Middle East & North Africa
Internet Infrastructure

Internet Society

MIDDLE EAST & NORTH AFRICA INTERNET INFRASTRUCTURE

Draft paper

by Michael Kende

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01

SECTION 1. INTRODUCTION

The Internet provides significant economic and social benefits for countries, regardless of their current state of development. It enables developing countries to grow and helps to meet the United Nations Sustainable Development Goals; it enables emerging economies to accelerate the process of joining the global economy; and it helps more advanced countries sustain their progress and develop a competitive advantage.

For users, it facilitates education and access to healthcare; it can provide training and help to find employment; and it can help entrepreneurs to turn their ideas into innovations, and their innovations into income. Internet applications can bring together families, friends, and colleagues, they can help citizens interact with their governments, and they can provide news and entertainment.

The Internet Society has long supported and promoted the development of the Internet as a global technical infrastructure, a resource to enrich people's lives, and a force for good in society. In this mission, we have developed a policy framework for enabling Internet access, which has three components: expanding infrastructure; fostering skills and entrepreneurship; and supportive governance[1]. In this paper we focus on expanding and upgrading infrastructure in the Middle East and North Africa region.

The paper builds on a large body of work conducted by the Internet Society with relation to barriers to investment in infrastructure[2], the benefits of having local Internet traffic exchange points[3], the benefits of hosting content in the country[4], and the means to promote the development of content[5]. While these papers were written for other regions, they developed a number of relevant learnings and concepts.

The newly established Internet Society Middle East Bureau now seeks to apply the learning of those papers to the Middle East and North Africa (MENA) region; papers on the other elements of the enabling environment – capacity building and governance – will follow. This paper builds on a significant level of engagement in the region, based on workshops in Saudi Arabia, Kuwait, and Oman attended by participants throughout the region, as well as further discussions and inputs from stakeholders in other countries not able to attend in person.

[1] "A Policy Framework for Enabling Internet Access" (Internet Society, April 2017), https://www.internetsociety.org/wp-content/uploads/2017/08/bp-EnablingEnvironment-20170411-en.pdf.
[2] Robert Schumann and Michael Kende, "Lifting Barriers to Internet Development in Africa: Suggestions for Improving Connectivity," Report for the Internet Society, 2013, https://www.internetsociety.org/wp-content/uploads/2017/08/Barriers20to20Internet20in20Africa20Internet20Society_0.pdf.
[3] Michael Kende and Charles Hurpy, "Assessment of the Impact of Internet Exchange Points – Empirical Study of Kenya and Nigeria," Report for the Internet Society, April 2012, https://www.internetsociety.org/wp-content/uploads/2017/09/Assessment-of-the-impact-of-Internet-Exchange-Points-–-empirical-study-of-Kenya-and-Nigeria.pdf.
[4] Michael Kende and Karen Rose, "Promoting Local Content Hosting to Develop the Internet Ecosystem" (Internet Society, January 2015), https://www.afpif.org/wp-content/uploads/2017/10/Promoting-Local-Content-Hosting-to-Develop-the-Internet-Ecosystem.pdf. Michael Kende and Bastiaan Quast, "The Benefits of Local Content Hosting: A Case Study" (Internet Society, May 2017), https://www.internetsociety.org/wp-content/uploads/2017/08/ISOC_LocalContentRwanda_report_20170505.pdf.
[5] Michael Kende, "Promoting the African Internet Economy" (Internet Society, November 22, 2017), https://www.internetsociety.org/wp-content/uploads/2017/11/AfricaInternetEconomy_111517.pdf.

02

OVERVIEW OF INTERNET INFRASTRUCTURE

Internet infrastructure is a means to an end. It brings people online to be able to access the Internet, and to encourage more local skills and literacy training. It helps build and enhance businesses, and enables companies to host their content and services for local and regional usage. Beyond the infrastructure, more and more countries are finding it important to build a local digital economy to enable more local content and services to be produced that will fill data centers and increase use of local Internet exchange points. The digital economy, in turn, is a stepping stone to the digital transformation of the entire economy, in which all organisations and citizens – business, government, research, students and others, are fully online and part of the global Internet.

In this paper we focus on the Internet infrastructure, policies, and efforts needed to develop a digital economy, as seen in Figure 1.

- *Access infrastructure*. This is the entire value chain of infrastructure that carries traffic to and from international points; delivers the traffic throughout the country on a national basis; and connects users to the Internet in order to access relevant content and services.
- *Content infrastructure*. This includes Internet Exchange Points (IXPs) where traffic can be exchanged on a local basis, and data centers, where content and applications can be hosted. Using local content infrastructure lowers the time needed to deliver traffic and access content, improves quality of service, strengthens the capacity of local experts, and lowers costs, which in turn helps to promote Internet adoption and usage.
- *Digital economy*.[6] This is the ecosystem to create content and services to fully utilize the access and content infrastructure. A digital economy enables entrepreneurs to innovate while also providing consumers with the ability to use their new services, and it helps bring existing sectors online to transa

[6] Some countries in the region and elsewhere refer to this as the development of a 'digital hub', which is a digital economy as we describe it, with aspirations to serve other countries in the region. We focus on the digital economy as the foundation to transform the entire economy of the country, and acknowledge that additional benefits could derive from serving the greater region.

