugal, Spain and France have regulated the access to the incumbent's ducts and poles to ensure the barriers to entry for new entrants are minimised.

The most prevalent form of access in Europe is unbundled local loops, which provide the highest degree of flexibility for competitors – notably, a number of them used unbundled loops to offer IPTV services even before incumbent operators, creating a significant amount of competitive pressure in the process.However, as incumbents begin to invest in new NGA networks, such as FTTC or FTTH, it is increasingly difficult to unbundle the loop, as much of the fibre in the network is shared between the downstream households and therefore cannot be unbundled in the same manner as a copper local loop.

Bitstream access is also common in Europe. It tends to afford a great deal of flexibility for new entrants.Bitstream access can be illustrated with reference toFigure 3.5, where the incumbent network operator continues to operate the access network and the exchange, while the DSL bitstream traffic will go over the backhaul from the DSLAM to the competitive operator instead of the incumbent's ISP, with potential variations in whether the incumbent or the competitive operator provides the network access server.One of the strengths of bitstream is that, unlike with unbundled local loop, a similar model can be applied going forward to future NGA networks (as seen in Figure 3.6 and Figure 3.7, the entrant can continue to receive the bitstream at the backhaul level).

Based on international best practice, the bitstream offer can be included in the RIO for dominant operators, and regulations must ensure that alternative operators are not at a disadvantage with respect to dominant operators when using wholesale inputs or services.In particular, the bitstream offer should provide enough variationsto enable competitors to match the retail offers of dominant operators, at similar QoS, along with variationswhere the competitor accesses the bitstream offer within the dominant operator's network, with corresponding differences in the wholesale tariff.

4.2.3 Impact of NGN on wholesale obligations

While the wholesale obligations discussed above will increase competition under the *status quo* in the current regulatory environment as well as in the future NGN environment in Sri Lanka, the nature of NGN lends itself to additional considerations regarding the promotion of competition.In particular, international best practice shows that certain regulatory principles may promote service-based competition, and also that the nature of interconnection may change as traffic migrates to IP-based NGN technologies.

Regulatory principles for service-based competition

Although convergence into NGN can facilitate competition in services such as VoIP with little or no interaction with the owner of the network (as discussed in Section 2), international best practice shows that several regulatory principles c an help to foster such competition while providing a level-playing field. Two important principles that have been identified are technological neutrality and net neutrality:

Technological neutrality –The general principle is that regulations should be applied to similar services regardless of the underlying platform. The corollary is that legacy regulations should not necessarily be applied to new services unless they are needed. In this light, one application is that important regulations, such as QoS or emergency access, should be applied to services that consumers would reasonably expect to be similar to their existing legacy service – for instance, any fixed telephone service using a traditional handset should have similar regulations regardless of the underlying transmission technology or access network. Likewise, such regulations should not be applied to a VoIP service such as Skype that is offered on a computer, as consumers would not have an expectation of similar featuresas with a traditional service.

- **Net neutrality –** The general principle is that a vertically integrated Internet access provider should not discriminate against any individual provider or class of service that compete in upstream services such as voice or video. However, in certain situations a provider may wish to manage the network to prevent congestion on contended resources, such as the wireless access network, or to offer a managed service with guaranteed QoS such as IPTV. On the other hand, as discussed above, verticallyintegrated providers may have an incentive to degrade or deny access to services such as VoIP or video services that compete with their own services. Principles that prevent such discrimination should be extended to the NGN regulatory framework.

4.2.4 Recommendations

The TRCSL is of the view that the imposition of wholesale obligations on dominant operators will foster and maintain competition in an NGN environment that will ultimately benefit consumers.

The recommended wholesale obligations include mandating interconnection between networks and requiring dominant operators to publish a RIO setting out prices, terms and conditions upon which they will provide wholesale services to a competitor. However, the TRCSL anticipates that the RIO should provide the option for both TDM and IP interconnections during the NGN transition period (Phase II).As more and more operators complete their transformation to NGN, an IP-based RIO will likely be necessary during the full migration phase (Phase III).

In particular, the TRCSL considers that the feedback from one respondent regarding the terms to be incorporated into an NGN RIO serves as a good starting point. The proposed terms include:

- timelines for negotiation and execution of interconnection agreements
- compensation for migration
- standardised reference offer applicable to all types of competitors
- conciliation of disputes
- billing and payments including pricing models
- charges
- interconnection services provided (e.g., access, core network, application layer, LLU)
- technical specifications including QoS parameters, signalling and physical interface
- manual of operations and processes.

Given there is general support for amending the existing interconnection rules, the TRCSL's choice of either amending the Interconnection Rules 2003 or promulgating a totally new set of rules will depend on which option is the most efficient from an administrative point of view and creates the least transitional problems. The TRCSL's current preference is to modify the existing Interconnection Rules 2003 given that the operators are familiar with them and therefore are more likely to provide more useful inputs, as well as allowing them to draw from their experiences in applying the interconnection rules under legacy networks.

As part of the implementation of asymmetric regulation along with the corresponding RIO, the TRCSL recognises that the competitiveness of all markets must be studied and appropriate remedies be put in place where dominant operators has market power. One area where there is typically market power is in the core network for leased lines and international access, and in addition this is an area where facilitating wholesale access can significantly lower the costs of entrants and increase retail competition. This will be particularly important as broadband is deployed and higher bandwidths are needed to serve customer demands.While the largest operators opposed this approach in their consultation response, the need to provide such access to entrants is consistent with international best practice and represents and efficient means to increase competition in the short run.

Thus, in order to encourage competition, the TCRSL seeks to adopt the recommendations of some of the consultation respondents by regulating leased lines, including domestic backhaul to mobile base stations, and international access at the landing stations.The TRCSL is aware that dominant operators would not necessarily agree with such regulation, but as demonstrated in many other countries, the regulation of leased lines would increase competitiveness to facilitate wholesale access to capacity, and this will be particularly important going forward to promote broadband by accommodating the increased capacity demands from advanced services.In addition, the TRCSL strongly believes that the other focus of regulation should be with respect to underserved areas.

Further, the TRCSL agrees with some of the consultation responses regarding the need for wholesale access network services, and particularly bitstream service, but considers that it should be implemented as part of the implementation of asymmetric regulation (in line with one of the respondents' comments about bottleneck or essential facilities). The TRCSL will consider designating these services and including them in the RIO subject to a market review to identify the relevant wholesale services.

Lastly, the TRCSL notes that there appears to be general industry support for technology and net neutrality, thereby paving the way for it to adopt these principles. In terms of net neutrality, the TRCSL may allow a service provider to retain the ability to offer different levels of services at different prices as a means to manage data traffic. Essentially, the TRCSL may consider allowing operators to throttle or slow down such services to manage service-level quality across their users, but require that any operator who practices such traffic shaping/throttling to make public such practices, in order to enable consumers to make educated choices. This is the practice in the UK, where broadband ISPs are required by Ofcom to disclose their speed of service and traffic management principles. The TRCSL may also consider allowing operators to provide premium-tier services – e.g., a dedicated line for streaming video or other services that would benefit from prioritisation such as e-Health services. However, this ability must be subject to a non-discrimination requirement such that vertically integrated providers will not be able to unfairly disadvantage their competitors.

Finally, the TRCSL notes that these principles should apply in particular to voice services, whereby vertically integrated facilities-based operators cannot discriminate against service-based operators providing competing voice services, and consumers must be sufficiently educated on the characteristics of the voice service that they have purchased, e.g. whether it meets certain QoS requirements similar to the PSTN today, or whether it is 'best efforts', similar to Skype for instance.

4.3 Retail obligations

In addition to wholesale obligations to promote competition, it is important for the TRCSL to protect users from a lack of competition in certain markets, and also to ensure that competitive operators continue to deliver service features that may be important to consumers today. The following subsections focus both on obligations relating to tariffs, which may only be necessary for dominant operators, and also on non-price protection (such as ensuring access to emergency services even in competitive markets).

4.3.1 Tariffs

International experience has shown that, in the absence of effective competition in the market, dominant operators may have little incentive to keep their retail tariffs low. Regulatory oversight is therefore required to keep prices at a level deemed appropriate for consumers, while still allowing the operator to make a reasonable return on its investment.

In a market where competition has not developed sufficiently, it is common for tariff controls to be applied to all operators for all or specified services that they provide. Operators will be required to seek the regulator's approval before they can offer a new tariff or even a promotional tariff. The basis for tariff approval is typically the cost of service provision or some form of international benchmarking.

Currently, according tosection 5(k) of the Telecommunications Act no 25, the TRCSL haspower "to determine, the tariffs or methods for determining such tariffs, taking into account government policy and the requirements of the operators in respect of the telecommunication services provided by the operators,provided that the tariff rates, call charges and other charges in force immediately prior to the transfer date shall continue in force and shall be deemed to be the tariffs specified under the Act, until revised or amended."

Today, in practice, tariffs have to be approved by the TRCSL for all operators and all services, and restrictions can include maximum rates, to protect consumers from market power, as well as the minimum floor rates imposed on mobile operators in response to aggressive pricing by new entrants.

As competition develops in the market, a strict tariff control regime may create unnecessary delays for operators seeking to introduce new tariffs and to respond to competitive threats. In addition, such tariff control can also hamper the ability of operators to make longer-term strategic plans, as it creates uncertainty

in terms of tariff level changes and therefore future revenue streams. Finally, in a competitive market, tariff review imposes a growing burden on the regulator as the number of tariffs it has to approve increases.

One possible approach to addressing these issues is to restrict tariff control to those operators with a dominant position in the relevant market. As a result, in markets where there aredominant operators, tariff control can not only continue to play the role of consumer protection, it can also prevent dominant operators from abusing theirmarket power to harm competitors.On the other hand, competitors with no market power would not be subject to the regulatory burden of tariff control, in order to lower their regulatory burden and further foster competition.

As a particular telecoms market becomes more competitive, dominant operators may be allowed to apply for a removal of tariff approval requirements for that market.

