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Next Generation Digital Infrastructure:

Challenges and Opportunities for Development in the Arab Region

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I. Executive Summary

The ten-year review of the World Summit on the Information Society (WSIS) in 2015 called for close alignment between the WSIS process and the 2030 Agenda for Sustainable Development, where the role of information and communication technology (ICT) is explored as a means for implementing the Sustainable Development Goals (SDG). This paper looks at priorities and challenges related to next generation digital infrastructure in the Arab region, in an attempt to explore possible linkages between the WSIS action line 2 and the SDG 9.

The past thirty years have witnessed tremendous growth in the capabilities and reach of information and communication technologies. They have become a critical enabler of social and economic change, constantly offering new ways for addressing development challenges, through creativity and innovation. About 3.7 billion people are connected to the Internet today, fast approaching half of the world's population, and the digital economy is growing at more than 10% a year. The development of next generation digital infrastructure is an integral part of this growing economy, driven by evolving user needs and trends, increased broadband speeds and video, and a growing mobile and wireless industry. The deployment of next generation networks has proved to be an essential driver for the foundation of an inclusive information society that integrates ICT in all aspects of life.

In its first part, this paper will look at the global landscape of next generation digital infrastructure. It will explore the main elements of the ecosystem, the different stakeholders, as well as prevailing usage trends accompanying the evolution in broadband technologies. It will further explore the main drivers for the rollout of next generation networks and the emerging models for deployment.

In the second part, the paper will take a more focused look at the Arab region, exploring the context for next generation digital infrastructure rollout, the main deployment models and the regional landscape to date. Additionally, it will attempt to define the prevailing regulatory and operational challenges, and the opportunities that lie ahead in addressing them through a roadmap of strategic tools and measures.

At the end, a brief overview of the changing ICT landscape will be presented, exploring the rise of the App Economy and entailing the needed shift in regulatory paradigms and in national policies.

II. Introduction

A. Context

In 2015, the U.N. General Assembly renewed the mandate of the World Summit on the Information Society (WSIS) for 10 years, until 2025. The ten-year review of WSIS high-level event[1] called for close alignment between the WSIS process and the sustainable development process. In 2025, a review of the implementation of the WSIS outcomes will be an input into the review of the 2030 Agenda for sustainable development. In this context, the WSIS process convenes an annual global forum that serves as the platform for discussing the role of information and communications technology (ICT) as a means for implementing the Sustainable Development Goals (SDGs) and for the alleviation of poverty.

The WSIS, held in two phases (2003 in Geneva and 2005 in Tunis), has the objective of reduction and eventual elimination of the digital divide. The WSIS outcomes included the Geneva Plan of Action, comprised of 11 WSIS Action Lines[2], and the Tunis Commitment[3], aiming to build a people-centered, inclusive and development-oriented information society, focused on key subject areas: Internet governance and financial mechanisms, in addition to universal access to information and knowledge, democracy, sustainable development, freedom of expression and the free flow of information. In the 2015 ten-year review of the WSIS, the overarching message was that development is digitally based, and that the WSIS process has strong links with the Sustainable Development Agenda and Goals; additionally, new topics were emphasized, including human rights, trust, security and Internet Governance.

The WSIS Process, led by the ITU, facilitates the development of the knowledge society and digital economy and supports the implementation of the SDGs, and has prepared in 2015 the WSIS-SDGs Matrix[4] that links the WSIS 11 action lines with the SDGs. These linkages emphasize the crucial role of ICTs as catalysts for the achievement of all the 17 SDGs[5], and the analysis of the connections and relations between the action lines and the targets of SDGs strengthen the link between WSIS aim of harnessing ICTs to achieve the development goals.

Within its mandate, ESCWA, similar to other U.N. Regional Commissions, continue to play a leading role in the Arab region in strengthening the impact of ICTs for sustainable development; and has in its work programme several activities related to the WSIS and SDGs. These include the Arab High-level Forum on WSIS and 2030 Agenda for Sustainable Development[6], held from 8 to 12 May 2017, at the UN-House in Beirut, Lebanon, and including an experts meeting on "Shaping the Digital Future in the Arab Region", and a conference on "Digital Technologies for SDGs".

The purpose of the paper is to study the linkages between the WSIS action line 2 with the SDG 9, with special focus on priorities and challenges related to digital infrastructure in the Arab region. This study is presented as a contribution to the Arab High-level Forum on WSIS and 2030 Agenda for Sustainable Development, May 2017, and was discussed during the session titled "Regulatory and Operational Challenges of Next Generation Digital Infrastructure".

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[1] http://workspace.unpan.org/sites/Internet/Documents/UNPAN95707.pdf
[2] WSIS-03/GENEVA/DOC/5-E, Para.4, (12 December 2003), http://www.itu.int/net/wsis/docs/geneva/official/poa.html
[3] WSIS-05/TUNIS/DOC/007-A, (15 November 2005), https://www.itu.int/net/wsis/docs2/tunis/off/7.html
[4] https://www.itu.int/net4/wsis/sdg/, https://www.itu.int/net4/wsis/forum/2016/Outcomes/#sdgs
[5] http://www.itu.int/en/sustainable-world/Pages/default.aspx
[6] https://www.unescwa.org/events/arab-forum-information-society-sustainable-development

B. Background

The past thirty years have witnessed tremendous growth in the capabilities and reach of information and communication technologies. They have become a critical enabler of social and economic change, constantly offering new ways for addressing development challenges, through creativity and innovation. Many studies performed globally have demonstrated solid links between advanced ICTs and the diversity and strength of societies and economies. With the adoption of the SDGs in 2015, as part of the 2030 Agenda for Sustainable Development, the UN General Assembly agreed upon a new approach to development. The 17 SDGs, which came into force on 1 January 2016, create expectations for governments, with the assistance of other stakeholders, to assume ownership and establish national frameworks to attain these goals. (See Figure 1.) The Agenda for Sustainable Development specifically acknowledges the role of ICTs and the Internet as horizontal enablers for development, and crosscutting means of achieving the SDGs.

Figure 1: The Sustainable Development Goals
(Source: United Nations)

The development of next generation digital infrastructure has proved to be an essential driver for the foundation of an inclusive information society that integrates ICT in all aspects of life. SDG9 calls upon governments to "Build a resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation"[7], to support economic development and human well-being. It focuses on the need for increasing universal access to ICTs and providing affordable and equitable access for all. It also draws linkages to the importance of ensuring a conducive policy environment, enhancing scientific research, encouraging innovation and supporting domestic technology development.

The World Summit on the Information Society on the other hand draws a roadmap for developing information and communication infrastructure as an essential foundation for the Information Society. Within the frameworks of national development policies and strategies, it calls upon governments, through action line C2, to support an enabling and competitive environment for the necessary investment in ICT infrastructure and for the development of new services, with special focus on promoting the development of technologies, applications and content suited for the needs of disadvantaged and vulnerable user groups. It further stresses on the need to strengthen broadband network infrastructure, encourage public/private partnerships, explore systems that can provide high-speed connectivity, and optimize connectivity among major information networks by encouraging the

[7] http://www.un.org/sustainabledevelopment/infrastructure-industrialization/

creation and development of regional ICT backbones and Internet exchange points, to reduce interconnection costs and broaden network access.