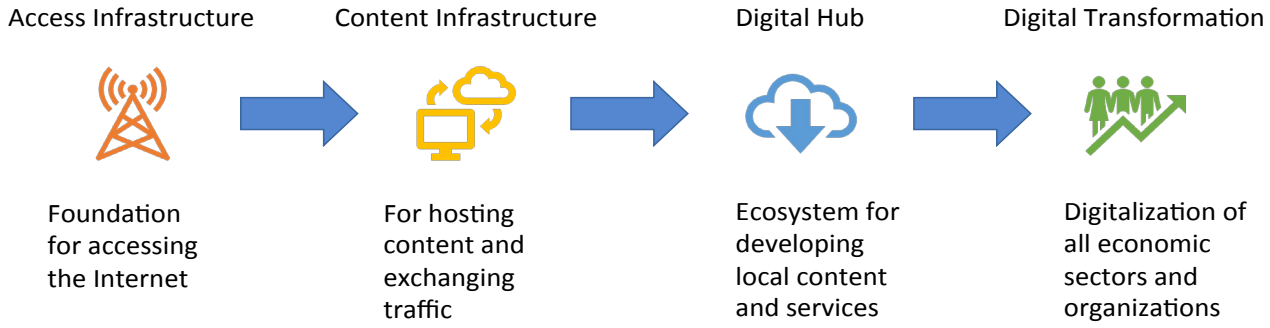


Figure 1: Overview of Internet Infrastructure Impact (Internet Society)

The economic benefits of developing Internet infrastructure are significant, at three separate levels, as summarized in Figure 2.

- A long series of studies has shown that increased adoption of broadband increases the GDP of the country. For instance, a recent study showed that a one percent increase in fixed broadband adoption increases GDP by 0.08%, while the same increase in mobile broadband adoption increases GDP by 0.15%. As adoption grows within the region, this can accumulate to significant increases in GDP[7].
- In economic terms, the digital economy can be measured as a percentage of a country's total GDP, and typically contributes a single digit amount. According to one study, the share of the digital contribution to GDP in the US was 8%, in the leading European economies was 6.2%, and in a leading sample of Middle East countries, was 4.1%.[8] Within the Middle East, the percentage varied from 8% in Bahrain to 0.4% in Qatar. Given that the digital economy provides good jobs and incomes, growing the contribution in each country to the US level or beyond is already a significant benefit.
- Further, using the digital economy to transform the rest of the country, as measured by a digitization index presented by the ITU, will lead to further increases in GDP. According to an ITU study "Achieving broadband penetration is only one aspect of required policies; maximization of economic impact can only be achieved through a holistic set of policies ranging from telecommunications to computing to adoption of Internet and electronic commerce."[9]

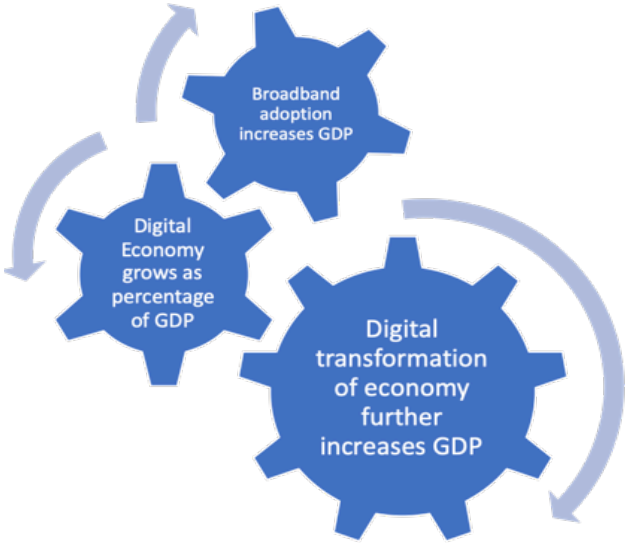


Figure 2: Overview of Economic Benefits (Internet Society)

[7] An early study was Christine Zhen-Wei Qiang, Carlo M Rossotto, and Kaoru Kimura, "Economic Impacts of Broadband," in Information and Communications for Development 2009: Extending Reach and Increasing Impact (World Bank Group, 2009), http://siteresources.worldbank.org/EXTIC4D/Resources/IC4D_Broadband_35_50.pdf. More recently, see Raul Katz and Fernando Callorda. 2018. The economic contribution of broadband, digitization and ICT regulation. https://www.itu.int/en/ITU-D/Regulatory-Market/Documents/FINAL_1d_18-00513_Broadband-and-Digital-Transformation-E.pdf

