Secretariat discussion paper for the open-ended Working Group on the Asia-Pacific Information Superhighway

Open-ended Working Group on the Asia-Pacific information Superhighway

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Introduction

As is the case in other infrastructure sectors such as transport, energy, inland-waterways, the coherence and integration of ICT networks constitutes a typical case of regional public good. As such, regional cooperation and coordination are essential in ensuring well-functioning ICT transmission networks, and costs and benefits may not always accrue to individual countries in a uniform manner. As in other infrastructure sectors, therefore, there is a need for long-term regional cooperation in ICT infrastructure issues.

Despite the substantial gains reaped from broadband Internet across all sectors, progress has been unevenly spread across Asia and the Pacific. The reasons for these persistent inequities across the region, and within countries, are complex. The Internet is the product of different types of hard and soft infrastructure, continuous technical innovation and agreements between various parties, all of which are interlinked through business models that continue to evolve. One of the key underlying components is the availability of international bandwidth, which provides a general measure of the capacity to deliver affordable and reliable broadband Internet. The physical infrastructure of the Internet, mainly submarine and terrestrial fibre optic networks and Internet exchange points (IXPs), plays an important role in determining the supply and price of international bandwidth in Asia and the Pacific.

In the coming years, demand for international bandwidth is expected to grow significantly in Asia and the Pacific. In addition to higher economic growth and deeper regional integration, a significant transition to higher capability mobile devices amongst the people of Asia and the Pacific is expected to drive the increased demand. These devices are capable of hosting bandwidth-intensive applications for video streaming, social media and cloud computing services, and are becoming the norm at home and in the workplace. GSMA Intelligence forecasts that global 4G and 3G connections in 2020 will number more than two billion and three billion respectively, with much of this growth coming from developing countries[1]. This will lead to much higher levels of data transfer and require an enormous increase in overall international bandwidth capacity. It is important to note that smart mobile devices receive the last leg of data through a wireless network, but still require backhaul networks to carry data from towers and servers to the global Internet. The rapidly increasing demand for data over wireless networks, therefore, will put an increased pressure on backbone networks in the region. Furthermore, the deeper integration of ICT into intelligent transport systems and other Internet of Things applications will also increase the need for bandwidth and will increase pressure on limited radio spectrum resources, further adding to the need for data transmission through fibre[2].

Increasingly also, mobile broadband internet traffic is being offloaded to WiFi, in order to lessen the stress on mobile networks. Analysis and Mason estimated that in 2013 the share of Internet traffic generated from mobile devices that use mobile networks will fall from 38% in 2013 to only 20% in 2018, with the bulk of the increase going to WiFi networks, in a context where overall mobile broadband traffic is to be multiplied by six[3]. This enhanced role of WiFi will doubtlessly increase the need for fibre optic networks for traffic aggregation and long distance backhaul.

The growing appetite for bandwidth is leading operators and carriers to renewed efforts for deploying fibre for capacity, in particular submarine fibre optic cables. In April 2015, TeleGeography estimated that 65 Tbps of new capacity was deployed in 2014, which is comparable to nearly the entire amount of

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[1] Available from www.gsmamobileeconomy.com/GSMA_ME_Report_2014_R2_WEB.pdf.

[2] ESCAP (2015): *Intelligent Transportation Systems for Sustainable Development in Asia and the Pacific*. Upcoming ESCAP working paper.

[3] Internet Society: *Global Internet Report 2014 – Open and Sustainable Access for All*. Available at: https://www.internetsociety.org/sites/default/files/Global_Internet_Report_2014_0.pdf.

bandwidth in service globally in 2011. This trend is led by private networks, particularly those of large content providers which deliver services such as video[4].

The widening digital divide is a legitimate source of concern in the ESCAP region, in particular in view of the rapidly increasing demand for bandwidth. In this context, the national and regional broadband fibre optic cable networks are undergoing growing pressures. This will accentuate the need for fibre network upheaval and for the addition of new routes to complement existing ones.

The first section of this paper starts with exploring the current shortcomings in ICT transmission infrastructure – mostly fibre optic cables – that can be addressed by better regional cooperation in developing Asia-Pacific. The second section investigates how better cooperation in Internet traffic management could enhance broadband connectivity in Asia-Pacific. The third section analyses issues related to the improvement of ICT network resilience, while the fourth section briefly reviews the need to improve connectivity in rural and underserved areas. The paper concludes by laying out key issues for the consideration of the Working Group.

I. Improving broadband infrastructure for an Asia-Pacific Information Superhighway

With regards to physical infrastructure, the Asia-Pacific Information Superhighway initiative seeks to improve broadband connectivity by (i) building "missing" linkages for a better regional coherence of national fibre networks, (ii) maximising the co-deployment potentials of cross-sectoral synergies, and (iii) promoting open-access to publically funded infrastructure. These three elements are analysed in the below section.

a. Improving ICT physical infrastructure connectivity through the building of missing links

The current terrestrial networks of fibre optic cables in developing countries of Asia and the Pacific are typically dominated by submarine access to international transit. While in the OECD countries, backhaul (national) networks are increasingly interconnected terrestrially, in developing countries – including many ESCAP countries – backhaul networks are poorly meshed and follow a "river system" pattern whereby networks spread from submarine landing stations thinning out into countries' hinterlands[5].

In developed counties' markets, the widespread interconnectivity of terrestrial backhaul networks, coupled with the presence and active use of numerous Internet Exchange Points (IXPs), result in highly competitive backhaul markets, which in turn contribute to the relatively low costs of broadband to consumers. Meanwhile, in developing countries, network configuration and the heavy reliance on submarine networks for international transit, tends to reinforce the role of incumbent operators and data carriers. Smaller (Tier-2 and 3) Internet Service Providers rely on a limited number of options to procure international transit, which limits the scope of competition to bring down prices on backhaul (national backbone) networks. As key infrastructure such as cable landing stations or international gateways at borders tend to be owned and managed by incumbent operators, these usually have an incentive to overcharge their potential competitors for access to such infrastructure. An example in point was the high access facilitation charges and colocation charges at cable landing stations in India, until the Telecom Regulatory Authority of India (TRAI) intervened to redress this situation and enforce a steep decline in

[4] TeleGeography Research Update, 23 April 2015 "Global Network construction resurgence".
[5] OECD Digital Economy papers No. 232: *International Cables, Gateways, Backhaul and International Exchange Points* (OECD, 2014).

such charges[6]. The charges for access to the cable landing stations were deemed by some observers to be 251 times higher than in comparable jurisdiction[7]. Such higher costs limit price competition and ultimately penalize the final consumers. Generally, the role of incumbent operators that have historical ties to Governments tends to be predominant in the management of such infrastructure. As an indication of the situation in another developing region, the World Bank recently estimated that in 13 out of 19 Middle East and North African countries, access to international submarine cable connectivity is under the sole control of the incumbent operator[8]. The resolution of such regulatory issues can have repercussions across borders, as they may affect the conditions under which countries can access bandwidth in their neighbouring countries. There is, therefore, an incentive in bringing such issues and their potential resolution at the regional level, for example through the Asia-Pacific Information Superhighway.