4.3.2 Recommendations

Given that NGN is still in its infancy stage, rather than imposing tariff controls on dominant operators – which requires approval for every single tariff –the TRCSL may consider retaining the power to impose tariff controls (including reviewing any specific tariff offering) on a service-by- service basis at the initial stage. However, if the operator has SMP in a relevant legacy market such as fixed voice service, the TRCSL would consider imposing tariff controls on the related IP service (namely VoIP) until the operator does not have SMP in the fixed voice market so that dominant operators cannot evade regulation by changing the underlying technology of their service offering.

4.4 Charging mechanisms

To help identify the wide range of options available to regulators for setting charging mechanisms, it may be helpful to identify two distinct components of any charging regime:

- **Interconnection charging** concerns payments *between operators* to compensate each other for traffic exchanged between their networks. These interconnection rates are typically paid in order to enable an operator to recover the cost (either partially or fully) of carrying and terminating traffic that originates on another operator's network.

- **Retail charging** concerns payments *from consumers to operators* for services provided; from an operator's perspective, the way it sets its retail prices represents a choice about how it chooses to recover its costs from its own customers, and can potentially cover both originating and terminating calls, as well as any fixed costs and other value-added services.

In principle, the interconnection charging regime and the retail charging regime are independent.One reason for this is that typically the interconnection regime is regulated, while the retail charging regime is not regulated and instead subject to commercial decisions.However, in practice there is a link, because the operators will seek to recover their costs from interconnection and retail charging, and what can be recovered from interconnection will impact the retail charging and vice versa, as described below.

4.4.1 Definition of charging mechanisms

The following paragraphs define the types of interconnection and retail charging regimes that have arisen at this level:

· **Interconnection charging regime:**

– *Calling party network pays (CPNP)*:This regime is most commonly employed so far in traditional circuit-switched networks (fixed and mobile).Under CPNP, the network operator of the calling party pays for the whole call and the receiving party's operator receives a payment for the termination service provided to the calling party's network.

– *Bill and keep*(also known as *sender keepsall*):Under bill and keep the receiving network operator does not receive payments at the wholesale level for the termination provided. Instead, it recovers its costs incurred for termination – and any payments for upstream connectivity – by billing them to its end customers.Peering is a form of bill and keep that is common in the Internet, and in some countries bill and keep is also used for mobile calls.

- **Retail charging regime:**

– *Calling party pays (CPP)*:Under a CPP regime, consumers pay a per-minute outgoing charge and are not charged for receiving incoming calls.The termination cost is paid by the calling party's network, which covers the cost in the outgoing rate it charges its subscribers.

– *Receiving party pays (RPP)*:Under an RPP regime, consumers are charged a per-minute rate for all outgoing and incoming calls that they make. This regime is also commonly referred to as a mobile party pays (MPP) regime as it is the alternative to CPP for mobile networks in a number of countries including Singapore and the USA.

4.4.2 The link between the interconnection and retail charging regimes

In principle, the interconnection charging regime and the retail charging regime are independent. An example of this is seen in Singapore, which uses bill and keep for its interconnection regime between mobile operators, and yet there are both MPP and CPP pricing (free incoming call plans) in the retail market. Likewise, while in the USAmobile termination rates are low, mobile operators have historically chosen MPP pricing. These arrangements are possible due to the fact that, while the interconnection charging regime is regulated, the mobile retail charging regime is not.

Indeed, the retail charging regime in most jurisdictions is unregulated and hence shaped by two main factors, as shown in the figure below.

Figure 4.3: The retail charging regime is separate from, but closely linked to, the interconnection charging regime, and influenced by competitive pressures [Source: Analysis Mason]

On the one hand, the (regulated) interconnection charging regime (represented by the blue box) determines the interconnection revenues operators receive and interconnection payments they make. Operators will generally seek to recover their net costs less net termination revenues through retail charges. Thus, in countries where termination rates are fully cost-based, there is no pressure to recover termination costs through retail pricing, and where termination rates are less than cost, nominal or zero, there is a need to recover those costs through retail pricing.

On the other hand, competitive pressures (represented by the orange box) from other operators and substitute services tend to push retail prices down. In the absence of competitive pressures, operators could charge what they like on top of the cost of termination. Competition not only pushes prices down, but may also encourage operators to allocate costs to the services that cause them.

However, even in competitive markets, operators try to differentiate their services, and an operator may make a commercial decision to cross-subsidise one service with another, for example in order to attract subscribers.

International examples of this include StarHub's introduction of 'free incoming' retail call plans when it entered the market in Singapore (which started with contract plans but now even extends to prepaid subscribers) in spite of the bill and keep interconnection regime that prevents it from receiving termination revenues. Since StarHub is not able to recover termination costs from the calling party's network, it mustrecover terminating costs from elsewhere – for example through increased charges for outgoing calls, increased monthly subscription prices, increased future earnings from a larger customer base, or a daily flat rate for receiving unlimited incoming calls.

There can be significant differences for regulators, operators, and ultimately consumers between the different charging mechanisms, which is outlined below.

4.4.3 Impact on consumers

Consumers are directly impacted by the retail charging regime, and only indirectly impacted by the interconnection regime.However, as a general rule, in countries with a CPNP regime, call termination rate is not recovered from the receiving party, but rather the wholesale termination rate, which must be paid by the calling party under CPP.Likewise, under bill and keep the terminating operator cannot charge a termination rate, but rather charges its own customers for receiving calls under RPP.As a result, there can be a significant difference between CPP and RPP with respect to both usage as well as penetration, as follows.

Under CPP, the calling party is charged for the entire call, with a portion of the call charge typically passed on to the other network for termination, such that the recipient of the call does not have to pay for receiving the call.On the other hand, under RPP the call charge is typically lower, because the receiving party can recover the cost of termination from its own customer and not from the calling party.As a result, in CPP countries the retail prices for calls are the highest, and the minutes of use are lower.Conversely, in countries with low mobile retail prices, corresponding to bill and keep, usage is significantly higher than in countries with high retail prices, which are typically CPNP.

This means that bill andkeep may be associated with incentives for efficient network usage.On the other hand, the interconnection regime can have a significant impact on penetration levels, notably in mobile services.Under CPP, the cost of receiving a call is free, and as a result a prepaid phone that is predominantly used for receiving calls is very attractive and drives up penetration levels.At the same time, under CPNP a termination fee can be levied on calls from the fixed network and international calls, which can help to subsidise the cost of building the network.This lowers the costs for consumers and may also be attractive to operators, as explained below.

4.4.4 Impact on operators

In many markets, it can be seen that the interconnection charging regime has an impact on investment incentives, as the termination rates may help to subsidise deployment.At the same time, interconnection charging mechanisms may differ with regard to the incentives they produce for efficient network usage and the resulting impact on revenues.
For instance, CPNP in the form ofcapacity-based charging (CBC) may provide incentives for efficient network usage. Operators buying capacities upfront will try to exploit this capacity in an optimal way. By contrast, under an element-based charging (EBC) system, efficient network usage is less likely.If, for example, termination rates exceed marginal costs, this will lead to a suboptimal level of network usage.

On the other hand, the risk of a non-optimal level of network usage is circumvented under bill andkeep, as this system does not require efficient termination costs to be determined. Moreover, the flexibility under bill andkeep to apply different tariff schemes at the retail level may also be conducive to an efficient network usage because operators can offer tariff schemes best suited to customer needs.As describedabove, under RPP, network usage is significantly higher, which may be efficient and increase overall revenues.

4.4.5 Impact on regulators

There is no question that the regulatory burden is higher under CPNP, with regards to having to regulate the termination rates. The reason for this is that under CPNP there is a 'termination monopoly', as follows.Without regulation, the receiving network can set the cost for termination, with little incentive to keep this rate low even in a competitive retail market.The reason for this is that the termination rate must be paid in order to reach the network's subscribers, but it is paid by the subscribers of the calling network, not the subscribers of the receiving network, and thus there is little incentive to keep the termination rate low.Put differently, under CPNP, there is no market pressure to keep the termination costs low as these costs are not borne by the provider's own endusers. To the contrary, there might even be an incentive to raise rival's costs and keep wholesale prices high as a collusive device.On the other hand, bill andkeep constitutes an approach that is more closely adjusted to market mechanisms.Since the cost of making and receiving calls is charged to an operator's own customers, with no termination rate, competition will work to lower the costs of the calls in place of regulation.

As a result, many if not all regulators using CPNP have had to grapple with regulating termination rates, leading to lengthy and cumbersome regulatory and legal disputes (both between market players and NRAs but also among market players) on the appropriate level of termination rates. Such disputes increase uncertainty for the market players involved as it is difficult to invest without knowing what the termination rates will be over time.It can benoted that, having finally imposed cost-based termination rates on mobile operators, European regulators are now pushing for rates to fall significantly over time, likely to begin to deliver benefits to consumers from the resulting lower retail calling rates.[29]

4.4.6 Recommendations

The move to NGN may increase the pressure to move to bill and keep for voice services.The interconnection charging regimes for different types of service (for example, mobile voice, fixed voice, IP data) are different as a consequence of past regulation that was developed for a world where mobile and fixed networks were felt to provide distinct services because the technologies for the provision of fixed and mobile voice calls were separate; the markets for voice calls were in turn quite separate from markets for data services such as email and SMS. In addition, Internet interconnection was typically unregulated, and used peering, a form of bill and keep, which has an impact as calls begin to migrate towards VoIP technologies.

This growing and universal trend towards the adoption of IP-based technology in fixed and mobile networks, the development of fixed–mobile convergent services, and the growth of non-voice multimedia services on all networks means that the traditional distinction between fixed and mobile voice services, and between voice and data services, is likely to become less relevant in the future.As a result, there may be a movement towards having all traffic treated the same, and this may migrate to bill and keep under the Internet.Nonetheless, there is a significant impact on operators and regulators involved in migrating from CPNP to bill and keep.The TRCSL will conduct a study of the long-term impacts of a move to bill and keep, which it would likelyaccomplish by lowering termination rates over time in order to provide the industry with time to adapt to the new long-term regime.