[8] Europe included France, Germany, Italy, Sweden, and the United Kingdom. The Middle East included Bahrain (8.0%), Kuwait (5.1%), Egypt (4.4%), United Arab Emirates (4.3%), Saudi Arabia (3.8%), Oman (0.8%), and Qatar (0.4$). "Digital Middle East: Transforming the Region into a Leading Digital Economy" (Digital McKinsey, October 2016), https://www.mckinsey.com/~/media/mckinsey/featured%20insights/middle%20east%20and%20africa/digital%20middle%20east%20transforming%20the%20region%20into%20a%20leading%20digital%20economy/digital-middle-east-final-updated.ashx.

[9] Katz and Callorda, 2018, p. 22.

03 OVERVIEW OF MENA REGION

The MENA region has an open definition in terms of the countries included, so we will take a broad definition to ensure general applicability of our report and recommendations. While the countries share a number of attributes such as geography and language, there are a number of significant differences. Figure 3 below highlights two relevant differences: the level of Gross Domestic Product (GDP) per capita[10] , reflecting the wealth of each country, and the percentage of the population who are currently using the Internet, reflecting different stages of Internet development.

Broadly speaking, there are two groups of countries; those with GDP above USD 40,000 per capita, whose Internet penetration exceeds 90% and even approaches 100%, and those with GDP under USD 20,000 per capita, whose Internet penetration is below 70%. The first point is that GDP per capita has an impact on Internet adoption levels, both because users have more disposable income for Internet, and also because there are likely to be more resources – both in the private sector and in the government – to invest in infrastructure. Other factors include higher literacy and education, and likely higher level of relevant local content to address a wealthier market.

That said, policies can make a difference in the levels of Internet adoption. For instance, we can see on the left-hand side of the graph that Morocco, with the lowest per capita income in that group, has the highest Internet penetration levels, which implies that Morocco may have some policy best practices to consider. On the right-hand side of the graph, Bahrain has the lowest income level of that group, but higher Internet adoption than Saudi Arabia and UAE, with higher income levels, and a rate effectively equal to Qatar, with much higher income levels. Again, that suggests policy best practices worthy of consideration.

[10] Given the differences in stages of development of the countries across MENA, for GDP per capita, we use purchasing power parity (PPP) exchange rates, which provide a good measure of well-being, which in turn would drive decisions to adopt broadband. See https://www.imf.org/external/pubs/ft/fandd/2007/03/basics.htm.