Linkages of the WSIS action line C2 with the SDG 9, were explored by the 2015 WSIS-SDGs Matrix, as mentioned in the above section. High-speed broadband has been recognized as an essential enabler of sustainable development. At the same time, harnessing ICT for development and bridging digital divides will require greater and sustainable investment in ICT infrastructure and services. In 2016, the Action Line C2 Facilitator`s Meeting focused on the "Implementation of Information and Communication Infrastructure Goals, covering technical, economic and policy aspects", as identified by the WSIS-SDG Matrix. It discussed how newest and affordable ICT technologies, in conjunction with innovative ways for funding ICT development and challenges, can be addressed to accomplish the SDGs. The various aspects of broadband implementation to be considered by multi-stakeholders were identified to include new technologies (technical aspects), affordable infrastructure (economic aspects) and public policies to foster the development of broadband infrastructure (policy aspects).[8]

Moreover, and in order to further identify intersections with the information and communication technology, especially as related to the Arab region, it is important to take a closer look at the targets identified for Goal 9, as listed below:[9]

1. *Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all;*
2. *Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries;*
3. *Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable credit, and their integration into value chains and markets;*
4. *By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities;*
5. *Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending;*
6. *Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support to African countries, least developed countries, landlocked developing countries and small island developing States 18;*
7. *Support domestic technology development, research and innovation in developing countries, including by ensuring a conducive policy environment for, inter alia, industrial diversification and value addition to commodities;*

[8] http://www.itu.int/net4/wsis/forum/2016/Content/documents/outcomes/WSISForum2016%E2%80%94WSISActionLinesSupportingImplementationSDGs.pdf

[9] http://www.un.org/sustainabledevelopment/infrastructure-industrialization/#d6c8e12dbefa1065e

8. *Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020;*

In order to achieve those targets, set out by SDG 9, it will be important for the Arab countries to focus on strategic investments in key areas such as infrastructure, research and innovation. It will be also vital to develop resilient telecommunication networks, advance innovation in technologies both on the supply as well as the demand sides, and ensure ubiquitous access to ICT is provided at affordable prices for all. Further, there is need to increase regional and transborder telecommunication infrastructure within the Arab region, by initiating policies that encourage private sector investment in regional cable infrastructure.

In this context, priorities and challenges facing the Arab region in achieving SDG9 are explored, and means of strengthening the linkages with WSIS C2 are investigated, along with their related impact on achieving sustainable development. While focusing on local and regional specificities, challenges facing the development of high-speed broadband in Arab countries are analyzed in the following sections of this document. Specifically, the development of next generation digital infrastructure and associated regulatory and operational challenges are studied within the Arab context, exploring how addressing those challenges on a strategic level can contribute to achieving the SDGs and lay the foundation for an inclusive information society in the region.

III. Next Generation Digital Infrastructure

A. The Global Landscape

For billions of people already, and for billions more to come, the Internet is fast becoming the essential infrastructure for their everyday digital interaction and services. About 3.7 billion people are connected to the Internet today, fast approaching half of the world's population, according to Internet World Stats.[10] As more critical services in high-impact areas such as healthcare, education and government services become dependent on the Internet in the years to come, access to digital services will only become more essential for everyone and we will witness a continued expansion of the digital economy. Accordingly, the digital economy is growing at more than 10% a year, significantly faster than the economy as a whole, and is expected to reach a share of 25% of the global economy by 2020.[11] (See Figure 2.) The growth of the digital economy is having a far-reaching impact in emerging markets, where it has become an increasingly important source of social change and economic growth.

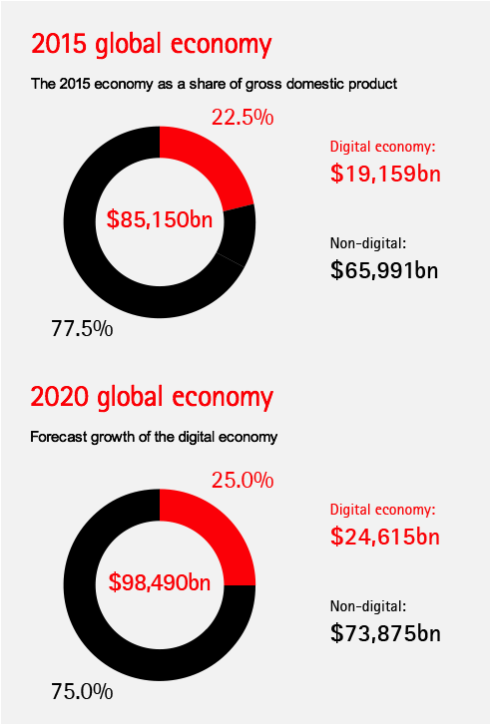

Figure 2: Outlook of the Digital Economy as a Percentage of the Global Economy (Source: Accenture)

Yet the costly and complex infrastructure necessary to carry the traffic that makes digital services possible is hardly immune to breakdowns; it needs investment and maintenance; has its limitations in terms of reach, penetration and capacity, which require continued innovations to be addressed and overcome. Most importantly, there is need for the

[10] http://www.internetworldstats.com/
[11] https://www.accenture.com/us-en/insight-digital-disruption-growth-multiplier

continuing collaboration of various partners, across governments, companies, users and others, for this infrastructure to keep functioning and further develop. It is therefore imperative to examine the landscape of next generation digital infrastructure, its present and future challenges and explore approaches for addressing them from a technological, commercial and policy perspectives, before they affect the flow of information and services that serve the digital economy.

Elements of next generation digital infrastructure can be generally grouped into three distinct blocks: networks, devices and applications. (See Figure 3) Next Generation Networks (NGN) – 'one network for all', comprise the underlying infrastructure, which provides high-speed broadband connectivity, the precondition for performing all digital transaction. A wide range of terminal devices enable user access to various applications and networks, and provide a converged user experience: any service, anytime, anywhere. In addition, billions of connected devices 'talking' to each other as concepts of IoT, M2M and smart cities start to mature worldwide. Constantly growing innovative applications in all aspects of our daily life, driving demand and network utilization in unprecedented rates.