For landlocked countries, the lack of diversity of terrestrial routes is even more constraining as they obviously have no direct access to submarine cables for international IP transit. The market structure and conditions of access to bandwidth in neighbouring countries therefore dictate the terms under which Landlocked Developing Countries can procure international transit.

The limited number of fibre interconnections across countries also limits the availability of total and per-capita international bandwidth. Again, this issue is affecting more severely landlocked countries that do not have direct access to a submarine cable landing station and who rely on few and outdated terrestrial connections. Bandwidth could be improved in these countries through deliberate efforts to interconnect national fibre backbone with those of neighbouring countries through state of the art high-speed connections.

In this context, the required improvements in regional fibre networks can be realised either through improvements of existing infrastructure (notably by upgrading the capacity of transmission and routing equipment), or by deploying new fibre connections. Simply upgrading existing transmission capacity can be a viable option when network redundancy and competition for international transit issued are already resolved. However, in many ESCAP developing countries, deployment of additional fibre connections is often a preferable option to improve market competitiveness and network redundancy.

The ESCAP secretariat's undertaken initiatives of mapping the existing fibre infrastructure, as well as a series of in-depth subregional studies of broadband infrastructure have facilitated the identification of bilateral connectivity in the greatest need of upgrade. This list of potential priority projects is provided in the annex (page 20). This list includes pairs of countries between which current transmission infrastructure has been identified as being non-existent (such as Nepal-China, Malaysia-Indonesia on the Borneo Island), or insufficient either due to the obsolescence of current linkages (such as Kyrgyzstan-Uzbekistan, Turkmenistan-Uzbekistan), or insufficient to ensure satisfactory redundancy on key trunks of the regional network (such as Bhutan-India, India-Myanmar).

The list in the annex can constitute initial material for discussions by the Working Group on regional fibre network improvements. However, it is not exhaustive[9] and additional analytical efforts will be required to

[6] http://www.trai.gov.in/WriteReadData/WhatsNew/Documents/Final%20CLS%20AFC%20&%20CLC%20Regulations%20_21.12.2012.pdf

[7] http://www.asiapacificcarriers.org/sp/user/attach/2012-04-19_APCC%20Response%20to%20TRAI%20Consultation%20on%20CLS%20Charges%20190412%20FINAL.pdf

[8] World Bank 2014: *Broadband Networks in MENA, accelerating High-Speed Internet Access*.

[9] Terabit Consulting studies realised for ESCAP do encompass additional projects identified as "medium" and "low" priority.

complete it and update it regularly. In this context, the secretariat could provide analysis of network performance (upload/download speed, latency, jitter, etc.) in the concerned countries.

b. Tapping cross-sectoral synergies for fibre-optic deployment

Fibre deployment involves different types of costs. It is generally agreed, however, that the dominant constituent in fibre deployment costs is, by far, civil engineering works. A recent review of available literature by the secretariat[10] shows that in general, close to 80% of the costs for deploying terrestrial fibre networks is associated with digging, trenching and laying down the conduits in which fibre is subsequently laid. Moreover, securing rights-of-ways for the passage of fibre, as well as construction permits can be a time-consuming and complicated process.

Thus, there is a strong incentive to resort to infrastructure-sharing to deploy fibre optics between major population centres, at reduced costs. This involves deploying fibre, or at least the ducts for subsequent fibre deployment, along infrastructure such as major roads, railways, power transmission lines, pipelines or waterways. Many modern infrastructure segments deploy fibre by default, for their own Supervisory Control and Data Acquisition (SCADA) purposes. This is the case of high-voltage electricity transmission networks which also use fibre for optical ground wire (OPGW). Modern railway systems typically use fibre for internal communication needs, while pipelines need them for distributed sensing technology[11]. Road transport will increasingly require fibre optic cables to consolidate and transmit information in the context of future intelligent transport systems. Some of the fibre deployed along these infrastructure networks can be used for telecommunication and Internet data traffic purposes. This creates additional economic opportunities for the owner of the underlying infrastructure.

Good practices abound in the Asia-Pacific region for fibre optic co-deployment[12]. Among other examples, China TieTong Telecommunication Corporation integrates the telecommunication systems of Chinese railways. In India, POWERTEL has emerged as a major national carrier having one of the largest national terrestrial fibre backbones deployed mostly along the power grid. The World Bank is currently considering supporting a subregional fibre optic network deployed along the electric transmission lines to be built under the CASA-1000 project, which will link Kyrgyzstan to Pakistan through Tajikistan and Afghanistan[13]. On the other hand, it has been reported that Afghanistan, which is completing its fibre optic network ring, is facing coordination issues in systematically deploying duct along major segments of roads that are being funded through external assistance[14]. This could unduly slow down the completion of the Afghan backbone and undermine the advent of Afghanistan as a fibre optic regional hub in line with its strategic geographical position at the heart of Asia[15].

ESCAP countries should seek to tap on the numerous cross-country or pan-regional infrastructure deployment projects that are facilitated by the current high economic growth in the areas of transport,

[10] ESCAP (2014): *Working paper on Harnessing Cross-sectoral Infrastructure Synergies*. http://www.unescap.org/resources/working-paper-harnessing-cross-sectoral-infrastructure-synergies

[11] Fibre optic distributed sensing technology can be used to help keep track of changing pressures, temperatures and ground movements, among other such uses which help in detecting and pinpointing the occurrence of events on pipeline networks before they develop into an actual threat. Ibidem.