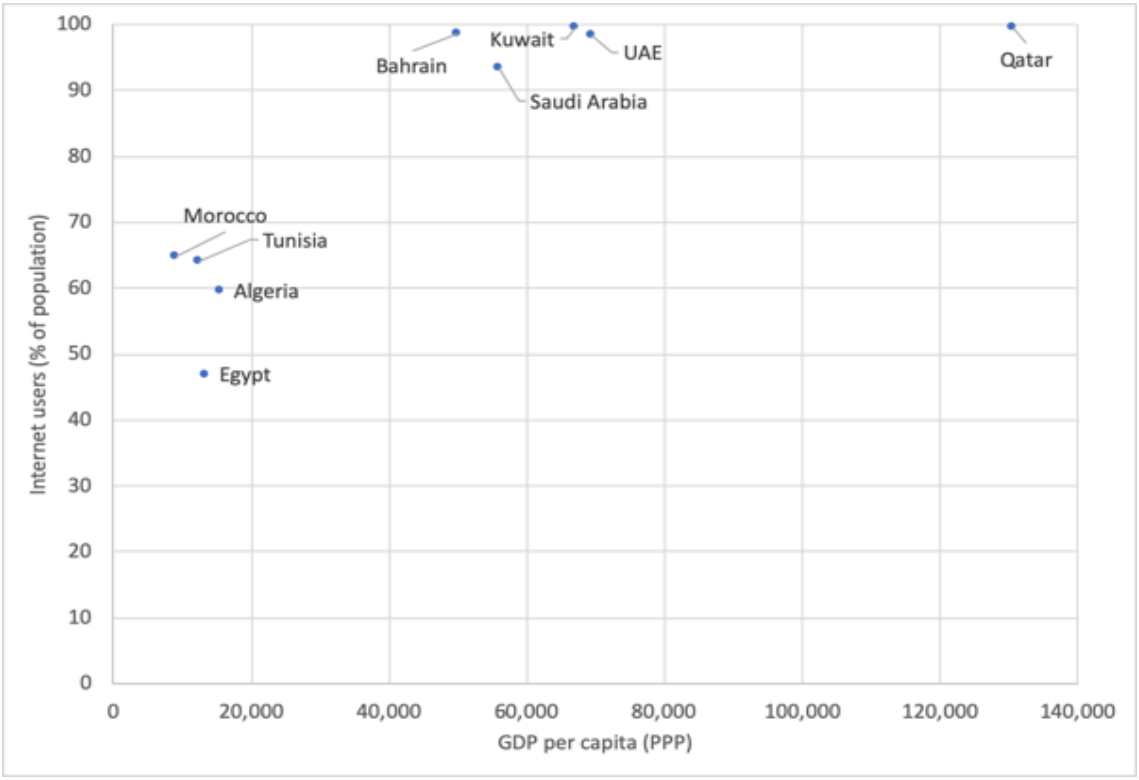


Figure 3: GDP per capita (PPP) and Internet adoption in MENA (IMF, ITU, 2018)[11]

These differences hold as we also examine the means by which individuals and households go online, namely mobile and fixed broadband access. For both types of access there are three sets of interesting questions – what is the level of population coverage, what technology is being used, and what is the adoption level? Starting with mobile, we can identify several different cases as per the below Figure 4, which highlights the eighteen countries in MENA that are the focus of this study.

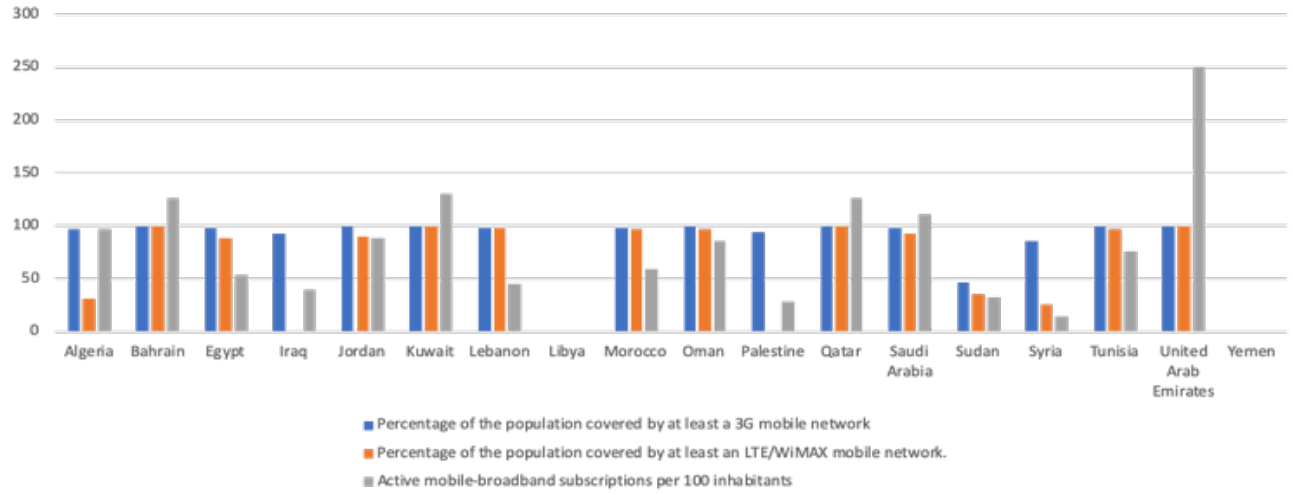


Figure 4: Mobile broadband availability and adoption (ITU 2018)[12]

[11] These are the countries in MENA for which the ITU has data on Internet adoption for 2018.
[12] The ITU does not have mobile broadband data for Yemen or Libya.

Figure 3 highlights the percentage of the population covered by a 3G mobile network and covered by LTE/WiMAX (4G). Note that this relates to population, rather than geographic territory covered, but gives a good indication of the populated areas in a country where mobile broadband can be used. The graph also gives the number of active mobile broadband subscriptions per population. Note here that this counts multiple subscriptions per person, as can be seen by the countries with greater than 100% subscriptions, such as most notably United Arab Emirates. With respect to the three questions:

- Coverage. Overall the population coverage level for at least 3G is generally quite high, at or near 100%, other than several countries, mostly notably Sudan, which do not have full coverage. For these countries, the focus should be on increased deployment.
- Technology. In addition, in many countries the 4G coverage is at or near the 3G level, with the exception of a few countries such as Algeria. For these countries, the focus should include upgrading existing networks.
- Adoption. Again, the adoption levels tend to be quite high, including multiple subscriptions, but in some countries, there is a significant gap between the availability and adoption of mobile broadband, for instance Egypt and Lebanon. This suggests a focus on increasing demand, by making it more affordable and providing more relevant content and services.