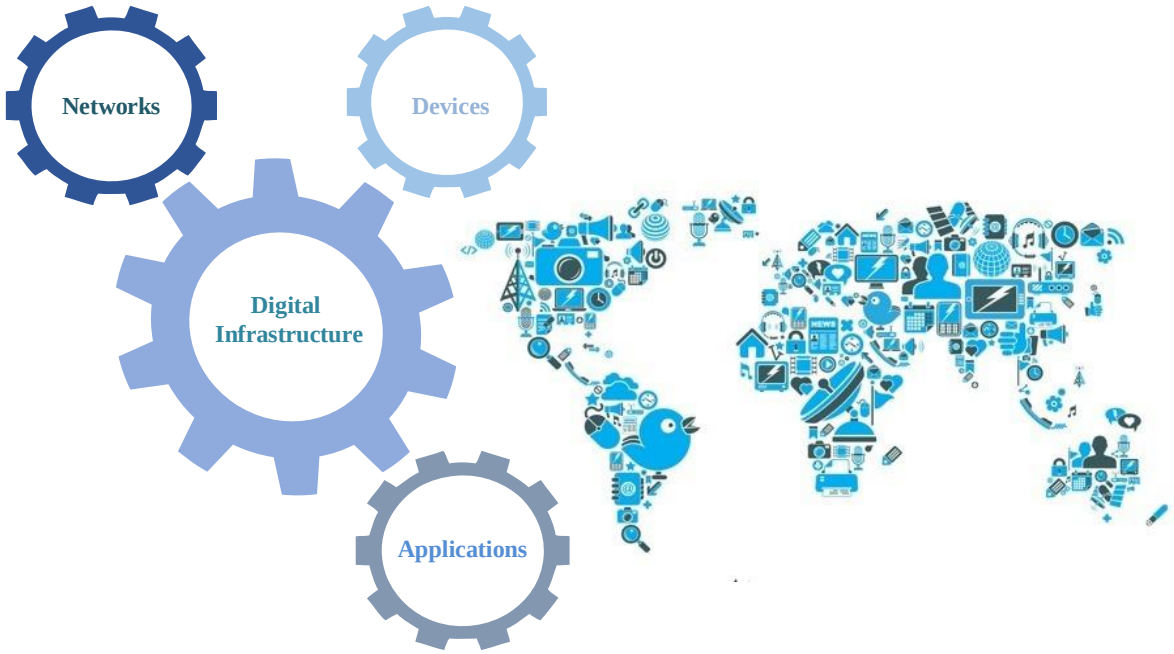

Figure 3: Elements of Next Generation Digital Infrastructure

In terms of stakeholders, it is important to understand that the digital infrastructure has its own eco-system of participants, which in a way or another contribute to its development and functioning. Telecom operators, ISPs, providers of digital services, content providers, and manufactures of hardware and software, all play an important role in constructing and maintaining the infrastructure. Another important player, are governments, which are responsible for policy making and regulations, as well as resource management, specifically in terms of spectrum for wireless and mobile infrastructure. In many instances, they also play an important role in partnering with and incentivizing the private sector to invest in and develop the next generation digital infrastructure. Other stakeholders within this ecosystem include Non-governments organizations (NGOs), industry associations, standardization bodies, multi-stakeholder associations, as well as intergovernmental organizations (IGOs), mainly the International Telecommunication Union (ITU) and the UN agency. Together, all those stakeholders, are responsible for the different building blocks of the digital infrastructure, whether fixed and mobile networks, submarine cables, exchange points, data centers, devices and network equipment, content and content delivery platforms, as well as standards and protocols. (See Figure 4.)

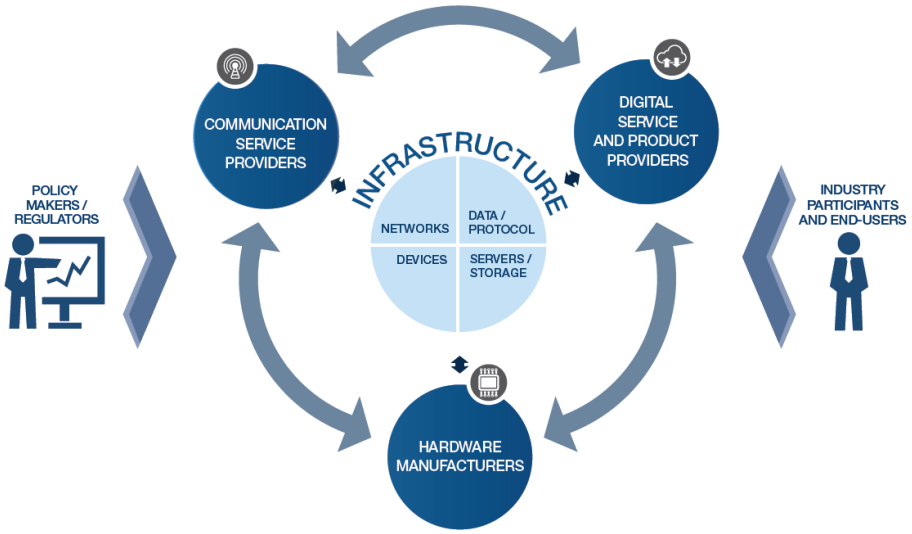

Figure 4: Stakeholders of the Digital Infrastructure Eco-system (Source: World Economic Forum)

In terms of technologies, broadband networks continue to grow worldwide, with fixed networks providing higher levels of achievable speeds and capacities that outstrip capabilities of mobile networks. Fixed broadband deployments take many forms either through investment in cable infrastructure, upgrades to the inherited fundamental copper-based networks, or deployment of FTTX technologies, including all flavors of FTTH, FTTP, FTTC, … etc. Figure 5, shows fixed broadband active connections, by technology, and the share of Next Generation Access Network (NGA) connections worldwide 2011–2020, as per an Analysys Mason Report. Since future demand is unquestionably strong, the rationale for investment is directly related to evolving user needs, to the need to create fixed networks with lower OPEX and to build backhaul and transmission networks that are highly distributed to cater for future mobile and wireless requirements.

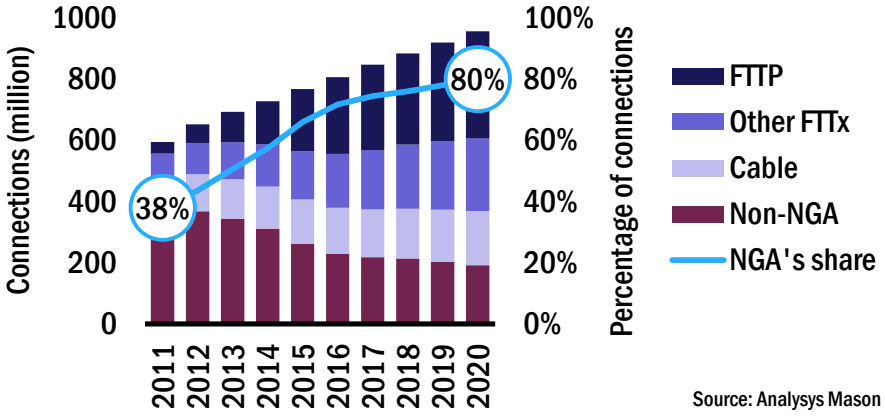

Figure 5: NGA Connections by Technology Worldwide 2011–2020 (Source: Analysys Mason)

In general, the deployment of next generation networks is driven by evolving user needs and trends, which are marked with increased broadband speeds, more and more video, and growing mobile and wireless devices. According to the CISCO Visual Networking Index (VNI) Forecast 2015-2020[12]:

- Monthly IP traffic will reach 25 GB per capita by 2020, up from 10 GB per capita in 2015, accounting for a threefold increase in global IP traffic over 5 years. In more familiar terms, global IP traffic in 2020, which will reach 511 terabits per second, will be equivalent to 142 million people streaming Internet high-definition (HD) video simultaneously, all day, every day, or to 58 million DVDs per hour.

Year	Global Internet Traffic
1992	100 GB per day
1997	100 GB per hour
2002	100 GBps
2007	2,000 GBps
2015	20,235 GBps
2020	61, 386 GBps

Table 1: The Cisco VNI Forecast (Source: Cisco)

- Smartphones traffic in 2020 will reach 30 percent of total IP traffic, up from 8 percent in 2015, and traffic from wireless and mobile devices will account for two-thirds of the total IP traffic by then.
- Globally, mobile data traffic will increase eightfold, between 2015 and 2020, growing almost three times as fast as fixed IP traffic and reaching 30.6 exabytes per month by 2020.
- Fixed global broadband speeds will nearly double, reaching 47.7 Mbps in 2020, up from 24.7 Mbps in 2015.
- Global IP video traffic will grow threefold from 2015 to 2020, as every second, a million minutes of video content will cross the network by 2020, while Internet video to TV traffic continues to grow at a rapid pace, increasing 3.6-fold by 2020.
- Virtual reality traffic will increase globally 61-fold between 2015 and 2020.

In this context, it is worth noting that IP traffic is growing fastest in the Middle East and Africa (followed by Asia Pacific), as it will grow at a CAGR of 41 percent between 2015 and 2020, reaching 10.9 EB per month by 2020. Noting this tremendous growth in user needs, the coming section will take a closer look at the main drivers for NGA rollout from a supply and demand perspective.