[12] Ibid.

[13] http://www.unescap.org/resources/presentation-world-bank-regional-broadband-programs-and-proposed-central-asian-regional

[14] Presentation by MCIT on Afghan Fiber Optic Ring, http://www.unescap.org/resources/presentation-afghan-fibre-optic-ring

[15] Currently, Afghanistan already has fibre optic connections with five of its six neighbours and is considering building a new fibre linkage with China. Ibid.

energy, water, etc. ESCAP member States could decide to systematically co-deploy fibre along regional infrastructures, on an open-access basis.

The ESCAP secretariat has proposed to systematize co-deployment of fibre optic cable along the Asian Highway and Trans-Asian Railway, two transport international agreements for which it acts as secretariat. This proposal by the ESCAP secretariat was discussed during the 4th session of the ESCAP ICT Committee in Bangkok, in October 2014. The proposal will be examined by the respective organs in charge of the two Agreements under the ESCAP aegis later this year. Concretely, this could entail systematically deploying additional ducts and/or fibre when building the infrastructure that constitutes these two networks. In the case of the Trans-Asian Railway, spare fibre could be deployed in addition to that installed for the use by the railway itself. In both cases, the additional ducts and fibre could be rented to telecom operators or other data carriers, in order to provide an additional source of income for the roads and railways entities.

The Asia-Pacific Information Superhighway Working Group should explore ways to maximise such cross-sectoral synergies when building additional linkages in the region.

c. Improving regulatory frameworks and promoting open access to public-funded infrastructure

As identified above, regulatory frameworks and market practices in Asia-Pacific often limit competition in both the international transit and national backbone segments of broadband transmission markets. This is typically the case when such conditions maintain incumbents in dominant positions through the control of key infrastructures such as cable land base stations or international gateways. Accelerating reforms to foster competition on broadband transmission markets is seen as a key priority to lower the costs of broadband for final consumers. Successful policy measures in this respect involve simplifying the licencing regimes for access to submarine and cross border connections, and reducing the exclusive control of incumbents on international gateways and submarine cable land base stations[16]. As uncompetitive regulatory frameworks and practices have a potential regional impact, especially in LLDCs, the working group on the Asia Pacific Information Superhighway should review cases where accelerating such reforms could have a positive impact on regional broadband connectivity.

The deployment of new fibre links, including as suggested above, along segments of the Asian Highways and Trans-Asian Railways as they are built or maintained, should be accompanied with mandatory open-access requirements. Open-access requirements involve allowing all duly licensed operators to obtain access to the fibre infrastructure (or fibre infrastructure services) on an equal non-discriminatory footing, and under transparent and cost-recovery pricing basis. Open-access typically requires establishing clear guidelines of non-discrimination between telecom operators and access to the utility infrastructure at fair prices, which include the recovery of costs in addition to a small profit margin. Rental and maintenance charges of passive infrastructure may need to be regulated to ensure that the physical infrastructure owner receives adequate incentives to continue building and maintaining it. The objective of promoting open-access to fibre (and other key data transmission infrastructures) is obviously to foster competition and thereby reduce broadband prices. While reviewing good practices in the European Union, researchers reported[17] that mandated (open) access to passive infrastructure was an important measure to decrease the

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[16] ITU 2013 : *Trends in Telecommunication Reform 2013: Transnational aspects of regulation in a networked society*. https://www.itu.int/opb/publications.aspx?media=paper&parent=D-REG-TTR.14-2013

[17] Matt Yardley, Rod Parker and Mike Vroobel, "Support for the preparation of an impact assessment to accompany an EU initiative on reducing the costs of high-speed broadband infrastructure deployment", a study prepared for the European Commission, DG Communications Networks, Content and Technology, by Analysys Mason Limited, 2012. Available from www.ec.europa.eu/digital-agenda/en/news/support-preparation-impact-assessment-accompany-eu-initiative-reducing-costs-highspeed.

cost of network deployment. The “dig once” sets of policies of the United States of America require that individual states in that country install broadband conduits during the construction of federally funded highway projects. Access to such conduits should be available for a cost-based charge[18].

Open-access requirements should systematically be enforced when public funding is used to build transmission infrastructure in Asia Pacific. This could constitute one of the key principles underlying the Asia-Pacific Information Superhighway.

II. The Asia-Pacific Information Superhighway for regional Internet traffic management

Perhaps uniquely among other forms of critical infrastructure, the communications networks comprising the Asia Pacific Information Superhighway consist of cables and hardware as well as complex and interconnected software. In order for these systems to function effectively, it is necessary for these components to be well coordinated. For example, Internet traffic has long been designed around the principle of self-regulation and cooperation. The equanimity of this approach has often been identified as one of the conditions which has promoted the rapid network growth and great value created by Internet adoption. These network protocols and governance systems, such as domain name systems and routing mechanisms, are just as critical as the cables and hardware of these networks. Experience has shown that failures in Internet traffic management can be just as disruptive to communications systems as hardware failures in physical components of the network.

A regional approach — or at least coordinated subregional approaches — can add significant value compared to more chaotic approaches. If coordination is lacking, countries may choose to improve international connectivity by negotiating on their own for transit capacity with neighbouring countries, without contemplating the impact of such decisions on the wider region. Such bilateral approaches have contributed to the existing fragmentation of backbone networks in the region. Developing bilateral relationships with networks in other countries, without an overarching regional framework, would also limit competition at cross-border links and international gateways. A cohesive regional network, however, would bring less connected countries directly into the global Internet, stimulating overall demand and ultimately, leading to lower broadband prices and improved economic growth overall. Among the technical tools available to address these issues are content delivery networks and Internet Exchange Points.

a. Benefits of Internet traffic management

In order to have connectivity to the global Internet, an ISP must be connected to at least one other ISP which already has global Internet connectivity. This is called buying transit. In this model, all Internet traffic flowing between smaller ISPs (also called "Tier 2" ISPs) has to pass through their upstream providers' networks. Some of the Tier 2 ISPs decide to interconnect themselves directly, in order to reduce the amount of different networks the traffic has to traverse, and at the same time save some transit costs. This practice is called peering.