A similar analysis can be done for fixed broadband, as shown below. One difference is that the population coverage of any particular technology is not known, unlike the case of mobile broadband. Instead, the figure below shows the percentage of households that have adopted fixed broadband according to the height of each country's column, and then within the column it shows the level of adoption of each technology, whether it is DSL, fixed wireless, or the more advanced fiber or LAN solution.

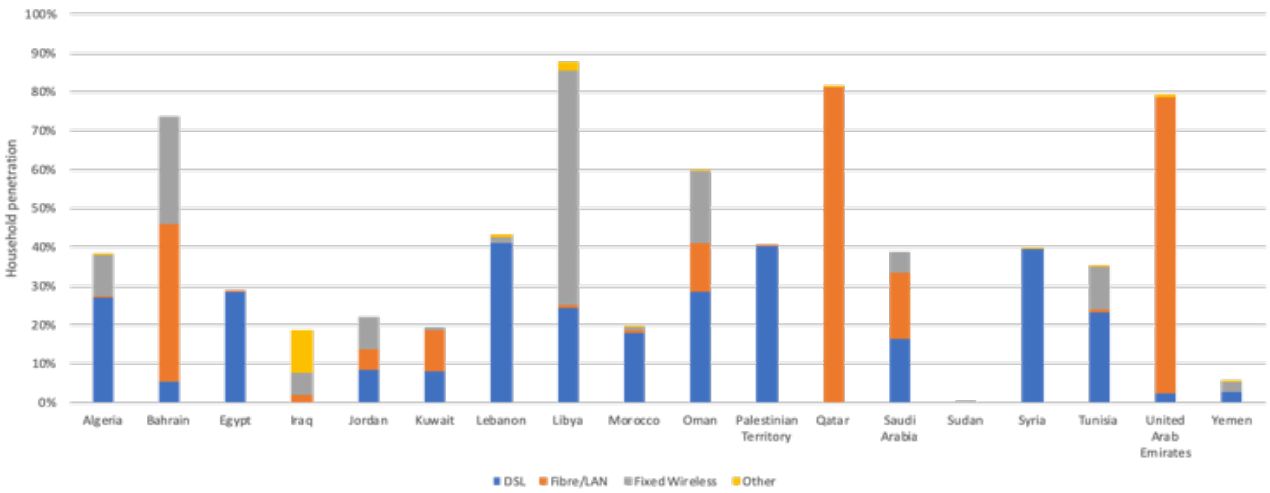


Figure 5: Fixed broadband technology and adoption (TeleGeography 2018)

The countries show considerable variation, from Sudan with little fixed broadband adoption, to Libya with almost 90% of households with broadband adoption. Further, a number of countries have little or no fiber to the home, such as Egypt and Lebanon, although in Egypt we note that Telecom Egypt has put fiber to the curb (FTTC) in 90% of their fixed broadband network, with the goal of achieving 100 % by mid-2020. On the other hand, Qatar and UAE are essentially all fiber to the home access, with a very high penetration rate.[13] In the latter countries, some copper was replaced with fiber, and where there was no copper network, the buildout went straight to fiber.

With respect to content infrastructure, there is again variation within the region. The table below shows that from the eighteen countries in MENA sampled, 9 of them have an IXP listed with TeleGeography, with some of them having more than one. Further, 14 coun-

tries have at least 70 data centres.

In terms of a presence in the data centres, we have sampled several companies delivering content, either their own or third-party content, which have published maps of their points of presence (PoPs). Google has three levels of network presence for delivering its own content – first, putting in a Google Global Cache, with static content such as YouTube videos. 17 of the 18 countries have at least one of these. Next is an Edge Point of Presence, where Google has built out its network and peers with ISPs; two countries have an Edge PoP. Google does not have a data centre in the region, which represents its largest level of investment and presence. Three independent content delivery networks (CDNs), Akamai, Cloudflare and Limelight, have PoPs in up to 12 countries in the region.

The data in Table 1 is expanded at the country level below in in Table 3 and Table 5, in Section 3.

Content Infrastructure	Number of Occurrences	Number of Countries
IXP	15[15]	9
Data Centres	70	14
Google Global Cache	47	17
Google Edge PoP	2	2
Akamai presence	19	11
Cloudflare presence	12	12
Limelight presence	4	4

Table 1: Content infrastructure in MENA (TeleGeography Internet Exchange Map; PeeringDB; Packet Clearing House; Data Center Map; Google, Cloudflare, Akamai (2019)

It is critical to build Internet infrastructure, but also to develop a digital economy in order to create the content and services that leverage the infrastructure. While countries in the region are working to promote innovation, according to the latest Global Innovation Index from the World Intellectual Property Organisation (WIPO), no country in the region ranks higher than 36th, and several are ranked below 100. This index ranked 129 countries on their innovation performance, looking both at the inputs, including education and infrastructure, and outputs, such as mobile app creation[15].