4.5 Consumer protection

Consistent with the current regulatory requirements imposed by the TRCSL, a number of consumer-protection measures are considered to be important to extend to NGN, including without limitation:

- compliance with QoS requirements issued by the TRCSL
- unrestricted access to emergency services (service-dependent)
- advanced disclosure of all prices, terms and conditions
- periodic, accurate and timely bills
- restrictions on service termination and suspension
- procedures to address unsolicited telecoms services or equipment
- dispute resolution procedures and safeguarding of end-user service information.

[29] As a result of the high mobile termination rates formerly imposed, for many years it was cheaper to make a call from the UK to mobile subscribers in RPP countries such as the USA or Singapore than it was to call a mobile subscriber across the street.

New protections may need to account for the new role of users in an NGN environment, as customer equipment and networks will be intelligent, with many services and equipment being able to be customised by the user, for example to increase usability and accessibility.Existing and new protections are likely to be important even under a competitive market, to ensure that competitive pressures do not result in an under-provision of service quality, emergency access, and other features that consumers rely on today.

The TRCSL will also closely examine whether there is a need to impose any additional duties on dominant operators in each market. Such duties might include obligations to provide unbundled telecoms services, and to provide services to any end user upon reasonable request on non-discriminatory terms. In addition, the TRCSL sought to better understand whether the existing protection against anti-competitive consolidation is sufficient, or needs to be bolstered to prevent any loss of competitive gains in future.

The following paragraphs set out various consumer-protection concerns in the NGN environment about whichthe TRCSL is particularly concerned.

4.5.1 Access to emergency services and provision of emergency location

The TRCSL is concerned that calls to emergency services may not be adequately handled in the NGN environment. This is because VoIP servicesare dependent on mains power for their terminal equipment, and such VoIP services may not offer any access to emergency calls or reliability of the access may be affected in the event of a power cut or power failure, or failure of the broadband connection However, it should also be noted that some analogue phones use active power (such as DECT phones) which already have this problem.

Also, the nomadicity of NGNs makes it harder to link a telephone number to a particular physical location. The TRCSL recognises that emergency location information is also important to emergency services as the information is used to dispatch and monitor relevant emergency assistance. In PSTN networks, a termination point is matched with a caller's location, which can be identified from the caller line identification (CLI). For VoIP providers that do not use or assign an E.164 number as a user identifier, this capability is no longer feasible. The TRCSL therefore encourages service providers to develop solutions to overcome such technical limitations, so as to continue to supply location information to emergency services (where technically feasible), and notify consumers where it is not feasible.

4.5.2 Reducing barriers to consumer switching

The TRCSL recognises that reducing the barriers to the switching process must result in a positive experience for consumers. This will help maintain competition as it will facilitate consumers to be more willing to engage effectively in the competitive process.

More cost-efficient switching process

Switching processes should be carried out in as cost-efficient a manner as possible in order to minimise the costs on the industry and hence the prices that consumers will ultimately pay.

At an industry level, if the systems for switching have high set up costs, this might act as a barrier to entry, which could in turn have a negative impact on competition because entrants to the industry would need to achieve significant scale in order to justify upfront investment in such costly systems.

At the consumer level, high switching costs cause detriment to consumers who go through the switching process, as well as deterring consumers who are contemplating switching from embarking on the switching process. The process for recovering switching costs or new customer acquisition costs should be objectively justifiable, proportionate, non-discriminatory and transparent, and should be likely to contribute to efficient switching processes and effective competition.

Cost efficiency may be achieved by promoting an industry framework for co-operation between all relevant service providers in order to facilitate the transparent and inclusive governance of consumer switching arrangements so that these can be developed by the industry, as markets evolve, under appropriate regulatory direction. Having such a level of co-operation between all service providers involved in the switching process will facilitate consumer switching.

Uninterrupted service during switching

The switching process should minimise any unnecessary overlap of the old and new provider by avoiding unwanted service breaks which cause inconvenience to consumers. The switching process should be reliable and capable of being rectified quickly if things go wrong. In addition, consumers should not be subject to any fees imposed by the service providers as a result of the service providers' own errors during the switching.

Simple switching process

Another way to minimise unnecessary hassle for consumer switching is to have simple switching processes. Switching processes should ideally be as simple as possible for consumers because consumers have to make decisions in a communications market with many suppliers and many different contracts. The implementation of a swift process for switching service providers, via the Internet, may be useful in this respect. Consumers should be able to transfer more than one service at a time. This is particularly relevant in the context of switching to, from and between bundled services. Additionally, consumer involvement should be no more than necessary in order to ensure that the burden of switching is not unduly onerous. The process should be highly automated, with the need for manual intervention minimised.

Provision of clear information to consumers

The provision of consumer information plays a critical role in competitive markets. This is because markets work best when consumers are fully informed about what they are buying. Without this, consumers may make incorrect decisions or be reluctant to switch. In addition, complex switching processes may mean that those who start the process may fail to complete it, therefore preventing them from getting the best deals available and preventing more efficient firms from growing.

Finally, further protection may be afforded to consumers by giving them the opportunity to stop the switch where they have not given consent to the switch or where they simply wish to change their mind. There should also be a quick and reliable restoration process so that consumers switched in error can have their original service restored quickly, with minimum effort, and at no cost.

4.5.3 Privacy and security, protection of personal data

Within the context of NGN, the problems to be addressed are likely to be similar to those that already exist for legacy Internet/PSTN services, for example:

- misuse of NGNs that causes harm to consumers
- potential for fraud and identity theft
- privacy concerns and potential for misuse of personal information.

Operators will need to consider the potential security threats at every level of their network infrastructure as well as at the customer level (e.g., laptops and smartphones), in order to protect the integrity of the network. Hence, the provision of high quality of service and network security management will continue to play a critical role in the brand reputation and associated customer satisfaction in an NGN environment.

Other general consumer-protection provisions will continue in the NGN, including without limitation: compliance with QoS regulations issued by the TRCSL (see Section 3.9, which recommends having an NGN Advisory

Committee to assist the TRCSL to define certain thresholds for QoS parameters); procedures to address unsolicited telecoms services or equipment; dispute resolution procedures and, particularly, mechanisms to safeguard end-user service information (EUSI). The TRCSL will continue to work with the industry to clearly set out the means by which end users may consent to use their EUSI, the approved purposes for which EUSI can be used by a service provider, and the means by which consumers can withdraw such consent.

When considering the protection of personal data or information, the starting point for most analyses lies with rights to privacy. The right to privacy is a basic human right enshrined in the 1948 United Nation's Universal Declaration of Human Rights and the 1981 European Convention on Human Rights (Article 8). Since the 1970s, many developed countries have responded to concerns about privacy risks arising from the collection and use of personal data by relying on 'fair information principles' to govern the appropriate use of personal data. For example, such principles were laid out in the 1981 European Convention for the Protection of Individuals with regard to Automatic Processing of Personal Data, following the development of the OECD's Guidelines on the Protection of Privacy and Transborder Flows of Personal Data in 1980.

According to these principles, personal data can be collected lawfully for specific and limited purposes only, and can be stored only for as long as necessary to fulfil the purpose. Data must be accurate and adequate for the intended purposes, and individuals have a right of access to and correction of their personal data. The Convention also established special protection for data of sensitive nature, such as, for example, data on the individual's religious and political beliefs or medical records. Many of these principles have been formally adopted through data protection legislation at the national level.

4.5.4 Number portability

There are benefits which accrue to all consumers through enhanced competition made possible by number portability, by removing the cost and inconvenience of having to change telephone numbers when switching providers. Removing the cost and inconvenience of changing telephone numbers would make consumers, particularly business consumers relying on incoming calls as part of their business, less reluctant to change their service providers. The unwillingness of such consumers to change service providers poses a barrier to entry, as new entrants may be unable to gain new customers. Therefore, this cost to consumers switching to other carriers potentially inhibits efficient competitors from entering the market and creating market power for the incumbent or incumbents. In the absence of number portability, competing service providers may have to offer significantly lower prices and/or provide significantly higher quality services than the customer's existing service provider in order to compete effectively. This disincentive may discourage efficient entry and retard the promotion of competition more generally. Number portability, by reducing the costs to customers associated with changing service provider, therefore helps promote competition.

The benefits of competition will likely include lower prices for commodity services such as local voice and international long-distance calls.Customers not switching numbers can also benefit from the resultant enhanced competition, as it may no longer be necessary to change operators in order to obtain lower prices. New operators will also be more motivated to increase the efficiency of their networks and lower their cost of service to retain their existing customers, and focus on meeting their needs for both incoming and outgoing traffic. Competition enhanced through number portability is likely to result in a greater variety of products and services as operators seek to differentiate themselves in the marketplace. Operators are also more likely to discover what customers are willing to pay for, and likely to seek to more actively meet their customers' needs. While prices and consumer expenditures on new services may rise, the value received by consumers could possibly rise even more.

Number portability, by reducing the costs incurred by customers when changing service providers, will promote competition in the provision of carriage services. The ability of customers to move more freely between service providers reduces the 'lock-in' effect that providers can have over customers, as well asincreasing the pressures on firms to compete against each other in the provision of carriage services. This will most likely result in the more efficient use of telecommunications infrastructure by encouraging innovation and higher productivity.

4.5.5 Recommendations

As to whether additional consumer-protection requirements should be imposed on dominant operators, the TRCSL is of the opinion that all operators should be required to treat their consumers fairly, and therefore the TRCSL does not intend to impose any consumer-protection obligations solely on dominant operators.

Further, the TRCSL does not agree with one respondent's view that consumer-protection standards have no bearing on the implementation of NGN. Quite the contrary, consumer-protection considerations feature very strongly in most jurisdictions, particularly when designing regulatory frameworks for novel service offerings. In this case, as explained in the consultation paper, "existing and new protections are likely to be important even under a competitive market, to ensure that competitive pressures do not result in an under-provision of service quality, emergency access and other features that consumers (have come to) rely on today."

Besides the list of proposed measures set out in Section 4.5, the TRCSL may prescribe additional measures and safeguards with the migration to NGN, and emphasises the importance of ensuring that consumers are sufficiently informed of the differences between VoIP and PSTN voice services, especially in terms of the availability of emergency services and QoS.

Access to emergency services and provision of emergency location.