An Internet Exchange Point (IXP) is one of the most critical pieces of the Internet’s infrastructure. Internet Exchange Points are a physical location where different networks meet to exchange traffic with each other and thereby keep local traffic flows local. IXPs which facilitate the open sharing and

[18] United States Government Accountability Office, “Planning and flexibility are key to effectively deploying broadband conduit through Federal highway projects”, Washington, D.C., 2012. Accessible from www.gao.gov/assets/600/591928.pdf.

coordination of traffic at the ISP-level would promote higher performance at lower prices. The establishment of additional regional and subregional IXPs, therefore, should form a key part of efforts to develop pan-Asian terrestrial networks. This is made possible by facilitating local traffic being exchanged locally. Submarine cable dependency would be decreased as the development of well-balanced terrestrial networks is promoted. Swapping capacity on each other's networks is done by using IRU (Indefeasible Rights of Use) or fibre swaps for inter-city or inter-border network at the IXP. The comparative economic value of this approach can be seen in other markets, such as Europe. For instance, the price of a 10 Gbps connection between large cities in the EU is less than 915 US dollars per month; a far lower rate than is commonly available in the ESCAP region.

Peering reduces upstream costs, with the costs of creating a physical connection between two ISP's networks being justified through the savings accrued by sharing traffic more efficiently. The economic impact of Internet Exchange Points demonstrates this effect. An IXP is a single physical network infrastructure (typically an Ethernet local area network) to which many ISPs can connect. Any ISP that is connected to the IXP can then exchange traffic with any other of the other ISPs connected to the same IXP, thus overcoming the scalability problem of individual interconnections. Such peering practice is called "peering" with IXPs are often referred to as "peering points" or "public peering points". By enabling traffic to take a shorter path to many ISP networks, an IXP can improve the efficiency of the Internet, resulting in a better service for the end user.

IXPs are not, typically, involved in the peering agreements between connected ISPs; whom an ISP peers with, and the conditions of that peering, are a matter for the two ISPs involved. IXPs do however have requirements that an ISP must meet to connect to the IXP; also, since the physical network infrastructure is shared by all the connected ISPs, and activities of one ISP can potentially affect the other connected ISPs, IXPs generally have clear terms of service.

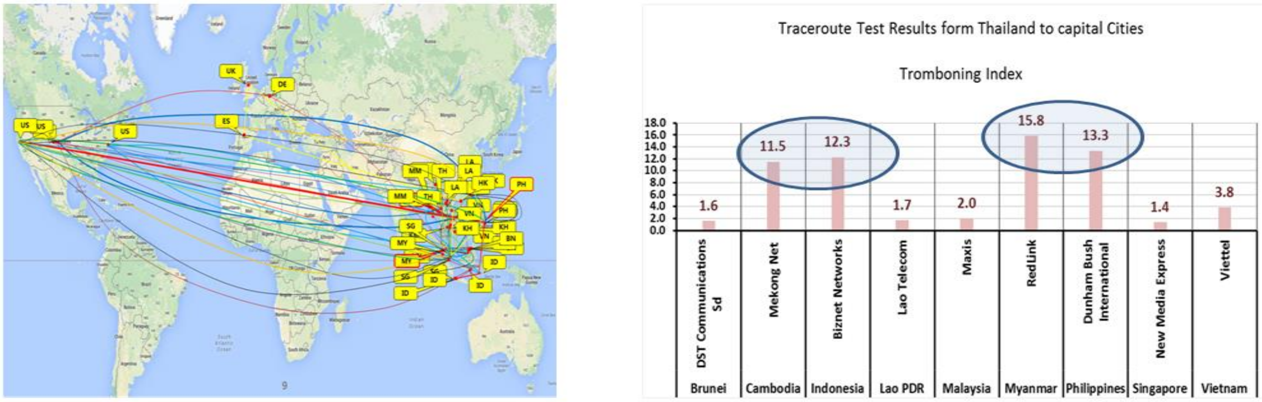
Benefits of an Internet Exchange Point include:

1. Keeps local Internet traffic within a local infrastructure, and reduces costs associated with traffic exchange between networks.
2. Builds the local Internet community and develops human technical capacity – better net management skills and routing.
3. Improves the quality of Internet services and drives demand by reducing delay and improving end-user experiences.
4. Convenient hub for attracting hosting key Internet infrastructures within countries.

b. Network management is a critical issue

As shown in Figure 1, there is a significant amount of traffic which originates and terminates in the ASEAN region, but is routed through the United States of America or Europe. This traffic pattern is known as "tromboning". For instance, analysing the routes from Thailand to each ASEAN country found that tromboning can be quite severe for Cambodia, Indonesia, Myanmar and the Philippines. In particular, the routes are unnecessarily long, even though Myanmar and Cambodia are neighbouring countries to Thailand. This phenomenon impacts transit price by overusing expensive backhaul network capacity for traffic which could be handled locally. Because the traffic goes back-and-forth international submarine cables, domestic services are also at potential risk of failure, if failures are experienced on submarine cable systems.

Figure 1: Internet traffic routes from Thailand to capital cities



Source: A Report on "A Pre-Feasibility Study on Conceptualization, International Traffic & Quality Analysis, Network Topology Design and Implementation Model for the Asian Pacific Information Superhighway in the ASEAN Sub-region", ESCAP

In general, most countries in the region have some level of bilateral fibre connectivity with their neighbours. However, in order to solve the issue of Internet traffic coming back from other continents through Tier 1 providers, it would be necessary to introduce and systematically manage the tromboning index and ensure stable regional interconnection and minimize damage from failures. To prevent Internet failures between neighbouring countries caused by submarine cable network failures from natural or artificial disasters, direct terrestrial cross-border interconnection between countries is essential and the network must be configured so as to find alternate routes in time of failures.

III. Building e-resilience through the Asia-Pacific Information Superhighway

The presence of multiple telecommunications operators in competitive environments has generally been an enabling factor in making networks more resilient. Because in liberalized environments, multiple suppliers and technologies exist, even long-held assumptions such as the technical and economic infeasibility of building multiple undersea cable stations have had to be re-examined. Competitive markets can encourage redundancy, which is created by the existence of multiple, competing networks. Even if one were to fail, it is unlikely that all networks in a specific locality would fail at the same time. Where multiple undersea cable and satellite paths controlled by different companies exist, various kinds of formal and informal arrangements can be made to ensure redundancy and business continuity.