One important aspect of developing a digital economy is the ability to buy and sell online. Particularly in countries with little traditional financial inclusion, mobile money – using a mobile phone to transfer funds and purchase items -- provides a means to transact with other individuals and businesses. However, eleven of the countries do not have mobile money, according to GSMA, making it difficult to participate in the digital economy.

[13] According to the FTTH Council Europe, the top ranked countries in the world for FTTH penetration are UAE and then Qatar. See Roland Montagne, "FTTH Council Europe - Panorama: Europe Broadband Status" (idate, March 12, 2019).
[14] This includes an IXP in Kuwait that has been established at the end of 2018, but has not yet shown up in the TeleGeography Internet Exchange Point Map.
[15] See https://www.globalinnovationindex.org/Home.

04 APPROACH TO ANALYSIS AND RECOMMENDATIONS

Given the differences between the countries in terms of both access infrastructure and content infrastructure, we will take a tiered approach to the analysis and recommendations.

- *Access infrastructure*. The focus for all countries is on increasing the availability of next generation mobile and fixed technology. This will help countries extend their networks, while it will enable the countries with less developed networks to adopt new technologies. In addition to last mile access networks, international and national networks are needed to support the last mile networks with sufficient bandwidth. It is also important to focus on adoption, by increasing affordability and the availability of relevant content and services.
- *Content infrastructure*. The countries with existing content infrastructure can level up their current IXP(s), and build new IXPs as networks expand to other cities. The countries can also increase the number of data centers, while encouraging companies to host more content in the country. The less developed countries can seek to build IXPs, and data centers, and increase the presence of CDNs. Many of the recommendations across the countries will be similar in this respect.
- *Digital Economy*. All countries have an incentive to develop or improve their digital economy - the ability to build infrastructure, host content, and attract investment from high-tech companies, while building your own local high-tech sector. Training local people for local high-tech sustainability is critical to this effort. By doing this, countries will increase the level of development, particularly in high-tech sectors with revenue and job opportunities, it is important to keep pace with other countries in the region and globally. It is valuable to try to get a first-mover advantage in emerging products or services to help gain an edge in the ongoing process of digital transformation of the economy.

The paper examines each of these areas of infrastructure in turn, with recommendations and next steps.

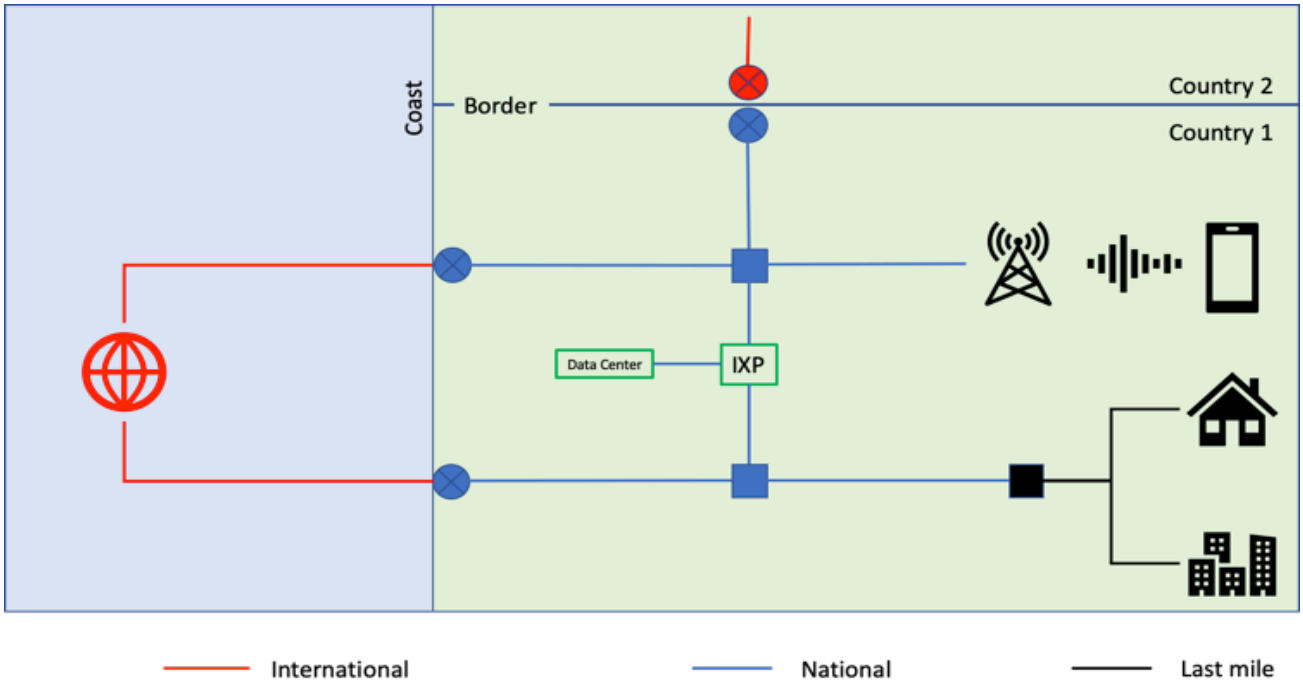
05

SECTION 2. ACCESS INFRASTRUCTURE

Access infrastructure consists of a value chain that carries Internet traffic from international locations to national points of presence and then to end-users. It must have sufficient capacity to not congest, particularly during peak usage times, and to support new and emerging services and applications. It must also be available at a cost that makes access affordable for end-users, while also providing redundancy and resilience to support enterprise applications.