B. Drivers for NGN Rollout

There is broad consensus that rollout of next generation networks is a key driver for sustainable development. There is also general agreement on the supremacy of capacities provided by fibre technology. So far, modernization and upgrade of the fundamental copper-based networks have been possible, but clearly, the time has come to move decisively to fibre. Further upgrades to copper work only for short network segments close to the user's premise. Complete or mainly fibre networks are now needed not only to provide very fast fixed access, but also to accommodate the needs of the latest mobile backhaul networks.

However, the rollout of NGAs and fibre deployments, have not been equally successful everywhere. They are being implemented with a great level of variety from one region to the other and from one country to another. As one might think, many factors drive the rollout of NGA and influence the pace at which various forms of fibre deployment (different FTTx models) take place in different countries. The Body of European Regulators for Electronic Communications (BEREC) identifies three

[12] http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/complete-white-paper-c11-481360.html

main categories of drivers for NGA rollout: supply side factors, demand side factors and the degree of infrastructure competition.[13]

Supply side factors are all those factors that directly (or indirectly) affect the cost and quality of fibre deployment. They can vary greatly even within the borders of the same country, favoring FTTC in some areas and FTTP in others. They are mainly related to:

- **Population density and urbanization:** The more an area is populated, the lower are the per unit investment costs. FTTP is more likely to be rolled out in densely populated areas whereas FTTC is more likely to be deployed where the population is more dispersed.

- **Network related factors:** Network factors are an important driver of the type and extent of NGA rollout. The availability of high quality ducts, especially for the last mile, greatly decrease the deployment costs for FTTP. Where there are less ducts, FTTP deployments require additional civil works, which significantly increase costs, making deployments of FTTC/VDSL more viable. The quality of the copper in the last mile, as well as the legacy network architecture, also affect the cost and the choice of NGA technology deployment. Shorter local loops and higher quality of the copper last mile decrease FTTC/VDSL costs and reduce their time to market. Other technologies such as G.fast and VDSL vectoring can provide much higher speeds but require regulatory approaches that allow for operator exclusivity. In many cases, other infrastructure ducts (of utilities) can also be used to push NGA rollout. This requires sharing or co-investment agreements between infrastructure owners and telecommunication network operators

- **Retail prices:** Service revenues and investment incentives are directly affected by retail prices and hence influence the NGA deployment plans. Retail prices are determined by supply and demand, but from the supply side, they are generally influenced by the cost of service delivery, the level of competition and the associated regulatory requirements. While factors such as civil work can greatly increase the cost of service delivery, initiatives by government or municipalities for demand aggregation, can on the other hand enhance the business case. In many cases, price competition also plays a role in driving retail prices, such as prices of mobile broadband or cable services.

- **Legislative factors:** Legislations, such as those mandating access to ducts for example significantly decrease FTTP deployment costs. Other examples include legislations for incentivizing broadband take-up, by making household expenses associated with the installation and maintenance of broadband connections tax deductible (like for example in Germany and Denmark).

- **Investment from municipalities / government initiatives:** Owners of passive infrastructure, such as utilities or municipalities, can play an important role in advancing fibre rollout by lowering deployment cost. This is especially true where infrastructure competition is lacking or return on investment is considered too low by private investors. Some forms of government aids are most commonly coupled with coverage obligations and obligations to provide wholesale access to interested service providers.

Demand side factors cannot be created or enhanced by directed regulations. Nevertheless, their presence are quite impactful in accelerating NGA rollout. Demand for NGA-based services can come either from individuals and private companies, or from the public sector, such as demand coming from schools, health sector or public administrations. Public sector demand largely depends on government

[13] http://berec.europa.eu/eng/document_register/subject_matter/berec/reports/6488-berec-report-challenges-and-drivers-of-nga-rollout-and-infrastructure-competition

initiatives to digitalize public services. Examples for such initiatives include e-services in education, health and social care over broadband networks.

On the level of individuals and private sector, the existence of next generation applications and the willingness to pay for premium connections with higher capacities is the main driver for increased take-up rate of broadband services. The willingness to pay is generally relates to the value perceived by users for capacity-intensive services (for example IPTV, HD TV and video streaming applications, financial and public online services, social media or others), which trigger the need for higher bandwidth. In terms of private sector, financial institutions and ICT sector companies are the ones with higher needs for bandwidth, quality and redundancy, and they tend therefore to drive the demand and accordingly the rollout of fibre technologies.

It is worth noting that supply and demand are interdependent driving forces. Higher demand obviously triggers investment in more NGA deployment, but also the availability of high speed connections foster an increased use of high capacity service and elevate accordingly the demand.

Finally and most importantly is the presence of market competition and competing technologies. Infrastructure competition is probably the main factor that drives NGA deployment. In some cases, where enabled by regulations, independent FTTP network providers, play a considerable role in driving incumbent rollout of NGAs, either through competition forces or by fostering infrastructure sharing. Competition from cable operators equally drive NGA rollout (mostly irrelevant for the Arab region given the absence of cable services). On the other hand, mobile operators, with the rollout of LTE, can offer bandwidths, which are generally higher than those offered by copper. Nevertheless, mobile broadband services, despite the advancement in technology, are usually offered with capped usage limits, mainly because of spectrum scarcity. Accordingly, mobile broadband might not count as a direct competitor to fixed broadband. In fact competition from mobile has mostly led to lowering entry-level prices, which in the absence of users' willingness to pay for higher capacities, has made investments in fibre technologies more difficult.

Based on the combination of the aforementioned factors, countries are in different positions in terms of NGN deployment and the pace at which rollout takes place. As mandated, policy maker and national regulatory authorities (NRAs) work to develop a clear vision for their county-specific NGN targets, in terms of coverage, technologies and adoption rate, that is mostly dependent on situational factors. They strive to provide a favorable environment for investment while maintaining sustainable competition in their markets. Accordingly, different business and regulatory models for NGN deployments have emerged. The following section will attempt to shed light on some of those.

C. Emerging Models for NGN Deployment

Fulfilling National Fibre goals requires full collaboration of all local stakeholders, including industry and government. One of the main challenges that policy-makers face when devising necessary strategic models to attain those goals is how to achieve national economic benefit of fiber infrastructure while managing the considerable investment required. Various business and regulatory models, which generally require sophisticated public and private coordination, have emerged globally and have been implemented within different countries. A study by Arthur D. Little, on National Fibre Strategies[14], identifies five distinct strategic models implemented by countries around the globe:

- Private investment, unregulated;
- Graded government support, incumbent led;
- Graded government support, private led;

[14] http://www.adlittle.com/downloads/tx_adlreports/National-Fibre-Strategies_ADL-Report_HR.PDF

- Government controlled fibre;
- Private investment and heavy regulation.

Every model is characterized by a different source for funding, whether public, private or PPP, and by which entity is undertaking the rollout, be it the private sector, the incumbent, or a special purpose vehicle (SPV). Another characteristic is the level of regulatory intensity, whether heavy regulations or regulatory holiday. Determining the level of public investment is based on the involvement of government as investor or operator, while the level of regulatory intensity is determined based on the obligations imposed on fibre operator and the type of infrastructure sharing chosen. The degree of regulatory intensity, ranging from low (freedom) to high (mandatory open access and regulated pricing), combined with the degree of public investment, ranging from zero to full public funding, constitute the distinction between the various models. The more public funding is provided, the higher the related degree of policies and regulations for using the associated assets. Situational factors within each country play an important role in the choice of the most adequate model. Those include demographics, legacy technology, level of network competition, government intent and regulatory preference. (See Figure 6.)