Coherence and regional route redundancy in regional fibre networks constitutes a de-facto regional public good, and the typical public good dilemma occurs in this situation: that is, while the costs of building a more meshed network may accrue to selected individual countries, the benefits spread to the whole subregion in terms of creating alternative routes. Therefore, the costs and responsibilities of planning and building regionally coherent fibre networks would need to be discussed at the regional level.

The ESCAP/ITU maps of the Information Superhighway that visualises national fibre backbones and their cross-country linkages clearly reveal some of the instances where the national backbone configuration results in poorly cohesive international transit networks. As an example of this strategy, the One Belt One Road initiative emphasizes the value of deployment of cross-sectoral infrastructure projects in an integrated, regional approach. Further, Figure 2 below shows the example of Mongolia, which has only one connection with each of its neighbours, China and the Russian Federation. Building additional

direct connections between Mongolia's network and its neighbours would benefit the three countries, at the very least through additional network redundancy. If the new connections were built towards the west of Mongolia, for example along the Asian Highway 4 (AH4), this could also reduce the physical distance that data needs to travel along fibre between China and the Russian Federation, with potential gains in network latency on this key East-West continental route.

Figure 2: Interconnections of Mongolia's backbone with that of its neighbours

Source: ESCAP, based on ESCAP/ITU maps of the Information Superhighway.

The Kingdom of Bhutan constitutes another typical illustration of how beneficial better regional coordination would be in designing fibre network routes. The Kingdom's two international gateways are connected to the Indian network. However, all the fibre-based traffic in this part of India travels through a single point, the city of Siliguri, as North-Eastern India is not yet directly connected to international networks. Siliguri, therefore, constitutes a major bottleneck that exposes the domestic network of Bhutan to intense vulnerability, in what is already a highly seismic region[19]. A solution envisaged by the Bhutanese Government would consist in deploying fibre to Cox Bazar's submarine landing station in Bangladesh[20], through Samdrup Jongkhar (Eastern Bhutan) and Tripura/Agartala in North-East India. In addition to bringing much needed route diversity in Bhutan as well as North-Eastern India's provinces,

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[19] ESCAP, *Bridging Transport, ICT and Energy Infrastructure Gaps for Seamless Regional Connectivity* (Bangkok, 2014).

[20] See: "APIS Initiative, Way Forward Bhutan" (2014), available at: http://www.unescap.org/sites/default/files/Presentation%20to%20UNESCAP_II%20by%20Phuntsho%20Tobgay.pdf

such a project could potentially open new sources of revenues for Bangladesh's carriers. Regional coordination would be a requirement for this project to succeed.

a. Importance of designing for resilience

In order to promote resilience, fibre optic networks had been designed using ring topologies, whereby a single break could be worked around, albeit at a degraded network speed. Multiple breaks, however, can result in network failure. Therefore, ring architecture is not ideal when network availability is critical. It is now becoming more common to shift to even more robust mesh architectures, in which multiple, simultaneous breaks can be worked around. In a mesh network topology, all nodes are connected to every other node, thereby increasing redundancy and cost, the latter being its main disadvantage. With cost and complexity in mind, hybrid ring-mesh architectures may prove a more viable option.

Redundancy and resilience should be explicitly considered when promoting telecommunications infrastructure enhancement. Specifically, rules regarding critical infrastructure and essential facilities such as undersea cable stations should be formulated taking into account the need to reduce systemic risk. Especially in small island countries where there are few suitable sites, planners should earmark locations that are least vulnerable and ensure that they are made available to ICT infrastructure operators.

In addition, a proactive approach to leveraging ICT for e-resilience should encourage private sector suppliers to diversify locations of critical infrastructure and deploy multiple technologies, for example, by ensuring that backup satellite connectivity is maintained even after fibre connectivity is widely deployed. Reliance on undersea cables should be balanced by terrestrial cables where possible. Promotion of resilient network infrastructure through a diversity of cable routes should also be a policy objective. As such, encouraging terrestrial cable systems that run alongside the Asian Highway and the Trans Asian Railway Network is an important consideration for utilizing ICT for improving resilience.

b. Network topology considerations

Wireline and wireless access networks pose different challenges in terms of ensuring resilience. Post-disaster analysis of wireline networks after the Japanese Tsunami and Typhoon Haiyan in the Philippines showed that aerial cables were susceptible to greater damaged than buried cables. As a result, experts have promoted the use of ducts and buried cables. Post-disaster analysis of wireless networks has pointed to the criticality of power supply to Base Transceiver Stations (BTS). Provision of battery and generator back-up to a large number of BTSs is costly. Supplying fuel to BTS in the aftermath of a disaster is difficult when roads are damaged or blocked. As with any form of redundancy, increased capacity of back-up power throughout a mobile network can be prohibitive in terms of cost. Therefore, selected strategically located BTSs (e.g. BTS that are situated close to government buildings, hospitals etc.) may be equipped with enhanced back-up capacity.

Liberalization of telecom industries has provided alternatives to reliance on centralized facilities, such as those that were subject to the near complete destruction of the network in Mexico City in 1985. Solutions such as emergency sharing of infrastructure and domestic roaming, which are best facilitated in liberalized environments, now exist. In addition, regular contingency planning and careful consideration of the need for broad sharing of infrastructure should be undertaken before disasters strike. Critical elements must be strengthened and adequate redundancies ensured in order to increase resilience.

c. Changes in network reliability

ESCAP members and associate members have been making significant investments in the improvement of their networks. As a result, this infrastructure has demonstrated increased reliability and responsiveness. As measured by data obtained from user-initiated connection speed tests as processed by ESCAP, the percentage of information packets lost has declined significantly over the last three years (Table 1). This indicates both the usefulness of these networks in providing reliable communication services, and the importance of safeguarding critical infrastructure communications.