We break down the access infrastructure value chain into three parts, international, national, and last mile. This is shown in Figure 6 below, including with connections to an IXP and a data center. Each part of the value chain is detailed below.

Figure 6: Access infrastructure diagram (Source: Internet Society)



06 ACCESS INFRASTRUCTURE IN MENA

International. International connectivity consists of fiber-optic cables connecting continents to each other, and countries within continents. Submarine cables connect countries that have access to the sea. They cross oceans and other bodies of water (some lakes and land-locked seas), and they run along coasts. In addition, terrestrial cross-border cables are important for connecting countries and providing resiliency and redundancy. While MENA has no land-locked countries, these terrestrial connections also help to develop regional digital markets, and provide countries with access to a broader range of submarine cables in neighboring countries[16].

International connectivity is very important in countries without extensive content infrastructure. Without an IXP, a substantial amount of local traffic may be exchanged abroad. Without local data centers or many content caches, most content will be accessed from abroad. As a result, based on experience, up to 90% of a country's Internet traffic may be brought in from abroad. This has several implications.

First, the international transit adds latency to the delivery of traffic. That is both because of the distance the traffic travels, but also because it may add additional hand-offs, or hops, as traffic makes its way across international networks to the national networks. For instance, the following graph shows the latency for accessing a large selection of Saudi websites from Saudi Arabia. It shows that many of the websites have a latency of more than 125ms, and more than 12 hops (as demarcated by the red box), which typically would mean that they are hosted outside the country[17].

Second, international access is often expensive. ISPs in a country typically purchase international IP transit, a service sold by an international backbone provider that delivers international traffic to and from the national ISPs. Depending on the country, the IP transit cost can be significant. Based on available data, the cost per Mbit/s per month in MENA ranges from $10 to $67, compared with prices near or below $2 in the United States and Europe[18].

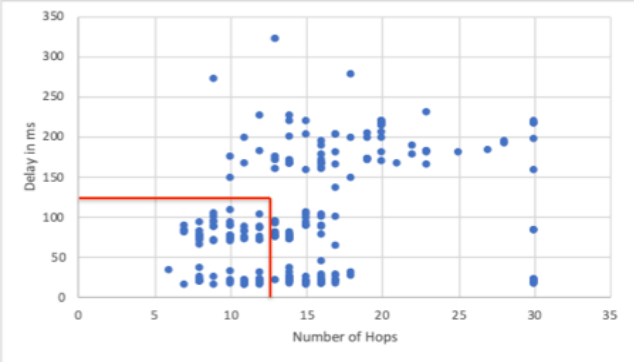


Figure 7: Latency and hops accessing websites in Saudi Arabia (Internet Society, 2019)

[16] See Internet Society, "Internet Crossing Borders: Boosting the Internet in Landlocked Developing Countries," June 20, 2018, https://www.internetsociety.org/wp-content/uploads/2017/10/2018-LLDC-Report-EN.pdf. While it covers land-locked countries, the issues related to border-crossings are the same as for countries that also have coastal access. For related issues, see also Mike Jensen and Michael Minges, "Ensuring Sustainable Connectivity in Small Island Developing States" (Internet Society, May 26, 2017), https://www.internetsociety.org/wp-content/uploads/2017/08/ISOC_Small_Island_Developing_States-201706015.pdf.

[17] While there is no direct evidence that the websites with high latency and/or hops are hosted outside Saudi Arabia, it does show that there is a significant issue with the performance that should be addressed with better hosting inside Saudi Arabia.

[18] The source is TeleGeography, and the data is the average price for a GigE international IP transit service, with a CDR of 500, in the second quarter of 2019.

Finally, the high cost of the international transit can lead to ISPs under-provisioning the amount needed for their end-users. This, in turn will result in congestion during times of peak usage, which will further increase the latency of accessing international traffic.

The cost of international capacity has significant impacts on developing the Internet in a country. If a country accesses up to 90% of Internet traffic over international connections, and those connections are expensive, this cost will have to be passed on to end-users. Not only will the cost of Internet access be high, but the purchase of data is likely to be very incremental. It is not possible to sell big bundles of data, much less the unlimited data packages common in North America and Western Europe, if the ISP must pay a significant amount to access the data from abroad.