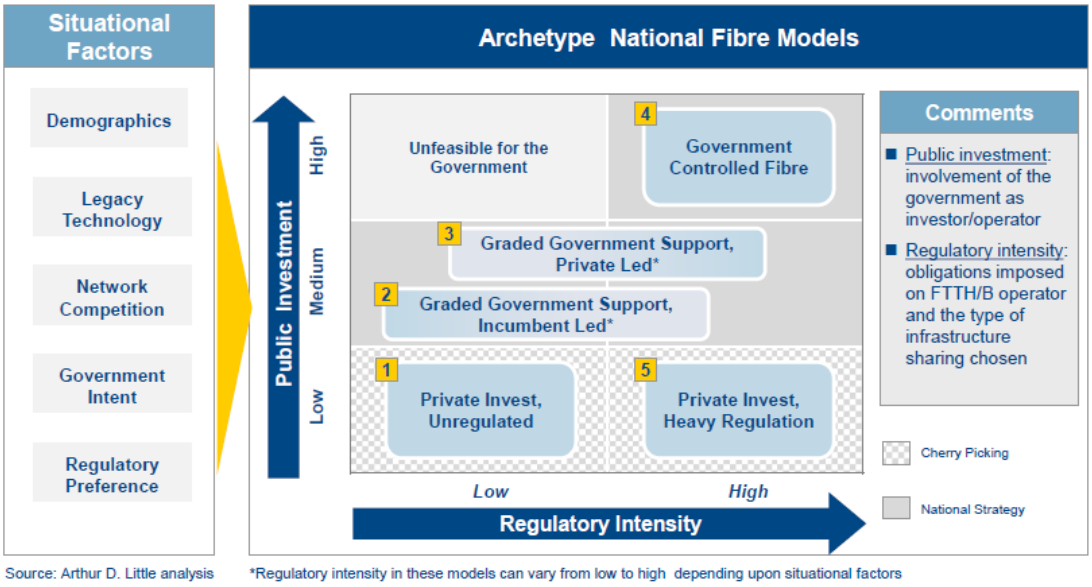

Figure 6: Global Analysis of National Fibre Models (Source: Arthur D. Little analysis)

For each of the above models there are pros and cons. There are also leading and lagging examples if we consider implementations by different countries. Generally, it is safe to say that there is a global tendency towards adopting a hybrid approach, where financially viable or attractive areas remain open for competition through private sector investment, while areas with lower viability are selected for controlled public support. It is also clear that some form of public support is essential to advance fibre deployment, as private investors would mainly choose to target optimal coverage, postpone medium profitability areas and almost never address non-viable locations.

Overall the choice of an adequate national strategy for NGN rollout, is not a simple decision, it requires thorough analysis of the local market conditions and the specific situational factors within a country. It is also important to remember that the role of government and the regulator should focus on coordination and overcoming challenges, like, for example, facilitating the sharing of utilities or municipalities infrastructures. Regulators should define, for supported areas, clear rollout parameters (coverage targets, speed, QoS, etc.) and maintain regulatory certainty. Competition at services level should be separated from infrastructure, for which differentiated regulations are applied. Further, the

focus on demand support policies and developing critical verticals is equally important as financing fibre rollout.

IV. Context of the Arab Region

In the Arab region, similar to other regions, the Internet and ICT usage are still low, but the growth rates are higher than elsewhere. The ITU indicates in its ICT Facts and Figures report of 2016, a percentage of 41.6% for individuals using the Internet in the Arab region. This is significantly lower than the percentage for developed countries, which accounts for 81%, and is slightly lower than the world average of 47.1%.[15] (See Figure 7.)

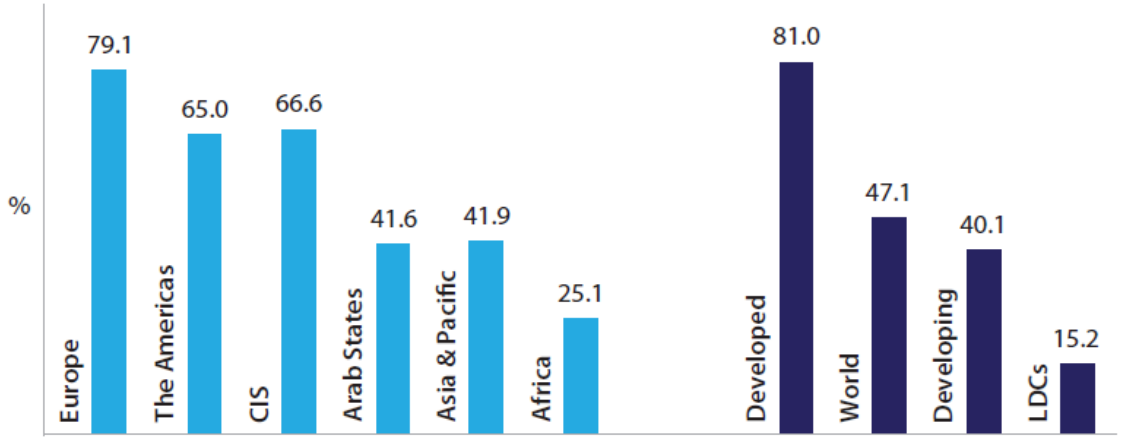

Figure 7: Percentage of Individuals Using the Internet (Source ITU)

With respect to broadband, IDATE indicates more than 29.2 million fixed broadband subscribers and 162 million mobile broadband subscribers in MENA[16] as of September 2016. The average percentage of fixed broadband subscribers of the total Households various greatly within the region from one country to another, with GCC countries having the highest average of 69% and the North African countries having the lowest of 21%. ADSL is still the leading access technology for fixed broadband services, but with increased demand for higher capacities, an intrinsic move towards NGNs can be observed. In countries such as UAE and Qatar, FTTP[17] can be seen already leading the fixed broadband market, while in other countries, mainly within the GCC area, a growing FTTP market can be observed. FTTP subscribers represent around 9% of total fixed broadband subscribers in the region as of September 2016.[18] On the other hand, for many end users in the region, mobile broadband is the leading choice, where 4G deployment has been mostly extended. The region is also starting to see some 5G deployment agreements in countries such as Kuwait, Qatar, Saudi Arabia and UAE.

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[15] ITU ICT Facts and Figures 2016 http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2016.pdf

[16] The definition of the MENA region is different than the Arab region as it includes Iran and depending on the definition excludes Djibouti, Mauritania, Somalia and Comoros.

[17] Also referred to as FTTH/B

[18] http://www.ftthcouncil.eu/documents/Reports/2015/IDATE-FTTH_Panorama_MENA_Sept_2016.pdf

A. Main trends of NGN Deployment in the Region

When exploring NGN deployment and fibre take-up in the region, it is interesting to observe not only the increase in subscription rates, but also the growth in subscriber numbers as a ratio of the number of homes passed. These numbers, which indicate the growth in NGA service take-up, seem to be improving for the region. From 2015 to 2016, fixed broadband subscribers using fibre, have increased to 9.2% in 2016 (growing from 7% in 2015), while subscription rates for homes passed by fibre have reached an average ratio of 44.8% (growing from 39% in 2015). FTTP subscribers have grown 26.2% from 2015 to 2016, in comparison to the 20% growth from 2014 to 2015. (See Figure 8.) This is an indication that not only are NGNs being deployed based on national strategies, but also that there is an increased interest by customers in adopting the technology, even if it remain overall quite low. With incumbents (and alternative operators in few cases) being the main players involved in FTTP rollout, it is expected that national programs and commercial evolutions of networks will boost NGN market in the region in the middle to long term.