TheTRCSL recognises that IP-based services may face certain limitations in the provision of access to emergency services. In this respect, the TRCSL will be working with the respective service providers to explore suitable technical solutions, whilst monitoring international developments on this front. In the interim, the TRCSL will require customers to be made aware when they are using a line for which location information cannot be captured automatically (or cannot be captured accurately).

Reducing barriers to consumer switching

To reduce barriers to consumer switching, the TRCSL is considering commissioning the regular publication, by an independent body, of the price and QoSindicators for the service providers. Additionally, there needs to be clarity on the type and level of information that is made available to consumers, both at the point of sale and after the sale has been concluded, as well as clarity about consumers' key rights and choices. At a minimum, the TRCSL considers that the following information related to switching should be made available to consumers in a clear and easily accessible format:

- a brief and precise description of the switching process
- when the switch will take place
- how long the process is expected to take
- maximum time the switch will take
- roles and responsibilities of all parties involved in the switching process (including the former service provider, the new service provider and the consumer)
- progress of the switching process, and in particular where there may be significant delay in the likely date of provision, the consumer should be informed of the existence of a right of cancellation and the process for exercising it
- any fees associated with the switching process
- the potential for any loss of other services and the maximum length of time of loss of service, as well as the potential for any change to contractual conditions, namely if the service has been purchased within a bundle
- key terms and conditions of the new service, including contractual liabilities and cancellation rights.

Privacy and security, protection of personal data

The TRCSL will continuously ensure that in the NGN environment, consumer interests (such as privacy and security) will be accorded rigorous protection through regulations, codes of practices and licence conditions (where necessary). This is an area that the TRCSL will focus on in reviewing the current telecoms service licences upon their impending expiration. Separately, the TRCSL, together with the appropriate Sri Lankan authorities, will further consider whether there is a need to promulgate a broad-ranging data-protection legislation.

Number portability

In addition to the recommendations for mobile number portability set out in Section 3.8.3, to further encourage and promote the take-up of services offered through NGNs, e.g. low-cost telephony through VoIP (instead of legacy plain old telephony through the incumbent's PSTN), the TRCSL will consider implementing a roadmap to achieve full number portability (including number portability for fixed lines) to be offered by all relevant licensees. The timeline for implementation should be closely tied-in with themigration roadmap to NGN, and at this stage the TRCSL anticipates that full number portability is a long-term initiative and will be introduced in Phase III (full NGN migration).

4. 6 Regulatory aspects of migration to NGN

As indicated above in Section 4.1.2, competition in the Sri Lankan telecoms market is currently primarily facilities-based, with operators required to build their own core and access networks in order to provide specifically licensed services such as fixed voice. Further, there has traditionally been a separation between the services offered over each network, based on licence requirements.

The process of migration to NGN is likely to significantly alter these traditional divisions, with a move towards facilitating service-based competition for a variety of services over a single next-generation core network. This is expected to fundamentally change the business models for existing operators. As indicated above in Section 2.2, a key objective of NGNs is to attract and stimulate the growth of a full range of content, application and service providers that can offer retail services through the NGN infrastructure, and so avoid the need to commit substantial initial investment in their own infrastructure. To achieve this result, the regulatory framework will have to progressively evolve.

At the same time, the TRCSL appreciates that investments in NGNs involve commercial uncertainty and risks to service providers, and that clear regulatory policies may help operators reduce this risk. A particular regulatory concern arises where NGN investments and decisions are left entirely to market forces, leading to haphazard NGN development and significant duplication of infrastructure, which may ultimately bring adverse impacts on the industry as a whole. Other regulatory concerns being considered by the TRCSL in migrating to NGN include:

- Incumbents may reap the most advantages from a transition to NGN, in comparison with other operators, as they leverage on their competitive advantage in network depth and control over the transition timetable.
- The converse is also possible, where existing legacy operators lose out to low-capex new entrants in an NGN environment (e.g. VoIP operators and IPTV content retailers that can avoid the costs of deploying their own telecoms infrastructure and do not need a complex integration with the legacy network).

As many of the general changes discussed in Section 4.1 relate to licensing, the TRCSL places particular emphasis on how the current licensing structure for telecoms should be revised. The TRCSL is considering a phased approach, in accordance with the progressive phases of NGN roll-out.The proposed migration will enable the TRCSL to set in place policies in advance of the fundamental shift to NGNs, as opposed to wholly maintaining the *ex post* policies imposed on legacy networks at the time of liberalisation.In this regard, the transition process may require a three-phase migration of licences to a regulatory model that allows for flexible facilities-based and service-based competition, with particular obligations on dominant operators in relevant markets:

- **Phase 1: Legacy network** – For the remainder of their current licence terms,[30] existing legacy operators may continue to be regulated under their existing telecoms licences issued under the Telecommunications Act No. 25 of 1991 (as amended). These licences are essentially facilities-based, in which operators maintain their own core and access networks to provide licensed services. Under this phase, the *status quo* would be preserved as far as practicable.

30 Most of the legacy PSTN licences issued to existing operators will expire within the next two years.

- **Phase 2: Transition to NGN** –Upon expiry of an operator's legacy licence, the TRCSL will issue appropriate new licences to the telecoms operator (possibly, in the form of an NGN Individual Licence), allowing a licensee to offer the full breadth of telecoms and/or broadcasting services that can be carried over its own telecoms network, systems and/or facilities. In this framework, a dominant operatorframework may also be created, imposing appropriate wholesale obligations on dominant operators – including a RIO, along with interconnection obligations appropriate to all facilities-based operators. To remove some of the investment risks and uncertainty associated with a new platform, in this Phase the TRCSL will consider the interoperability issues raised in Sections 3.5 and 4.2.3. This is to address the situation where potential new entrants may be reluctant to invest in any particular technical specification, out of concern that their technical specifications may not be supported by the incumbent operator(s).

- **Phase 3: Full migration to NGN** – In line with the implementation of a wholesale regime, a separate category of service-based licences (possibly an NGN Class Licence) will be created to allow operators (particularly new entrants) to offer retail telecoms services through the lease of telecoms network elements (on a wholesale basis) from the NGN Individual Licensee. A 'lighttouch' version of the Class Licence may also be introduced for basic telecoms services involving fewer regulatory concerns. Appropriate consumer-protection obligations will be imposed on all operators, as discussed below.

The terms of the licences (upon licence renewal), and corresponding legislation, will include obligations for interconnection and interoperability of networks in order to promote entry and reduce investment risk.At the same time, during the migration of service offerings from the traditional PSTN to NGN, the TRCSL may require services provided by telecoms operators to have the following characteristics to protect consumers:

- **Continuity** – Consumers must be able to continue using the legacy services they are used to, with essentially no change, if that is what they desire. Consumers must have the ability to choose services according to their specific needs.

- **Ease of migration** – To every practicable extent, consumers must be able to migrate seamlessly to new services offered by the same network operator. The TRCSL may issue further directions to telecoms licensees requiring them to submit detailed migration plans, with a view to ensuring that consumer inconvenience is minimised and consumers are not adversely affected by any service outage or degraded call quality during or after the migration process.
- **Ease of adoption**– In order to promote take-up of services offered through the NGN, existing telecoms licensees should not impose long-term contracts with the object or effect of 'locking in' customers to their existing service providers, and so prevent them from adopting competitive services offered through the NGN.
- **Timely migration customer support** – Other than providing timely customer/technical support to address any issues flowing from the migration to NGN, any changes to services, or ways in which NGN services differ from legacy services, should also be explained to the consumer in a clear and timely manner.

Again, it should be noted that it is not the TRCSL's intention to force the migration to NGN, but it will consider introducing incentives such as tax relief in order to ease the process for operators migrating to NGN.

4.6.1 Recommendations

The TRCSL is encouraged by the fact that NGN migration is already underway for a number of operators that have already made significant investment.

As for whether the legacy networks should be allowed to run concurrently, the TRCSL considers that only the dominant service provider(s) should provide a concrete migration plan, and that other operators are free to choose based on market considerations. This is because the TRCSL expects that, when dominant operatorsmigrate to VoIP services, the non-dominant operators will follow in order to fully exploit their own NGN switches and avoid having to perform TDM conversions. However, they should not be compelled to do so, as dominant operatorsmay then factor the impact on theircompetitors when theymigrates to full NGN as it could incur costs on competitors forced to follow the migration. While today the incumbent offers only TDM interconnection, once it has migrated to NGN it should also allow IP interconnection at the choice of the non-dominant operator, and provide a timeframe for the migration to full IP interconnection, allowing operators to plan their network deployment and interconnection resources accordingly.

5 Summary of recommendations

This section presents the TRCSL's recommendations for implementing the NGN policy and regulatory framework in Sri Lanka. The recommendations made by the TRCSL are organised as follows:

- recommendations from the technical analysis (Section 5.1)
- recommendations for regulatory and legal issues pertaining to NGN (Section 5.2)
- policy prioritisation and implementation timeframes (Section 5.3).

Please note that recommendations from the technical and regulatory analysis may overlap.

5.1 Recommendation from the technical analysis

The TRCSL's recommendations regarding technical aspects of NGN are summarised below.

Access network – spectrum

The TRCSL is planning to undertake the following programme of workto establish the future NGN policy and regulatory framework regarding spectrum:

- Undertake a study programme on spectrum management including the following aspects:
  - assess the assignment of spectrum among operators and ensure that this creates a level-playing field for all operators and potential new entrants
  - assess whether sufficient spectrum has been allocated in the preferred bands for operators to implement mobile broadband solutions
  - assess the impact of the digital dividend and how spectrum could be freed up and re-allocated to mobile operators.
- Review the terms of current 3G licences and investigate options to introduce specific HSPA/HSPA+ coverage obligations, by, for example, including incentives for the future allocation of LTE spectrum in the 3G licences.

Access network – infrastructure sharing

The following actions could be taken to encourage competition in the wireless broadband market:

- encourage the sharing of mobile infrastructure (sites and towers and backhaul) between competing operators
- facilitate access to backhaul for remote sites using either USO funds or the NBN to build backhaul, or by mandating wholesale leased-line accessfrom the incumbent.