Table 1: Percentage of packets lost

Country	**2010**	**2011**	**2012**	**2013**	**% reduction**
China	4.62	2.56	1.88	1.27	72%
UK	3.12	3.06	1.29	0.96	69%
New Zealand	4.90	3.58	2.05	1.57	68%
Malaysia	3.26	1.64	0.96	1.06	68%
Australia	3.00	3.28	1.72	1.14	62%
Republic of Korea	1.76	1.08	0.65	0.70	60%
US	3.25	3.66	2.47	1.44	56%
Turkey	6.87	5.40	4.42	3.22	53%
Singapore	3.60	3.08	1.96	1.86	48%
France	2.61	2.17	1.83	1.39	47%
Indonesia	2.15	1.48	1.09	1.20	44%
Viet Nam	1.80	1.60	1.12	1.03	43%
Philippines	1.93	1.79	1.13	1.21	37%
Netherlands	2.37	2.14	2.30	1.56	34%
Iran (Islamic Republic of)	1.86	N/A	2.40	1.24	33%
Russian Federation	1.54	1.15	1.19	1.30	16%
Average:	3.04	2.51	1.78	1.38	51%

Source: speedtest.net, retrieved June 2014, analysis by ESCAP

To enhance communications infrastructure, national highways are the preferred right-of-way to deploy an optical fibre transmission backbone. At the regional level, the Asian Highway acts as a meshed transcontinental road network, making colocation of infrastructure an intriguing opportunity which can offer a compelling option for redundancy to the Asian submarine cable networks. This could greatly reduce the risks of outage from accidents, sabotage or natural disasters. Installing fibre optic cables along the Asian Highway can help reduce the integration difficulties experienced by some landlocked countries. Ten out of the 32 members of Asian Highway are landlocked developing countries (LLDCs) (Table 2). Among them, Uzbekistan, for example, is a double-landlocked (surrounded by landlocked countries) economy. The growth rates in the international bandwidth traffic, as illustrated in the table below, emphasize the need to proactively plan infrastructure upgrades which will enable continued growth. Without measures such as peering, cable investments, and increased efficiency in Internet Exchange Points, bottlenecks could develop which would contribute to the digital divide among these countries.

Table 2: International Internet bandwidth consumption by LLDCs sharing the Asian Highway

Country (Alphabetically)	Annual bandwidth consumption (Mbps)					Annual growth rate				
	2008	2009	2010	2011	2012	2008	2009	2010	2011	2012
Afghanistan	245	265	912	1,897	3,147	29%	8%	244%	108%	66%
Bhutan	75	116	330	485	640	150%	55%	184%	47%	32%
Kazakhstan	3,752	11,123	36,967	74,368	122,566	155%	196%	232%	101%	65%
Kyrgyzstan	524	1,019	1,335	2,005	5,129	32%	94%	31%	50%	156%
Lao People's Democratic Republic	481	756	1,616	2,682	4,190	48%	57%	114%	66%	56%
Mongolia	2,169	3,621	6,372	11,180	17,280	1199%	67%	76%	75%	55%
Nepal	199	1,085	1,775	4,865	7,960	135%	447%	64%	174%	64%
Tajikistan	129	179	235	595	3,108	90%	39%	31%	153%	422%
Turkmenistan	344	54	69	290	400	1047%	-84%	28%	320%	38%
Uzbekistan	498	1,085	1,332	5,066	12,595	108%	118%	23%	280%	149%

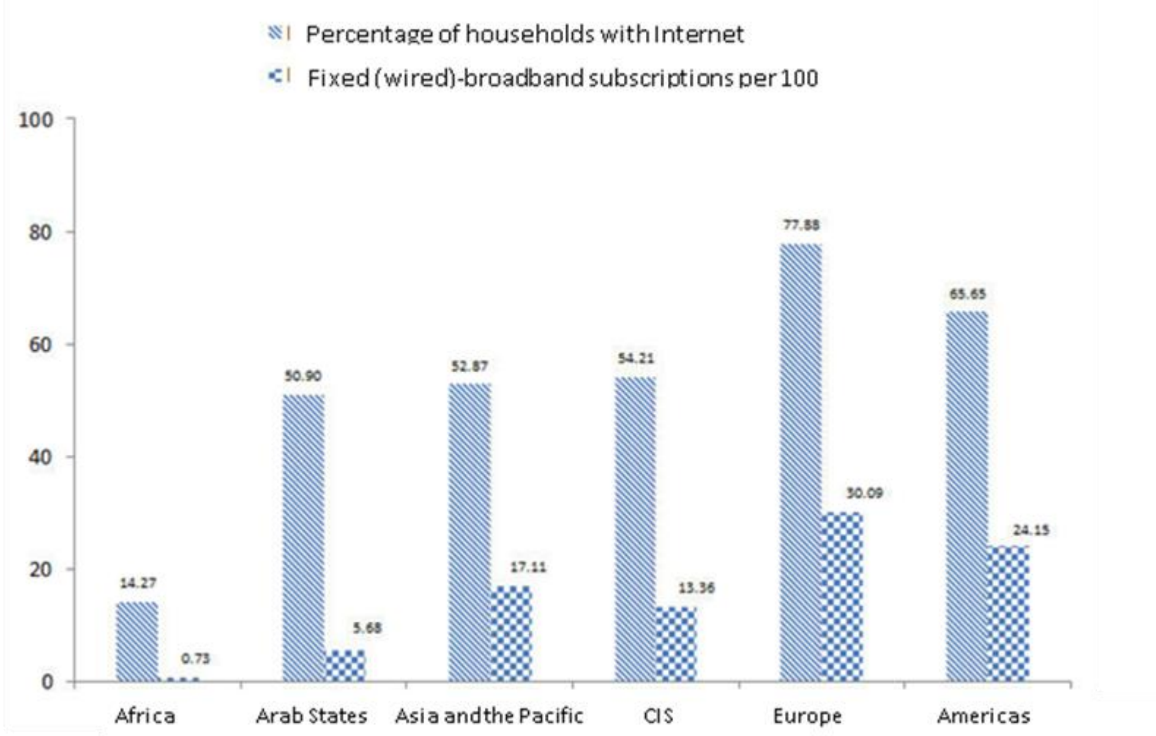
Source: TeleGeography Q2 2013.

IV. The Asia-Pacific Information Superhighway and broadband access in underserved areas

Information and communication technologies accelerate economic and social development, and will play an even greater role in the post-2015 era as the world turns to the implementation of the Sustainable Development Goals. Fixed and mobile broadband Internet, in particular, is a powerful facilitator in the flow of information across societies and promoting knowledge exchange, while driving innovation and economic growth. Broadband-enabled technologies such as smart grids, intelligent transport systems, integrated water management systems and big data are some of the efficiencies that will drive growth in all sectors of the economy. The Internet also plays an important role in modernizing government services and enhances the interaction and accountability between public administrations, citizens and businesses. These are only some of the potential benefits of broadband Internet that will make a tangible difference in the lives of people around the world.