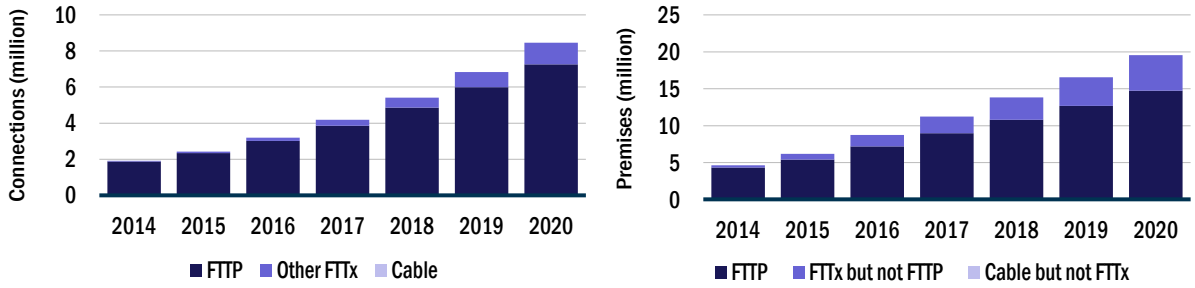

Figure 8: NGA Connections and Homes Passed in the MENA Region 2014-2020 (Source: Analysys Mason)

Nevertheless, there is great variance in terms of plans or approaches for NGN deployment, as well as their maturity across the Arab region. This is to be expected given the immense diversity in terms of infrastructure, political situation and economic development. There is a clear contrast between very little development in some countries and major upgrades, mostly triggered by monopoly fixed access, in other countries. (See Figure 9.) Clearly, there is no "one size fits all" model, and the best policy in any particular country will vary depending on local circumstances.

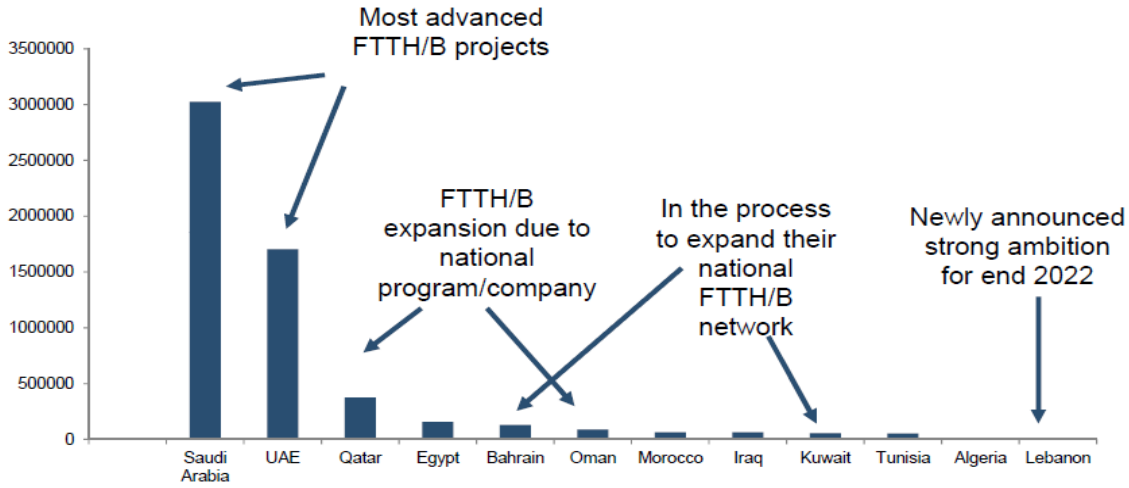

Figure 9: NGNs in the Arab Region: FTTH/B Homes Passed (Source IDATE)

Some NGN markets in the region, have demonstrated a vibrant and dynamic nature, such as in UAE, Saudi Arabia, Qatar and Oman, while other markets have observed ambitious announcement for progress, such as Bahrain, Kuwait and Lebanon. Other markets may have high potential, but seem to be steadier with few evolution and no significant plans. These variations in terms of investment in FTTx between markets of the region reflect the difference in income levels across the region.

In the GCC area, we see Qatar and the UAE having almost 100% coverage for FTTP, Saudi Arabia's incumbent and MNO[19] gradually rolling out FTTP, Bahrain being in a strong build-out phase and Oman's incumbent moving from basic ADSL to the using of the FTTP infrastructure being rolled out by the state-owned Oman Broadband Company. While in markets beyond the GCC area, there seems to be on average less investment in FTTx and in renewing the fixed access infrastructure, with FTTx coverage remaining too selective, for conversion levels to be meaningful.

Overall, most NGN deployments in the region remain mainly FTTP centric. In general, the near-absence of infrastructure-based competition from cable broadband has reduced in many instances the commercial incentive to invest in new NGA. Nevertheless, as mentioned earlier, conversion and take-up rates, in areas where FTTP has been rolled out, are quite high, which is typical for replacement networks and which reflects that replacement is preferred to overlay strategies. High FTTx ARPU in GCC countries is remarkable, although the conversion of pay-TV subscribers (all satellite-based) to broadband-based access remains a challenge. Second fixed NGA infrastructures in the region are few (only in KSA and Qatar), and their take-up is lower than the incumbent NGA. Bitstream network sharing on FTTP networks remains uncommon in the region, yet it is mandated in UAE and Qatar.[20]

In terms of development of fibre deployment and take-up rates between 2015 and 2016, reports by IDATE indicate the following:

- Algeria has a 10% increase in their subscribers and static position in their fibre projects and no variation in the amount of homes passed by fibre;

- Bahrain has a 56.3% increase in fibre subscribers, and a 44.4% increase in homes passed;

- In Egypt, the incumbent has started upgrading parts of its copper plant to fibre in 2014, with the aim to connect 4 million premises, using a phased FTTC deployment. Fibre subscribers have increased between 2015 and 2016, by 11.2% and the homes passed by 5.1%;

- In Jordan, there is a 6% of increase in fibre subscribers, but no clear projection of growth in homes passed;

- Kuwait's fibre subscribers increased by 64%, showing a take-up rate of 44.7%. There is a national plan that will increase FTTH homes passed to 67,000 by 2017 and to 100,000 in 2018;

- In Lebanon, a plan was announced to increase the number of FTTH homes passed to cover 600,000 by the end of 2017;

[19] Mobily is one of the few MNOs in the region to invest in fixed broadband infrastructure, although this is now quite common in the Asia–Pacific region.

[20] TRA directed Etisalat and Du to provide reciprocal bitstream services to each other, thereby enabling each operator to use the other's fiber access network.