National Backbone Network

The TRCSL is of the opinion that, considering the lack of fixed infrastructure in Sri Lanka, the NBN will provide a critical national infrastructure that operators will be able to access to provide NGN services. In order to ensure that the NBN provides an environment that will foster fair competition, the TRSCL is proposing to study the following issues:

- define the optimum mix of wireline and wireless technologies for the access network
- define precisely the wholesale services in both the access network and in the core network.

Next-generation services

The TRCSL believes that OTT applications such as Google and Skype should not be discriminated against for several reasons:

- it will be difficult to control all new applications that will be made available on the Internet
- these applications are in essence different services than those offered by operators in a closed network where QoS can be controlled.

Discriminating against OTT applications such as Google and Skype would send a strong negative message internationally regarding Internet policies in Sri Lanka, and may hamper innovation and investment.

The TRCSL has now decided to permit the importation of VoIP phones to ensure all consumers have equal access to VoIP technology, irrespective of the device they use to access it.

Telecoms and media convergence

The TRCSL believes that:

- engaging with the Ministry of Media and Informationand harmonising policies to promote competition regarding the issue of accessing TV content will be key to ensuring competitionin the Sri Lankan telecoms market

- a review of the market regarding TV content should be undertaken and appropriate measures enforced if SMPwere found in this area.

NGN ***migration, interoperability and standards***

According to the consultation responses, operators in Sri Lanka are currently planning to use different standards for interconnecting their legacy networks and NGNs.

Therefore, the TRCSL considers that it has a crucial role to play in the migration to NGN, especially in ensuring there is appropriate co-ordination among all operators to ensure interoperability.

The TRCSL also considers that it can play a role in the migration to NGN by providing regulatory clarity with the forthcoming NGN regulatory framework, which will be part of the objectives of this study.

According to the TRCSL,anNGN Advisory Committee, which would comprisethe key NGN stakeholders (i.e. incumbent operators, fixed and mobile operators, and data serviceproviders), should be created to advise the TRCSL on the following issues:

- **Workstream 1**: Interconnection and standards –technical specification of standards, interfaces and performance forinterconnection of both data and voice services, taking into account the migration roadmap of all key stakeholders.

- **Workstream 2**: Naming and addressing –technical specification of standards for numbering and namingharmonisationincluding the specification of how ENUM should be implemented.

- **Workstream 3**: Security –assessment of security issuessurrounding NGN, and specification of a co-ordinated plan for Sri Lanka.

- **Workstream 4**: USO – assist the TRCSL in designing the USO programme, including defining the objectives and the mechanisms for fund raising and disbursement.

The TRCSLis also of the opinion that it should be assisted by qualified consultants to drive each of these activities and ensure that the objective of each workstream is achieved within a timeframe decided by the NGN Advisory Committee at the beginning of the implementation stage.

The TRCSL also believes that commercial issues should not be within the scope of the NGN Advisory Committee's responsibilities. In particular, the Committee should not provide a forum for the participants to effectively collude by agreeing on commercial models, such as how and what to charge for NGN services (voice or data).

In addition, in order to facilitate the creation of a flexible framework that takes into account the different nature of operators' requirements at different phases of their migration to NGN,the TRCSL will define three phases:

- Phase 1: Legacy network
- Phase 2: Transition to NGN
- Phase 3: Full migration to NGN.

These phases will be used as a reference to help prioritise the definition of technical standards for NGN interconnection made by the NGN Advisory Committee, as explained in Section 3.1.The different phases will also serve as a reference for the implementation of different licence obligations to ensure that, at any time, operators are encouraged to invest and that competition is maintained.

Interconnection

The TRCSL recommends the adoption of an independent not-for-profit IXP for the exchange of local data Internet traffic. Since this would be a 'meet-me point', the TRCSL believes that the same sites couldbe used for both NGN voice (PSTN) and data interconnection, with appropriate licence modifications to allow VoIP to be exchanged in the IXP in addition to data.The TRCSL considers that it should be mandated for dominant operators[31] to interconnect at the IXP.This will provide other operators with the opportunity to interconnect at the IXP with dominant operators[31] if alternative operators believe it is more cost-effective for them to do so.A virtual IXP could be created, linking nodes in a number of data centres together, but the optimum number of such virtual interconnection points is subject to further study.These nodes could be connected by the NBN to provide transport between the data centres.

In line with the consultation responses, the TRCSL considers that peer-to-peer (peering) interconnections should still be permitted, especially if two operators agree on the technical standards and commercial terms to be used during Phase 2 of the migration to NGN.

One of the NGN Advisory Committee's core functions should be to assist the TRCSL to co-ordinate the development of the technical interconnection standards to ensure interoperability between all operators in Sri Lanka, and also to assist the TRCSL in determining the optimum number of virtual interconnection points.

QoS

The TRCSL believes that the industry-led NGN Advisory Committee would be uniquely placed to assist the TRCSL in specifying QoS parameters (such as delay, jitter, packet loss and bit error rate), as well as best-practice thresholds for the defined parameters.

During Phase 2 of the migration to NGN, the TRCSL does not recommend any active monitoring of these parameters, nor their enforcement by a third party as it may introduce some complexity in the migration process and delay the transition to NGN.However, the TRCSL is planning to enforce active QoS monitoring during Phase 3(full NGN migration).

The TRCSL also recommends that service transparency be introduced for the incumbent (*e.g.* how the service will be provisioned).

[31] If the market study reveals that there is a document operator(s) in the interconnection market.

Security

The TRCSL strongly believes that security is a very important issue in NGNs and, since all NGNs will ultimately be interconnected, a co-ordinated approach to security at the national level is required.

The NGN Advisory Committee should assist the TRCSL in supporting the development of national NGN security policies and recommend a set of security standards and architectures that would be enforced by the TRCSL to ensure security at a national level, especially if an independent IXP is created.

Numbering and addressing

The TRCSL is planning to issue a public consultation on numbering an addressing, focussing on the following topics:

- numbering plan
- implementation of ENUM.

The TRCSL will consult with key stakeholders on this issue and formulate a new numbering plan that will be compatible with the NGN environment. The consultation should aim to understand from key stakeholders in Sri Lanka what will be the demand for non-geographical numbers.

The TRCSL agrees with the consultation responses that ENUM has to be considered when devising the regulatory policy for NGNs as it will provide essential translation between legacy E.164 numbers and IP/SIP addresses. The implementation of ENUM requires a significant amount of collaboration between operators, as elements of the technical solutions are owned by operators themselves and other elements (located in the IXP domain) of the solution could be owned by a third party, in the same way as DNS domainsare operated today.

The TRCSL believes that the response to the naming and addressing consultation will providesolid background to the NGN Advisory Committee to advise the TRCSL on this topic.

Also, the TRCSL is planning to undertake a consultation process regarding mobile number portability in the short term.The TRCSL considers that number portability is a key factor in promoting competition, as a significant number of consumers are reluctant to take the expense and risk of changing their numbers. In the longer term (i.e. Phase 3 of the NGN migration),the TRCSL will consider the introduction of full number portability (for both fixed and mobile) also through a consultation process.

1.2 Recommendation for regulatory and legal issues pertaining to NGN

The TRCSL recognises that new regulations, based on international best practices, will generally foster an increase in competition and service availability, whilst facilitating the migration to NGN.The main recommendations made by the TRCSL in this regard are provided below.

Asymmetric regulation

- Issue a consultation on the topic of implementing asymmetric regulation, including the definition and assessment of dominance and resulting remedies, including wholesale access.

- Commission a further study on the competitiveness of all markets, investigate forms of asymmetric regulation, and ultimately formulate a framework of asymmetric regulation based on international best practices with elements that can be incorporated into the new licences in an NGN environment.One approach may be an entity-based approach, which exempts dominant operators from asymmetric regulation in markets already found to be competitive, while also retaining the ability to regulate wholesale termination even in markets where there is retail competition.

- Ensure that appropriate *ex post* remedies are in place where dominant operatorsare deemed to have SMP.

Licensing

- Maintain a two-tier licence structure comprising of individual and classlicences, which is technology-neutral and flexible.
- Concurrent with the review of the licensing structure, consider the relevant competition rules, investigation and enforcement powers under the empowering legislation.
- Conduct industry consultation focussing on the specific obligations for each category of licences required in an NGN environment, prior to the renewal of licences, and make the necessary modifications to licence conditions (upon renewal) to facilitate a smooth migration to NGN.
- Ensure that licence obligations are applied homogenously across the same licence category, except for dominant operators.

Universal Service Obligations

- Conduct a USO public consultation to seek inputs on the appropriate design of a USO programme including the following elements:
  - — determine the goals of universal service funding
  - — determine the necessary funds to meet the objectives
  - — design a funding mechanism that can meet the requirements set forward by the goals
  - — design a disbursement mechanism of the USO funds.

- Design the USO programme with the assistance of the NGN Advisory Committee.

Interconnection

- Impose obligations on dominant operators in the NGN, including mandating interconnection and requiring dominant operators to publish a RIO setting out prices, terms and conditions upon which theywill provide wholesale services to a competitor.

- Incorporate amendments for wholesale obligations into the existing Interconnection Rules 2003 (rather than constituting a totally new set of rules).

- Issue guidelines regarding services and pricing methodology to be incorporated into the RIO, and give final approval for any RIO issued by dominant operators. The TRCSL will act as an adjudicator to resolve disputes over the terms of a RIO or in situations where no agreement can be reached.

- Scale back on the role of regulating interconnection between non-dominant operators, and instead rely on market forces and commercial negotiations to foster agreements, but, nonetheless, maintain close regulation over mobile termination rates.

Wholesale access

- As part of the imposition of asymmetric regulation, discussed above:
  - — conduct a market review to identify the relevant wholesale services
  - — determine the wholesale obligations to be imposed on dominant operators for the legacy network and in the NGN, e.g. bitstream access, core network for leased lines and international access.
- Actively facilitate wholesale access which results in the lowering of costs of entrants and which increases retail competition.