However, while some of us take access to high-speed broadband for granted, a large segment of the population in the Asia and the Pacific region still remains unconnected and excluded from access to the myriad of economic and social opportunities offered online. While Asia and the Pacific region is home to several global ICT-leader countries that boast some of the world's highest rates of Internet user penetration, latest figures for broadband Internet access show that subscriptions to fixed broadband remain relatively low. There are 17.11 fixed broadband subscriptions per 100 inhabitants in the region, compared to 24.15 in the Americas and 30.09 in Europe. In some ESCAP subregions, the disparities are even greater. In South and South-West Asia and South-East Asia, for example, there are only 1.65 and 3.22 subscriptions per 100 inhabitants, respectively. And in least developed countries and Pacific island developing countries, there is on average less than 1 subscription per 100 inhabitants (Figure 3).

Figure 3: Comparison between percentage of households with Internet and fixed(-wired) broadband subscriptions per 100



Source: ESCAP calculations based on ITU, World Telecommunications/ICT Indicators database 2014.
Note: Data are weighted by country GDP in current United States dollars.

Governments, especially in developing countries, should take a greater interest in fostering the necessary conditions to get more people online; including ensuring universal, inclusive access to broadband Internet.

a. Universal access and the rural-urban divide

The access and use of ICTs in rural and remote areas is often portrayed by a number of challenges, including limited infrastructural development due to geographical locations and higher costs for delivering the attendant services. Mountains and other topographic barriers impede infrastructural development, and the maintenance of any existing infrastructure is likely to receive less attention in rural areas. There is also a perception that demands for ICT services would be lower in rural areas due to the lack of customers compared to more densely populated urban areas. As a result, those living in rural and remote areas tend to have comparatively limited access to ICTs and this is the emerging "rural-urban divide".

According to ESCAP estimates in 2014, around 52.3% of the population in the Asia-Pacific region live in rural areas[21]. Governments, including at the local level, must take a greater interest in the development of a strategic plan for broadband deployment to under-connected areas to ensure that citizens living in rural and remote areas also benefit from the economic and social opportunities offered by having access to the Internet. In addition, with the growing recognition of the potential of ICTs to drastically improve the way

[21] As quoted in the *ESCAP Statistical Yearbook 2014,* available on: http://www.unescap.org/sites/default/files/ESCAP-SYB2014_0.pdf

we work and live, including in the agricultural sector, demand for high-speed broadband in rural areas will only increase with time.

b. Role of the Government and the public sector

In the market-driven, private sector-led ICT industry, there is a lack of commercial interest in developing infrastructure in sparsely populated areas where there is uncertain return in investments. This is where the Governments can play an important leading role in reaching out to provide access to broadband in unconnected rural and remote areas.

Significant investments will be required to construct, deploy, maintain and operate sufficient terrestrial networks to reach rural and remote areas. For the period 2010-2020, it has been estimated that Asia and the Pacific will need to invest about US$8 trillion in infrastructure, of which around 10 per cent will need to be invested in the ICT sector, including fibre networks and Internet exchange points[22]. In addition to investments in new infrastructure, additional investments are needed to upgrade and augment the existing infrastructure.

Through public-private partnerships, Governments and the private sector stand to benefit mutually from combining their resources and expertise to share the investment costs in bringing high-speed broadband to rural and remote unconnected areas. Governments would benefit from higher growth and innovation, and operators would benefit from a larger retail market for broadband services. Most importantly, consumers would benefit from lower bandwidth costs and higher network quality. The box below showcases one such successful public-private partnership.

Box 1: Plan Vive Digital Colombia – National Fibre Optic Plan

In Colombia, the Government created a list of unconnected municipalities and offered public funding to co-finance backhaul networks if service providers were willing to connect these municipalities. The successful bidder was the firm that offered to connect the greatest number of municipalities. In that case, the winner of the tender connected 245 previously unconnected municipalities, far beyond the minimum expectations of the Government.

Source: OEDC, "International cables, gateways, backhaul and international exchange points", OECD Digital Economy Papers, No. 232 (18 February 2014).

In addition to infrastructure development, Governments must take a holistic approach to bring about a regulatory framework that will foster the necessary conditions to ensure affordable broadband services to those living in rural and remote areas.

V. Issues for consideration by the Working Group

Governments should take a stronger interest in the development of a strategic plan to bridge the digital divide between rural and urban areas and ultimately providing universal access to broadband Internet for all. Citizens should have the opportunities for equal access to the power of the Internet and to leverage its full potential. From a global perspective, developing countries cannot afford to fall behind and further risk being excluded from the rapidly growing digital economy.

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[22] Asian Development Bank and Asian Development Bank Institute, *Infrastructure for a Seamless Asia* (Tokyo, Asian Development Bank Institute, 2009).
Available from www.adbi.org/files/2009.08.31.book.infrastructure.seamless.asia.pdf.

ESCAP member States have marked their increasing support for a concerted regional approach to improve broadband connectivity. This was highlighted at the ESCAP ICT Committee, held in October 2014, where member States recommended the creation of the Working Group on the Asia-Pacific Information Superhighway, which was further supported by the adoption of ESCAP resolution 71/10[23]. The issues summarised below could constitute some of the main points for discussion for the Working Group, with regard to ICT infrastructure connectivity.

a. The role of the Working Group

Discussions by the Working Group could be nurtured by national consultations at the national level, the result of which could be fed into a steering committee or permanent bureau for the Working Group. Such a structure could be constituted of a smaller number of countries (4-5) that would organise a permanent dialogue on the issues at hand, with the support of the secretariat, and in due consultation with all interested parties. In that respect, the Working Group will need to agree on mechanisms for ad-hoc consultations of national, and regional stakeholders, notably the relevant actors in the private sector including telecom operators, carriers, ISPs, industry representatives. Relevant international expertise could also be tapped from international and specialised agencies such as the ITU, APT, WTO, and the World Bank and other financial institutions. Other institutions such as the Internet Society and research/think tanks could also be consulted. The recommendations of the Working Group could be fed into the ICT Committee of ESCAP.