- In Morocco, an increase of 52.3% in the number of homes passed is observed, marking 60,000 homes passed by Q3 2016 and 2500 subscriptions. This indicates a move towards fibre deployment in order to be ready for future fibre services, but a much lower take-up rate;

- For Oman, its fibre subscribers have increased 392%, while homes passed increased 23.1% and are estimated to reach 107,500 homes by September 2017;

- Qatar has almost ubiquitous FTTH coverage and is showing a growth in subscribers of 19.4%. In addition, the country is leading, with UAE, the ratio of fibre subscribers per households in region. By September 2016, this ratio reached 75.64% which is the result from 295,000 fibre subscribers and 375,000 homes passed, a significant take-up rate;

- For Saudi Arabia, the country has the largest FTTH coverage in the regions, with an increase in homes passed by 3.9% (reaching 3.02 million homes) and also an increase in their subscribers by 12.1% (reaching 684,520 subscribers);

- Tunisia has marked an increase of 101.6% of its fibre subscribers during 2016. However, the number of homes passed only increased 17.6%, from 2015 to 2016. This evolution shows a commercial focus to increase the subscriber base by telecom operators, but a much lower interest to expand their fibre networks;

- UAE has an FTTH coverage of 94% as of 2016.[21] By September 2016, there were 1,512,690 FTTH/B subscribers and 1,703,176 homes passed, resulting in a take-up ratio of 88.8% (fibre subs/households). The two telecom operators in the country have confirmed to have all their network based on fibre;

As for other countries within the region, there is no clear information on fibre take-up.

In terms of service offerings (prices and speeds), the region is clearly trying to enter the Gigabit race, but NGA prices and service offerings remain quite high. There are speed rates as high as 1 Gbps available in countries like UAE, Qatar and Bahrain, but the most widespread speed rate for NGA services is 100 Mbps, available in Oman, Jordan, Saudi Arabia and Tunisia. In the GCC area, most operators provide innovative converged TV and video services on their new NGN infrastructure. FTTH tariffs are relatively expensive, as retail prices can go as high as 600 USD per month for a 100 Mbps FTTH connection. The overall average for the region is quite high compared to other regions. (See Figure 10.)

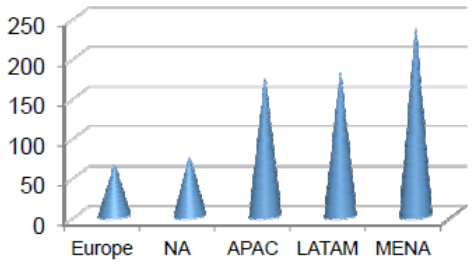

Figure 10: Average Monthly Cost for a 100Mbps (Source IDATE)

B. Regulatory and Operational Challenges of NGNs in the Region

In view of the status of NGN deployment in the Arab region, and in light of the various drivers for NGN rollout and the models emerging globally, this section will attempt to identify the main challenges and provide general policy recommendations, aiming to contribute to continued development of next generation infrastructure in this region. No doubt, any policies that best fit a particular country will vary depending on local circumstances. Nonetheless, moving as far as possible on each dimension will bring benefits to the particular NGN deployment in each market. However, the merit behind each policy

[21] UAE is leading the global FTTH ranking

recommendation should be tested and debated against situational factors and applied as appropriate in the different markets. The overall objective being to advance the contribution of next generation digital infrastructure and ICT as a whole to the development agenda, in order to achieve the sustainable development goals in the Arab region.

Generally, it is possible to observe four main groups of challenges: the governance dimension, regulatory intensity, affordability of prices and demand side levers. (See Figure 11.)

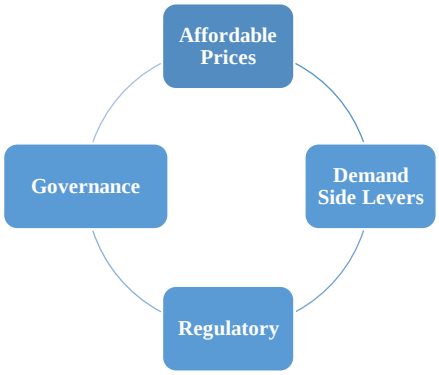

Figure 11: Regulatory and Operational Challenges

Within the **Governance** dimension, policy makers within the region should look at challenges of choosing the right models for financing NGNs and the appropriate execution vehicle. In that respect Governments are encouraged to examine the status of their digital infrastructure, assessing the limitations of private sector coverage and deciding whether existing access networks need to be upgraded and extended.

In some countries within the region, there may be need for stimulation by government through a national broadband network (NBN). The goal of an NBN would be to provide ubiquitous coverage, by building an extensive open fibre network, especially in areas where the private sector's rate of investment is not adequate enough. As said NBN investment is mostly dedicated to fibre, being a future proof technology that is able to provide the needed high speeds, nevertheless, NBN could also rely on wireless systems in low-density areas, such as LTE, WiFi and satellite.

Even in cases where direct government funding is not favored, there is a stimulating role that government can play through public-private partnerships, particularly as a catalyst for essential infrastructure projects. Public-private partnerships are a way to get big infrastructure projects off the ground, although it is important to ensure that the capabilities and experience of private market players are not lost and that public sector involvement does not lead to market distortions.

On the other hand in areas where existing operators are willing to finance new networks, usually more likely in urban areas, then there seems little reason for the government to intervene. Universal service charges should be imposed on those networks in order to support the NBN's operation in uneconomic areas. Overall an NBN should avoid overbuild in urban or economic areas, and should rather build a complimentary infrastructure footprint, focusing on areas that will never be served by the other operators, or will take a very long time to be served. Overbuild of fixed infrastructure greatly increases payback times for all operators and the capital spent on overbuilding in urban areas inevitably delays investment in rural areas, which represent the real problem for infrastructure coverage in most cases.

As said another challenge that needs to be studied according to local market conditions, is the choice of the execution model, which could be anywhere between a government controlled fibre, a graded government support that is incumbent or private led, or a private investment that has a specific regulatory intensity anywhere from fully unregulated to highly regulated. Obviously no one model is right or wrong, although the graded government support models are said to be most efficient in using public funds, while maximize speed, efficiency and coverage. Moving to a hybrid graded government support approach, would entail for NRAs in the Arab region to keep lucrative areas open to competition, while providing controlled support in areas that are less financially attractive. Controlled support means defining rollout parameters, coverage target, minimum speeds and quality of server parameters. In addition, NRAs would work to facilitate utilities and municipalities building and sharing of essential infrastructure. Competition pressure in this model would be applied at service level, completely

separated from the infrastructure level, which in that case would benefit from moderate, graded regulations in selected areas only.

Further, on the **Regulatory** dimension, the challenge is to choose adequate regulation intensity. This should address how competing services providers can access major fiber investment at reasonable prices in order to provide maximum benefits to end users, while at the same time ensuring that NGN operators have a return on investment. Regulatory frameworks and strategies that define how competition is to work must be clear or else they would constitute barriers to investment, since investors cannot risk large amounts in markets with un-clear regulations.

A said in areas where it may not be possible to have more than one NGN infrastructure, it is will be critical to regulate access rules and prices for using this network, while ensuring that NGN is built efficiently and at lowest cost. For that, NRAs would focus most on areas with the least competition, which are the ones with the highest barriers to market entry. It may be therefore effective to use for unattractive areas, a graded government support model, which is characterized by a differentiated regulation and public funding combined with hybrid models in investment.

Generally, it is worth noting that NRA's in the region need to consider the wider perspectives of regulations, not just network and telecom regulations. They should examine the overall national needs, which cover demand side as well as supply side issues. Furthermore, within the supply side they need to consider more than just the telecom operator's supply but consider beyond that the wide range of end-user services that are possible over the NGN infrastructure.

Regarding **Affordability**, as mentioned earlier, retail prices for NGA service offerings in the region remain comparatively high with respect to other regions. Working on different dimensions to apply cost reduction measures is imperative. One way is to reduce IP transit costs, possible through the establishing of Internet Exchange Points (IXPs) to encourage local peering and the localization of traffic. This needs to be coupled with national policies that create a favorable environment for local data centers and for Content Delivery networks (CDNs).