Technology neutrality and net neutrality

- For technology neutrality, the TRCSL will ensure that regulations are applied to similar services regardless of the underlying platform.
- For net neutrality, the TRCSL is planning to provide flexibility for the ISP, while ensuring that it cannot discriminate against any individual provider or class of service. In particular:
  - — allow operators to throttle or slow down certain types of services to manage service-level quality across their users, requiring at the same time that any operator that practices such traffic shaping/throttling makes public such practices, in order to enable consumers to make informed choices

— allow operators to provide premium-tier services, subject to a non-discrimination requirement such that vertically integrated providers will not be able to unfairly disadvantage their competitors.

Tariffs

- Relax tariff control in general and only apply tariff control to dominant operators if a market study finds dominance in a particular market. The TRCSL strongly believes that it should abstain from imposing tariff control across the board particularly for NGN services. Instead, the TRCSL will retain power to impose tariff control on a service-by-service basis, and only where the operator is found to be abusing its market power to harm competition.

Charging mechanisms

- The TRCSL recognises that in the longrun, as voice traffic moves to the Internet, harmonisation of charging mechanisms will be important. In the short term, the TRCSL will conduct a study of the impacts of a move to bill and keep, which it would accomplish by lowering termination rates over time in order to provide the industry with time to adapt to the new long-term regime.

Consumer protection

- The TRCSL considers that consumer protection should apply to all operators providing a relevant service, rather than just to dominant operators.
- The TRCSL is to collaborate more closely with existing telecoms consumer associations to better understand the requirements and issues of end users and ensure that:
  - information relating to consumer-switching processes are made available by the respective service providers in a consumer-friendly format
  - advertised broadband speeds are not exaggerated and in line with what end users can expect in practice
  - consumers better understand prices vs. quality for voice and broadband service offered by each operator to ensure consumers can make an informed decision
  - consumers are treated fairly by their operators
  - consumer interests are accorded rigorous protection through, for example, a broad ranging data-protection legislation.
- Ensure consumers have access to emergency services in the NGN environment by working with service providers to develop solutions to overcome technical limitations. Meanwhile, require that customers are made aware when they are making a call for which location information cannot be captured automatically or accurately.

Regulatory aspects of a migration to NGN

The transition process may require a three-phase migration of licences to a regulatory model that allows for flexible facilities-based and service-based competition, with particular obligations on dominant operators in relevant markets:

- **Phase 1: Legacy network** – For the remainder of their current licence terms,[32] existing legacy operators may continue to be regulated under their existing telecoms licences issued under the Telecommunications Act No. 25 of 1991 (as amended). These licences are essentially facilities-based, in which operators maintain their own core and access networks to provide licensed services. Under this phase, the *status quo* would be preserved as far as practicable.
- **Phase 2: Transition to NGN** –Upon expiry of an operator's legacy licence, the TRCSL will issue appropriate new licences to the telecoms operator (possibly, in the form of an NGN Individual Licence), allowing a licensee to offer the full breadth of telecoms and/or broadcasting services that can be carried over its own telecoms network, systems and/or facilities. In this framework, a dominant operator framework may also be created, imposing appropriate wholesale obligations on dominant operators – including a RIO, along with interconnection obligations appropriate to all facilities-based operators. To remove some of the investment risks and uncertainty associated with a new platform, in this phase the TRCSL will consider the interoperability issues.

[32] Most of the legacy PSTN licences issued to existing operators will expire within the next two years.

- Phase 3: Full migration to NGN – In line with the implementation of a wholesale regime, a separate category of service-based licences (possibly an NGN Class Licence) will be created to allow operators (particularly new entrants) to offer retail telecoms services through the lease of t**elecoms network elements (on a wholesale basis)** from the NGN Individual Licensee. A 'light touch' version of the Class Licence may also be introduced for basic telecoms services involving fewer regulatory concerns.

1.3 Policy prioritisation and implementation timeframes

The recommendations proposed by the TRCSL regarding the NGN policy and regulatory framework,indicatingprioritisation and timescales for each of these recommendations are provided below. There are four categories of recommendations:

- Higher priority, shorter timescale – Recommendations in this category should be addressed with some urgency, and can be done using targeted policies under the current framework.

- Higher priority, longer timescale – Recommendations in this category should be addressed with some urgency, but will either require more time-consuming changes, or can be done in a longer timeframe.

- Lower priority, shorter timescale – Recommendations in this category can be addressed with less urgency than the higher categories, but can also be implemented relatively quickly under the current framework and thus may be relatively straightforward to implement.

- Lower priority, longer timescale – Recommendations in this category do not take precedence over recommendations in any of the other categories. Their implementation, while beneficial for the process of convergence, is either not quite as critical to its progression as the other recommendations, or is not quite as effort-effective as the other recommendations.

The order of implementation or specific timescales for each of these recommendations is a function of the capacity and time that the regulatory authorities have available. If sufficient resources are available, it is possible to implement the majority of these recommendations in parallel or in rapid succession. However, this situation is unlikely, and as such the diagram below intends to provide a relative indication of the implementation times for each recommendation. Shorter timescales indicate potential implementation timeframes within a year or two (although the actual times will vary as the specific issues are investigated and addressed in detail).

Figure 5.1: Priorities and timescales of recommendations [Source: Analysys Mason]

In summary, in order to prepare for the transition to NGN networks, the TRCSL is planning to issue public consultations of the following topics:

- asymmetric regulation and wholesale access
- universal service obligations
- addressing and numbering (including ENUM and IPv6)
- mobile number portability.

Also, the TRCSL is considering to undertake the following studies:

- implementation of a not-for profit IXP
- spectrum management reform, considering LTE spectrum requirements and digital dividend
- USO programme, in collaboration with consumer associations and with the NGN Advisory Committee
- consumer-protection framework, in collaboration with consumer associations.

Finally, in order to renew the current operator licences which are expiring, the TRCSLwill:

- validate the recommendations to be included in the new licences
- decide what framework would be feasible to implement these new licences
- implement this framework in a relatively short timescale (six months), which will be challenging and will require significant legal support.

Annex A International case studies

As part of this consultation, a number of case studies have been developed to identify international best practice regarding migration to NGN. Five countries were reviewed: the United Kingdom, Ireland, India, Singapore and Australia.

A.1 United Kingdom

Introduction

Overall, the UK has seen widespread growth in broadband in the past few years.At the end of 2009, there were over 18 million high-speed Internet subscribers in the country, making it the world's fifth largest broadband market.

The incumbent, BT, is in the process of migrating its entire PSTN to a single NGN capable of handling the next generation of converged, multimedia communications services, known as the 21st Century Network (21CN). This network will allow high-speed Internet access, TV and VoIP on both fixed and wireless networks. At the end of June 2010, BT had enabled roughly 55% of exchanges, and expects to connect approximately 75% of households by the end of 2011. In addition to 21CN, BT also announced plans in July 2008 to invest GBP1.5 billion to rollout a fibre-based network capable of delivering speeds of up to 100Mbit/s.

Virgin Media has also rolled out increased broadband speeds in its fibre network, announcing plans to offer speeds of up to 200Mbit/s by 2012, and eventually 400Mbit/s over its existing network using a combination of DOCSIS 3.0 technology, channel bonding, and the introduction of a new cable modem to handle increased speeds.

Regulatory developments

BT was functionally separated in 2005 when the company provided a series of undertakings to the regulator Ofcom, designed to address concerns about investment and competition. A separate company, Openreach, was created to provide most of BT's wholesale products on an equivalence-of-inputs basis. The separation is widely considered to have been a success. As of 2009, 30 companies were offering unbundled services to homes and small businesses in the UK. In October 2010, Ofcom issued a decision requiring BT to virtually unbundle its new fibre lines, at prices set by BT, in order to allow other companies to offer super-fast broadband. In order to promote investment in competing infrastructure, the regulator will require BT to provide access to its underground ducts and telegraph poles.

The *Digital Britain* report published in June 2009 detailed proposals for improving and expanding the national's digital infrastructure, and contained more than 20 separate recommendations, including specific proposals on NGNs. An NGN consultation in July 2009 revealed that existing regulatory priorities for NGNs remained the same: providing incentives for efficient investment in NGNs, promoting effective competition based on NGN infrastructure, and protecting consumers from disruption during the transition to NGNs. In particular, the *Digital Britain*report recognises that NGA deployment is commercially viable for only 66% of the UK population, and that for the remaining 33% of the population a form of government subsidy was required to help operators deploy NGA in these areas. To address the above issue, the *Digital Britain* report suggested that a next-generation fund be required and could be raised by imposing a tax on all fixed lines. However, the new tory government elected in May 2010 decided that a tax on all fixed lines would not be a fair outcome for telecoms consumers, and is currently looking at new options for raising the next-generation fund.

Furthermore, NICC recently delivered two releases of an entirely new suite of interconnection standards for IP interconnection. Though BT's 21CN, which was originally intended for voice services, is moving quickly towards IP interconnection, revised plans mean that TDM and IP will co-exist for the foreseeable future and other operators may be forced to lead the adoption of IP interconnection.

It is also interesting to note that Ofcom has decided to clear the 800MHz spectrum in order to align with other European countries. The total amount of cleared spectrum is around 128MHz. Ofcom intends to auction the 800MHz spectrum later on this year. Ofcom believes that the 800MHz spectrum will be particularly valuable for next-generation wireless service providers and operators.

A.2 Ireland

Introduction

In December 2008, the Irish government announced that Hutchison 3G, the mobile operator, was the successful tenderer for the implementation of the National Broadband Scheme (NBS). The NBS provides broadband access to customers in areas that are deemed to have insufficient access to high-speed services, which represent 223 000 households and businesses. With the NBS, subscribers can expect wireless download speeds of up to 1.6Mbit/s and satellite download speeds of up to 1Mbit/s.

At the end of March 2010, Ireland was home to more than 1.54 million broadband subscriptions, with household penetration at 66%. It is noteworthy that due to the rural nature of the country, 40% of broadband connections are provided via wireless access networks (mobile broadband 35%, fixed wireless access 5%). The regulator ComReg has become aware that growth in the telecoms sector is slowing down and voice and data revenues have also taken a downward turn. The incumbent and former monopoly operator eircom has been attempting to protect its leading position in the sector.

eircom rolled out 125 digital exchanges in the early part of 2009 to increase its total to 680, and also launched a new information portal that details NGN deployments and roll-out schedules. eircom has invested EUR60 million in upgrading parts of its core network to handle IPTV and provide a minimum 8Mbit/s download speed.