b. Issues for discussion by the Working Group

i. *The development of the physical infrastructure to boost bandwidth and competition, as well as build network redundancy*
   The Working Group could discuss principles and mechanisms to identify priority infrastructure projects related to new deployment. Subsequent enhancement of the maps of the Asia Pacific Information Superhighway to include link capacity should be considered. In addition, the Working Group may want to consider the issue of harmonising the definition of national backbones so that these be mapped in an internationally comparable manner. Relevant international organisations such as the ITU should be included in establishing such norms. In order to facilitate the identification of potential network bottlenecks, the ESCAP/ITU maps of the information superhighway should also include information on network transmission capacity. Further, and based on analysis carried out in the past two years, the secretariat proposes a list of bilateral connections in need of improvement as a high priority (contained in the Annex). Other potential infrastructure projects could include submarine transmission infrastructure or multicounty terrestrial/maritime projects.

ii. *Identification of regulatory and competition issues of regional relevance*
   The Working Group could also identify major bottlenecks caused by regulatory issues or the lack of competition on key segments of the transmission networks in individual countries, with significant repercussions at the subregional level. The Working Group could then issue recommendations on addressing such bottlenecks or mitigating their impacts on regional traffic. The Working Group could also consider the promotion of open-access to publically funded infrastructures as a fundamental principle for the Asia-Pacific Information Superhighway. As well, operators accessing the network on equal, transparent and non-discriminatory terms would help lower the costs for international bandwidth. Open-access principles implemented across the

[23] *Strengthening regional information and communications technology connectivity through the Asia-Pacific information superhighway* (E/ESCAP/RES/71/10).

region would allow developing countries, LLDCs, and Pacific Island Developing States to receive bandwidth at fair and reasonable prices.

iii. *Building network redundancy*
In addition to reviewing the need for additional fibre deployment from a perspective of bandwidth and increased competition, the Working Group could discuss cases where additional fibre segments are also necessary to enhance network redundancy. The list of top priority links in need of improvement identified in the Annex of this paper could be used in that respect.

iv. *Ensuring network efficiency*
Together with deployment of physical infrastructure, the management of network traffic and system optimization should be promoted. In this regard, IXPs and CDNs have significant benefits for smooth network operations. Adoption of IPv6 and appropriate coordination between operators on issues such as routing table maintenance should be given equal priority to physical investments.

v. *Financing for development*
The Working Group could also play the crucial role of fund-raising for identified infrastructure projects. Once the Working Group will have identified an individual infrastructure project as being a priority, it could officially turn to national, regional and international funding institutions; including among others the Asian Development Bank (ADB), the Asian Infrastructure Investment Bank (AIIB), and the International Finance Corporation (IFC) to raise funds. For International Finance Institutions, the Working Group's support for a given project should constitute an endorsement of its value at the regional-level.

VI. Annex

Table: List of bilateral physical connectivity to be upgraded as a high priority

Country pairs	Status of fibre connectivity	Remarks
South-East Asia		
Indonesia/Malaysia	Although undersea connectivity exists between Indonesia and Malaysia, no direct connectivity is present between the countries' states on the island of Borneo.	
Lao People's Democratic Republic to Yunnan, Province of China	Enterprise of Telecommunications Lao operates a fibre link to Yunnan Province, China via Boten, linking to China Telecom at 2 Gbps.	The Lao People's Democratic Republic-China route would benefit from greater competition and redundancy in this key North-South axis.
South and South-West Asia		
Bangladesh/ Myanmar	A terrestrial fibre link between the two countries is in the process of being implemented.	Additional fibre links are needed in order to ensure that Bangladesh has redundant bilateral connectivity with more than one country. Myanmar to also benefit from additional routes.
Bhutan/India	Although Bhutan has two terrestrial links to India, both fibre paths converge in Siliguri, raising concerns about the vulnerability of Bhutan's international connectivity.	Diversification of Bhutan's fibre links to India is urgently needed in order to ensure the robustness of the country's international connectivity.
India/Myanmar	A 640-km terrestrial fibre link was completed in 2010 and is operated by BSNL and Myanmar Post and Telecommunications.	The India-Myanmar border is a critical corridor for connectivity between India and Southeast Asia and further afield, requiring multiple fibre links.
India/Pakistan	A terrestrial fibre link has been constructed between India and Pakistan, but remains dormant as of mid-2014.	Deploying more robust connectivity between India and Pakistan could be an important step towards closer economic partnerships.
Nepal/China	A link between China and Nepal via Tatopani was proposed in 2010, but as of 2014 the status of its development could not be confirmed.	Given Nepal's almost exclusive reliance upon terrestrial connectivity with India, this could enhance diversification connectivity via China.

Pakistan/China	A fibre link between Pakistan and China is currently under construction.	Both Pakistan and China would benefit from improved fibre connectivity, as the single fibre link under implementation is not considered to be a definitive, long-term solution for linking the two countries with robust connectivity.
North and Central Asia		
Kazakhstan/ Turkmenistan	One fibre link of STM-64 at 10 Gbps using SDH network technology.	Connectivity between the two countries is considered to be vulnerable due to the presence of only one link; Turkmenistan would gain significantly from additional transit paths via Kazakhstan onward to Russian Federation.
Kyrgyzstan/ Uzbekistan	One fibre connection using SDH network technology.	
Tajikistan/ Uzbekistan	Connected by only one link capacity STM-1 at 155.52 Mbps.	
Turkmenistan/ Uzbekistan	Relatively antiquated Trans Asia Europe Line.	Given the age of the only link between the two countries, additional fibre is urgently needed between Turkmenistan and Uzbekistan.
Turkey/Armenia	No activated fibre capacity between Turkey and Armenia could be identified.	
Mongolia/China	Only one connection.	Given the importance of Mongolia-China connectivity not only to Mongolia but also within the context of lucrative Europe-to-Asia demand, greater geographic diversity is needed in the fibre connectivity between the two countries.
Mongolia/Russia	Only one cable connection.	As is the case with the Mongolia-China crossing, the Mongolia-Russia crossing is a key outlet for Mongolian demand but it also serves lucrative Europe-to-Asia capacity, which is expected to increase significantly.

Source: ESCAP, based on Terabit Consulting.