A further measure is to address the Right of Way challenge in order to minimize costs associated with new infrastructure built and civil works. Governments and NRAs in the Arab region have an important role to play in this, by working closely with municipalities, as well as with utility owners, to avail access to ducts and/or expedite work approvals and coordinate civil work as needed.

Infrastructure sharing is another important measure to consider. In order to reduce the costs of network deployment, and to facilitate competition among operators, sharing of ducts and poles can be mandates. Such measures are mostly imposed on incumbent operators, based on an asymmetrical SMP regulatory approach. This can considerably reduce the retail cost to the end-user.

On the **Demand** side pillar, countries of the Arab region need to work on stimulating government demand while at the same time increasing demand from vertical sectors and from private companies. In that respect, it is critical to consider the NGN policy within a broader national digital agenda, in which national initiatives are adopted to connect the various government agencies to high-speed networks and make available public services through NGN platforms. It is also important to devise initiatives by government or municipalities for demand aggregation, as this can greatly enhance the NGN business case. In addition there is need to move on national level towards a complete adoption of ICT within the various verticals, especially those that are mostly critical for the region, such as the education and healthcare sectors. This can be achieved by mandating governmental agencies and ministries to connect to fibre, while at the same time adopting nationwide initiatives such as e-government, e-learning, e-health and others. With respect to increasing demand from the private sector, it may be necessary to apply supporting mechanisms to encourage the adoption of NGN services, such as tax incentives.

Generally, it is important to stress that the demand side pillar is critically important to leverage next generation digital infrastructure in order to achieve innovation and sustainable development. The supply network infrastructure is only one-half of the equation, and maybe even less, without a serious strategic plan to stimulate demand, it will not be possible to ensure a successful nationwide take-up of NGNs.

V. Rise of the App Economy and the Need for New Regulatory Paradigms

While this may not be the main focus of this paper, it is not possible to study Next Generation Digital Infrastructure, without considering the disruptive change that is taking place due to the rise of the App Economy. The App Economy, Over the Top Services (OTTs) and the Sharing Economy are all new names for a set of phenomena that represent a new episode of growth for the global ICT industry. This growth is based on the rapidly approaching ubiquity of handheld computing devices, increasing wireless bandwidth, rapidly maturing cloud services and the ongoing development of mobile operating systems and their associated apps.

Smartphones and tablets have a far bigger reach than computers in emerging economies. This increased reach is quite significant for the Arab region as it brings along a bigger user base and leads to enormous economies of scale. Systems built by app companies are clearly in a race for scale, and some are already spanning the world. We are starting to see near monopolies occupying various market niches, a phenomenon that is disrupting classical ICT business models and legacy regulations, in Arab countries as well as elsewhere in the world. The network effects that make app systems more valuable, with the tremendous increase in user number, is posing many challenges but also great opportunities to economic development in this region and beyond. (See Figure 12.) Facebook for example, which is an app that enjoys great popularity in Arab countries, is specifically powered by the great number of users it enjoys. App systems such as Uber and AirBnB are more attractive to users, when a greater number of drivers or rooms become available; at the same time, more users attract more drivers and rooms. This is a 'virtuous circle' that drives the growth of the biggest players.

Figure 12: Challenges and Opportunities for the Telecom Sector

No doubt, the transformation effect of the app economy on the broader economy is massive. As far as the telecom sector is concerned, the impact to existing market dynamics is disruptive and is causing a

clear power shift. On one side, apps and OTT services are rapidly driving demand for greater bandwidth and higher take up of NGNs, but on the other side, they are increasingly eating up on revenues and disrupting business model of classical telecom operators. It is giving rise to technology-driven companies, that are directly competing with the telecom operators and undermining consumer demand for classical telecom services. The capacity of operators to invest in NGN is increasingly being hampered, especially in regions with emerging economies. At the same time, significant regulatory imbalances are developing, specifically between traditional service providers and new apps and OTT providers, mainly in terms of applicable laws, taxes, licensing, QoS, interconnection, price regulations, privacy, lawful interception and others. There is therefore an urgent need to move towards new regulatory paradigms that address those challenges and open up opportunities. (See Figure 13.)

Figure 13: Evolution of Telecommunication Regulation over Time

It is important to understand that the traditional linear relationship between operator and subscriber, that has so far been local, is becoming rather global and may even no longer exist. Regulatory frameworks therefore must evolve as markets evolve, into future proof regulations, where concepts of technology neutrality and flexibility mark the necessary new arrangements and tools. Regulations need to focus on supporting innovation, enabling investment, stimulating competition, as well as ensuring consumer protection, data protection and privacy. The optimal approach to the rise of the app economy does not necessarily mean more regulation but rather better regulation.

It is also necessary to realize that established business models should not be punished, relative to newcomers, for complying with regulations, nor should new businesses be punished for innovating. This poses real challenges on harmonizing regulations between new and old businesses, which will become a necessity as all industry sectors are transformed. In doing it will be crucial to rethink the original motivations for regulatory interventions and the way in which new technologies can potentially provide innovative tools to address the original problems that were addressed by regulations. An example for that are reputational rating tools provided by crowd sourcing in comparison to traditional licensing, which both provide mechanisms to address consumer protection problems.

Further, it is vital to acknowledge that regulatory challenges span beyond the telecommunication industry. For instance, Uber is 'disrupting' the taxi business and Airbnb is doing the same to the accommodation sector. Clearly, the emergence of the app economy has implications for regulatory practices across multiple dimensions of the economy. This will give rise to collaborative regulations, where regulators, previously operating in isolation, will increasingly need to collaborate across industries and other domains to develop new regulatory approaches.

Finally, achieving collaborative regulation will require cross-sectorial work practices that focus on various pillars. One being, to establish inclusive dialogue across the different sectors and authorities (competition, customer protection, etc.…), another the sharing of guiding principles and best practices with other sectors on issues where ICT and telecommunications may be leveraged. Other pillars include defining mechanisms for effective coordination and accountability across the various sectors, as well as creating working synergies for ongoing dialogue and regulatory cooperation.

VI. Conclusion

The tremendous growth in the capabilities and reach of ICT is constantly offering new ways to enable social and economic change and address development challenges through creativity and innovation.

Stimulating the development of next generation digital infrastructure in the Arab region and addressing associated regulatory and operational challenges on a strategic level, can contribute to achieving the SDGs and lay the foundation for an inclusive information society in the region.

The growth in IP traffic in the Arab region is highest compared to other parts of the world, and user needs are evolving at a fast pace, however, the rollout of NGN and fibre deployments has not been equally successful everywhere in the region.

Moving from first-generation to second-generation broadband will require continued investment in network infrastructure. Policymakers and regulators will need to examine incentives to promote investment in NGN deployment and preserving competition given the local situational factors.

Stimulation through public support may prove necessary, especially in economically unattractive areas, where a graded government support model should be applied, characterized by public funding, differentiated regulations and a hybrid investment model.

Cost reduction measures need to be applied to address the high prices of NGN service offering that pose an affordability challenge and hamper take-up in the region.

Regulators need to examine overall national needs, covering both demand and supply side issues, and stimulate demand through nation strategic plans focusing on public and private sector programs.

The disruptive nature of applications makes it compelling for regulators to establish cross sectoral co-ordination procedures to ensure consistent regulation and comprehensive inter-working arrangements.

Next generation infrastructure mandates collaborative regulatory measures where the applicable regulation on all market players is converged, coherent, promotes competition and provides incentives to invest and be innovative.

There is merit in applying a conservative approach, adopting only as much regulation as is necessary and giving markets the opportunity to innovate and find appropriate solutions that meet consumer needs.

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