Other providers are also emerging, primarily to champion alternative forms of broadband access based on wireless technology.AirSpeed Telecom was awarded 10.5GHz radio spectrum in July 2009 to roll out 10Mbit/s services for business users in these countries, allowing them to access high-capacity bandwidth services with fast, uncontended Internet, data and voice applications. Imagine Communications, in partnership with Motorola, has also rolled out a quasi-national 4G WiMAX network.

Regulatory developments

The roll-out of NGNs has been a priority for the regulator. In July 2009, ComReg warned that the implementation of a cohesive national ultra-high-speed network could take three to five years to complete, during which time Ireland was in danger of being left behind in the smart-economy race. ComReg commissioner Alex Chisholm stated that a timely roll-out of very high-speed broadband networks in Ireland 'should not be taken for granted', given the potentially multi-million pound deployment costs in achieving the goal. He claimed that ComReg would do everything in its power to facilitate co-operation among operators in their plans to roll out high-speed networks capable of connection speeds of 25Mbit/s and above. To that end, ComReg has ordered that unbundled broadband connection costs be lowered from EUR8.41 to EUR0.77, and has awarded spectrum for fixed wireless services, including WiMAX.

In June 2010, eircom announced the launch of two large-scale, open-access and ultra-fast broadband fibre pilots passing up to 10 000 residential and business customers in Wexford town and Sandyford, Co. Dublin. In July 2010, eircom held bilateral meetings with industry and, together with ComReg, established the Industry Engagement Group to facilitate wider dialogue and co-operation with industry. In November 2010, eircom extended the pilots to include 8000 FTTC customers in two exchanges in Dublin.

Finally, it is worth noting that, in December 2010, ComReg published a consultation paper regarding the release of the 800MHz, 900MHz and 1800MHz bands.[33]

A.3 India

Introduction

NGN deployment in India remains in its infancy. Though the country has ~18.6 million Internet subscribers, fixed broadband penetration remains extremely low, and at the end of 2010 stood at 0.9%, up from 0.4% in 2008. While there has been some migration to NGN technologies in the core networks owned by the fixed incumbents, it will take many years to fully transition to NGN. Newer technologies (WiMAX and 3G) have recently been deployed, but the transition to NGA is critically dependent on variables such as the success of alternate access technologies (WiMAX and LTE) and the unbundling and market success of triple-play services which are now being offered by integrated operators.

In December 2010, the Indian regulator, the Telecom Regulatory Authority of India (TRAI), released the much-anticipated recommendations on a national broadband plan. TRAI has recommended the establishment of an optical fibre-based national broadband network for backhaul and access networks both in urban and rural areas. The objective set by TRAI for the national broadband plan is to provide 10Mbit/s FTTH in the top 63 cities, 4Mbit/s FTTC in other cities/ towns (352 cities) and 2Mbit/s access in towns/villages by 2014. The national broadband plan is targeting 75 million broadband connections (17 million DSL, 30 million cable and 28

[33] From mid-2011, the regulator plans to auction spectrum in the 800MHz, 900MHz and 1800 MHz bands, following the expiry of licences. Licence conditions for these bands will be both technology- and service-neutral.

million wireless broadband) by 2012, and 160 million broadband connections (22 million DSL, 78 million cable and 60 million wireless broadband) by 2014.

TRAI has estimated a total investment of approximately USD13 billion to deploy this network and suggested funding support from the Universal Services Obligation Fund (USOF) along with central government loans. According to TRAI, 2.9 million kilometres of optical fibre will be required to be deployed across urban and rural areas. To execute this deployment of optic fibre across the country, TRAI has also proposed establishment of the National Optical Fibre Agency (NOFA), fully owned by the central government, and State Optical Fibre Agencies (SOFA), jointly owned by central and respective state governments (51%:49%).

In addition to TRAI's recommendations on the national broadband plan, the Confederation of Indian Industry (CII), a leading Indian industry association, released a white paper in December 2010, developed by Analysys Mason, focussing on deployment models and required investments for developing rural broadband infrastructure in India. The study recommends a mix of optical fibre (backhaul) and wireless (access) network for providing broadband services in rural areas. According to this study, around 301 000 RKms of additional optical fibre deployment will be required for developing the rural backhaul network, and around 37 250 base stations will be required to provide wireless-based broadband access in rural areas, with an investment of USD8.6 billion. The study also recommends adoption of an operator-led public–private partnership (PPP) model for fibre backhaul infrastructure deployment and a reverse auction or direct subsidy to end users for access infrastructure. These recommendations, in conjunction with TRAI's proposal, are currently being used by the Ministry of Telecom/DoT as the reference point from which an executable policy and action plan are being developed along with key industry participants.

Regulatory developments

In January 2008, TRAI released recommendations on the growth of broadband, making WiMAX and 3G frequencies available for high-speed service, allowing cable TV operators to deploy broadband over their networks, and creating a USO fund to provide subsidies for providing broadband services. Provisions were also made for IPTV services – with telecoms operators owning licences to provide triple-play services, and ISPs with a significant net worth being allowed to provide IPTV services without additional licences.

India's USO framework, which is codified in the Indian Telegraph Act 1885, was adopted in 2002. In 2006, the government extended existing obligations to enable support for broadband connectivity and mobile services by 'eligible operators'.

In 2008, spectrum in the 2.5GHz band was allocated to public-sector operators, MTNL and BSNL, for offering broadband services. BSNL and MTNL have already started deployment of a WiMAX-based network across India.

In May 2010, TRAI released a paper advising the government on spectrum allocation policy. It recommended, inter alia, that the 700MHz band should be reserved for LTE.

The spectrum auction for 3G was completed in May 2010 and was allocated on a regional basis. In India, there are 22 regions or 'circles'. The main winners of the 3G auction included BhartiAirtel (13 circles), Reliance (13 circles), Aircel (13 circles), Idea Cellular (11 circles), Vodafone (9 circles), Tata Teleservices (9 circles) and STel (3 circles). Also, two slots of 20MHz each of TDD-based BWA spectrum in the 2.3MHz band (for WiMAX and TD-LTE) was successfully auctioned in June 2010.The six winners were Reliance Infotel (all 22 circles), Aircel (8 circles), Tikona (5 circles), Qualcomm (4 circles), BhartiAirtel (4 circles) and Augere (1 circle). It is interesting to note that four of the country's leading mobile operators – Reliance Communications, Vodafone, Tata Teleservices and Idea Cellular – had backed out of the BWA auction midway on grounds that the intensity of bids had driven the price of the BWA spectrum 'beyond rational levels'.

A.4 Singapore

Introduction

Singapore is one of the most connected cities in the world, with some surveys reporting that up to 99% of the population is covered by broadband networks. Singapore is currently in the process of deploying a national NGN, the Next Generation National Broadband Network (NGNBN).

The government has separated the deployment of the NGNBN infrastructure into two layers: active and passive. Following an RFP process, OpenNet was selected as the 'NetCo' with responsibility for deploying the network's passive infrastructure. OpenNet is a consortium of SingTel, AxiaNetMedia Corporation, Singapore Press Holdings and SP Telecommunications. Following a similar RFP process, Nucleus Connect (a wholly owned subsidiary of StarHub) was selected as the official 'OpCo' with responsibility for deploying active infrastructure and offering wholesale services to retail service providers. The roll-out of both the NetCo and OpCo are subsidised by the government up to USD590 million (SGD750 million) and USD196 million (SGD250 million), respectively. Alternative OpCos can enter the market and take wholesale passive services from OpenNet, although they will not have access to any government subsidy. From 1 January 2013, both OpenNet and Nucleus Connect will have a USO.

The deployment of the NGNBN is well underway. By the end of 2010, 60% of homes and offices were covered, and coverage is expected to reach 95% of homes by the middle of 2012. Installation charges from OpenNet for home and building owners will be waived when the network first reaches their location.

Nucleus Connect announced that it had commenced commercial operations in August 2010, offering wholesale services of up to 1Gbit/s. Five retail service providers (RSP) have so far signed up to offer broadband services through the NGNBN.[34] Wholesale prices from Nucleus Connect for an active end-user connection are SGD21 per month for a 100Mbit/s residential connection, and SGD75 per month for a 100Mbit/s non-residential connection. Retail service providers also have to pay additional recurring charges to Nucleus Connect for the carrying and handover of traffic in the core network.

Singapore's 'Intelligent Nation 2015' (iN2015) project intends to ensure that the copper access network, linking businesses, schools, hospitals and homes, is replaced by fibre by 2015.

Regulatory developments

In early 2010, the Info-communications Development Authority of Singapore (IDA) released a consultation paper on spectrum allocation for 4G services. It acknowledged that releasing spectrum in the 700MHz band for 4G services was, at present, difficult without regional co-ordination and would be subject to further discussions and consultation. However, it did propose that the 2.5/2.6GHz be useable for LTE until the rights expire in 2015, at which point the IDA proposed that they should be reassigned for 4G services. The IDA also indicated that any of the existing mobile band (PCMTS) can be used for 4G technology, as long as the PCMTS services remain provided.

In August 2010, the Ministry of Media and Information, Communications and the Arts released a consultation paper on proposed changes to the Telecommunications Act. Authorities have recognised that with increasing convergence there will be a need to maintain competition due to the probability of such services been

[34] http://www.nucleusconnect.com/workAndPlay.php?navid=4&itemID=16

transmitted over a small number of networks. The draft Bill includes a 'Special Administration Order', enabling the Minister to control a licensee's business when the public interest is at stake. It also empowers the Minister to direct structural or functional separation in case of future potential bottlenecks in the telecoms service market chain.

A.5 Australia

Introduction

In 2008, the Australian Competition and Consumer Commission (ACCC) announced the National Broadband Network (NBN) project, in which the state would invest AUD47 billionto oversee the construction of a new high-speed fibre-optic network that would cover 98% of the country. Bids were submitted, but the government rejected all of them, electing instead to create a new public–private company, NBNCo, that would oversee the project. The regulator has stated that speeds of up to 100Mbit/s will be made available to roughly 90% of homes, utilising FTTH technology, and that the remaining 10% of homes (primarily in remote areas) will receive speeds of up to 12Mbit/s. The network will operate on a wholesale-only, open-access basis with retail services being provided by separate, third-party operators.

Two key issues are currently facing Australian policy makers:

- the migration of existing copper customers onto the new fibre network
- the re-use of Telstra Telecom's infrastructure such as ducts and poles to lower the cost of the NBN.

NBNCo. is currently in negotiations with Telstra regarding both of the above issues. It is understood that the cost to the government to both gain access to Telstra Telecom's existing infrastructure and for the migration of existing broadband users to the NBN will be in the region of AUD11 billion.

Regulatory developments

In June 2010, Telstra Telecom, the government and NBN Co. reached Heads of Agreement to pave the way for the structural separation of Telstra Telecom into retail and wholesale arms.
The government has since introduced the Telecommunications Legislation Amendment (Competition and Consumer Safeguards) Bill 2010. This legislation provides for a post-Telstra Telecom regulatory environment.

In February 2010, the government released the National Broadband Network Companies Bill 2010. This legislation establishes the parameters of NBN Co. and formalises the government's commitment to sell the company in five years' time. The second Bill, Telecommunications Legislation Amendment (*National Broadband Network Measures – Access Arrangements*) specifies the terms of supplying wholesale services through the nation's fibre-optic network. In order to support the transition to the NBN, the government announced USO reforms, including the establishment of USO Co., a new entity that will address NBN-specific concerns such as migration of voice-only customers to fibre services, as well as more traditional USO functions. In October 2010, the government issued a discussion paper on USO and the proposed reforms.

In October 2010, the Australian Media and Communications Authority (ACMA) released a discussion paper on the 700MHz band. ACMA stated that it believes 'that the most likely configuration for this spectrum is for mobile telecoms services'. An auction for this spectrum will be held in 2012 with the spectrum becoming available in 2013. The government also acknowledged the likelihood of auctioning the 2.5GHz band for mobile broadband, LTE in particular, in 2012–2013.

Annex B Glossary of terms

3GPP	Third Generation Partnership Project.
ACCC	Australian Competition and Consumer Commission.
ACMA	Australian Media and Communications Authority.
ACR	Anonymous Communication Rejection.
ADSL	Asymmetric Digital Subscriber Line. A digital technology that allows the use of a copper line to support high bandwidths in one direction and a lesser bandwidth in the other.
AOC	Advice of Charge.
AS	Autonomous System.
ATM	Asynchronous Transfer Mode. A standard for cell-based high-speed data communications.
Bitstream access	A wholesale packet-based transport service.
Bottleneck	The part of a network where the economics of building alternative networks are such that effective competition is unlikely to emerge.
BPO	Business Process Outsourcing.
Broadband	A data connection defined as 'always-on', and capable of providing a download speed of a minimum of 256kbit/s.
Bundling	Linking the purchase of one product or service to another, either by selling as a package, or through the use of discounts for joint purchasing.
BWA	Broadband Wireless Access.
Capex	Capital expenditure
CB	Communication Barring.
CBC	Capacity-Based Charging.
CCBS	Completion of Communications to Busy Subscriber.
CDIV	Communication Diversion.
CDMA	Code Division Multiple Access. Family of mobile telephone access standards originated from the Interim Standard 95 (IS-95), which was developed by Qualcomm.
CLI	Caller Line Identification.
Contention ratio	The contention ratio is the ratio of the potential maximum demand to the actual bandwidth. The higher the contention ratio, the greater the number of users that may be trying to use the actual bandwidth at any one time and, therefore, the lower the effective bandwidth offered, especially at peak times. [Source: Ofcom]
Core network	The centralised part of a network, characterised by a high level of traffic aggregation, high-capacity links and a relatively small number of nodes.
COS	Class of Service. E.g. committed access rate (CAR), waited random early detection (WRED), waited fair queuing (WFQ) in context of MPLS.

CPE	Customer Premises Equipment.
CPNP	Calling Party Network Pays.
CPP	Calling party pays.
CW	Communication Waiting.
DBNO	Digital Broadcast Network Operator.
DIY	Do It Yourself.
DNS	Domain Name System.
DSL	Digital Subscriber Line.
DSLAM	Digital Subscriber Line Access Multiplexer.
DSO	Digital Switch-Over.
E.164	E.164 is an ITU-T recommendation which defines the international public telecoms numbering plan used in the PSTN and some other data networks. It also defines the format of telephone numbers.
EBC	Element-Based Charging.
ENUM	Electronic Numbering. A suite of protocols to unify the telephone system with the Internet by using E.164 addresses with DNS and IP addressing system.
EUSI	End-User Service Information
Ex ante	Before an event takes place.
Ex post	After an event takes place.
FDD	Frequency division duplex.
FM/AM	Frequency Modulation/Amplitude Modulation. Radio modulation schemes that differentiate signals by varying their frequency or amplitude respectively.
Frame relay	Legacy data network technology.
FTTC	Fibre to the Cabinet.
FTTH	Fibre to the Home. It refers to a broadband telecoms system based on fibre-optic cables and associated optical electronics for delivery of multiple advanced services such as the triple play of telephony broadband Internet and TV to homes and businesses.
GSM	Global System for Mobile communications. This is the most popular standard for mobile telephone access in the world.
HFC	Hybrid fibre coaxial
HSDPA	High Speed Downlink Packet Access.
HSPA	High Speed Packet Access.
HSUPA	High Speed Uplink Packet Access.
ICT	Information and Communications Technology.
IDA	Info-communications Development Authority of Singapore.
IEEE	Institute of Electrical and Electronics Engineers.
IETF	Internet Engineering Task Force.

IMS	IP-based Multimedia Sub-system.
IP	Internet Protocol. The packet data protocol used for routing and carrying messages across the Internet and similar networks.
IPTV	Internet Protocol Television.
ISDN	Integrated Services Digital Network.
ISP	Internet Service Provider.
ITU	International Telecommunication Union.
IX	Internet Exchange.
IXP	Internet Exchange Point.
LLC	Local Leased Circuits.
LLU	Local Loop Unbundling. A process by which the incumbent's direct exchange lines (DEL) are used fully or shared by other operators. This enables other operators to provide various services to customers.
Local loop	The access network connection between the customer's premises and the local exchange or remote switching unit, usually a loop comprising of two copper wires.
LTE	Long Term Evolution.
MCID	Malicious Communication Identification.
MDF	Main Distribution Frame. The equipment where local loops terminate and cross-connection to competing providers' equipment can be made by flexible jumpers.
MGW	Media Gateway.
MPLS	Multi-Protocol Label Switching. A technology-agnostic protocol used in NGNs to help ensure quality of service (QoS) especially for real-time applications. MPLS is a standards-approved technology for speeding up network traffic flow and making it easier to manage. MPLS involves setting up a specific path for a given sequence of packets, identified by a label put in each packet, thus saving the time needed for a router to look up the address to the next node to forward the packet to. MPLS is called multiprotocol because it works with the IP, ATM and frame relay network protocols. With reference to the standard model for a network (the open systems interconnection, or OSI model), MPLS allows most packets to be forwarded at the layer 2 (switching) level rather than at the layer 3 (routing) level.
MPP	Mobile Party Pays.
MSAN	Multi-Service Access Node. A common access point of presence (PoP) for providing different services.
MWI	Message Waiting Indication.
NAP	Network Access Points.
NAS	Network Access Server.
NAT	Network Address Translation.
NBN	National Broadband Network.
NBS	National Broadband Scheme.
NGA	Next Generation Access.

NGN	Next Generation Network.
NGNBN	Next Generation National Broadband Network.
NICC	Network Interoperability Consultative Committee (UK).
NRF	New Regulatory Framework.
NTE	Network Termination Equipment.
NTSC	National Television System Committee. North American broadcast TV standard.
Ofcom	Office of Communications. The converged regulator for the communications industries, created by the Communications Act in the UK.
OIP	Originating Identification Presentation.
OIR	Originating Identification Restriction.
OLT	Optical Line Termination.
ONT	Optical Network Termination.
Opex	Operational expenditure.
OSI	Open Systems Interconnection.
OTT	Over The Top.
P2P	Point to Point.
PAL	Phase Alternate Line. European broadcast TV standard.
PON	Passive Optical Network.
PoP	Point of Presence. A network location where access can be obtained by a third party.
PPP	Public-Private Partnership.
PSTN	Public Switched Telecommunications Network.
PVR	Personal Video Recorder.
QoS	Quality of Service.
RIO	Reference Interconnection Offer.
RPP	Receiving Party Pays.
RSP	Retail Service Provider.
SBC	Session Border Controller.
SDH	Synchronous Digital Hierarchy. A transmission standard widely used for leased-line services.
SECAM	*Sequential couleur a memoire*. Alternative European broadcast TV standard.
SIP	Session Initiation Protocol. An NGN signalling protocol.
SMP	Significant Market Power.
TEC	Telecommunication Engineering Centres (implemented in India).
TDD	Time division duplex.
TDM	Time Division Multiplexing. A data multiplexing scheme that uses defined time slots to multiplex data.

TIP	Terminating Identification Presentation.
TIR	Terminating Identification Restriction.
TRAI	Telecom Regulatory Authority of India.
USO	Universal Service Obligation.
UTRAN	UMTS Terrestrial Radio Access Network.
VDSL	Very high bit-rate DSL. It is an xDSL technology providing data transmission up to a theoretical limit of 52Mbit/s downstream and 12Mbit/s upstream over a single twisted pair of wires.
VoD	Video on Demand.
VoIP	Voice over Internet Protocol. It means sending voice calls using IP, using either the public Internet or private IP networks.
VPN	Virtual Private Network. A technology allowing users to make point-to-point connections over a public telecommunication network to emulate the service offered by a dedicated point-to-point private circuit.
WAN	Wide Area Network.
WiMAX	Worldwide Interoperability of Microwave Access. A wireless wide area network (WAN) technology.
WLL	Wireless Local Loop.
X.25	Legacy packet-switched technology.

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