The latency of international capacity is also a significant issue. Studies have shown that latency impacts Internet usage, whether it is using a search engine, or purchasing online[19]. Conversely, evidence shows that improvements in latency – for instance being able to access YouTube videos from a local cache – will significantly increase usage, as discussed further below. Thus, the high cost and latency resulting from using international capacity to exchange traffic will lower Internet usage, and should be a focus for countries in this situation.

Box: International Capacity.

International capacity is critical for connection to the global Internet. An international gateway is the link between international capacity and national networks, and can have a significant impact on the cost of international access.* In the MENA region, six countries still have a monopoly on the international gateway, five have allowed only partial competition, and only five have full competition, with two unknown. This can result in a high cost of international connectivity, with resulting lower capacity.

In the meanwhile, the submarine cable market is undergoing significant transformation. While the traditional consortium model still exists, some cables provide for open access, where allowed, enabling more ISPs in a country to access the capacity, even if they have not participated in the consortium. Further, more private cables are being built, and in particular, the large Internet companies, including Amazon, Google, Facebook, and Microsoft, are now becoming the largest investors and owners of submarine capacity, with plans and negotiations ongoing, but no fiber projects realized yet in the MENA region.

There are significant benefits associated with allowing these cables to land, and withholding open landing stations to bring the capacity into the country. Within the country, of course, any further bottlenecks on accessing national access infrastructure, IXPs, or PoPs will repeat or compound any barriers raised by international capacity. Fully opening the international and national markets will enable and facilitate new builds of fiber into countries in the region.

*See "Effect of Open International Gateways on the Broadband Connectivity Market" (United Nations ESCAP, February 15, 2017), https://www.unescap.org/resources/effect-open-international-gateways-broadband-connectivity-market.

While international capacity to Europe, Asia, and the Americas is critical to access the full global Internet, regional capacity, connecting the countries of MENA, also has important benefits. It helps provide access to content and services throughout the region, including both international content hosted throughout the region, and also to local content relevant to the region. It helps to provide resilience and redundancy for international connections, while also increasing the options available to countries for accessing international capacity. According to TeleGeography, however, 80% of the international Internet bandwidth serving countries in the region goes to Europe, and only 10% is within the region, with the bulk of the rest going to Asia.

[19] "Akamai Online Retail Performance Report," April 19, 2017, https://www.akamai.com/uk/en/about/news/press/2017-press/akamai-releases-spring-2017-state-of-online-retail-performance-report.jsp.

National. National infrastructure provides connections within a country; it is used as backhaul from submarine landing stations and cross-border terrestrial connections; it is used to connect each ISP's PoPs with their other PoPs; it is used to connect to any local IXP or data center; and it is used to connect end-user networks with one another and PoPs, for instance connecting mobile network towers together. Fiber is the new standard for all national connections to provide high bandwidth and reliable connections. There are regions of countries where deployment costs are high and/or demand is low, and below we will discuss recommendations for lowering the cost of deployment.

As these networks are the connection between the international capacity and end-user networks, the issues relevant to international capacity are also relevant here, particularly with respect to cost, as the cost of national capacity must be added to the cost of international capacity.

Together, the availability and affordability of international and national capacity will have a significant impact on companies' decisions to invest in a local data center and to put their content in the data center. Data centers require fiber connections, and carrier-neutral data centers would prefer to offer the customers in the data centers redundant and competitive fiber to ensure low cost and high reliability of the critical connections. Likewise, to put a cache or content server in a data center requires the use of international and national capacity to keep the content up to date; high cost or low reliability will reduce the willingness to put content in a country.

Last mile access. Last mile access networks are used by ISPs to reach their customers. They can be either fixed, serving a residence or an organization, or they can be mobile, for use anywhere there is coverage. We address each of these in turn.

- *Fixed networks.* Existing traditional telephone networks, using copper wires, can be upgraded to offer broadband based on DSL standards. DSL can offer relatively high speeds, and always-on connections, but it has limitations. First, the copper can be old or unreliable, limiting the usability of the connections, and it can be susceptible to interference and a target of theft. Even if it is high quality, however, there is a limit on the bandwidth speeds available with copper, and the speeds are lower the further the end-user is from the telephone office where the copper connection terminates.

In order to increase the speed and reliability of copper networks, operators can replace parts of the copper network with fiber, moving closer and closer to the end-user. They can install fiber to the node (FTTN), where a number of households can be served; fiber to the curb (FTTC) where each individual household is served, or replace the copper with fiber to the home (FTTH). Each step provides an enormous upgrade in speed and quality, but at an increasing cost.

Of course, there are also regions of a country where there is no traditional copper network, either because the telephone company had not begun to serve the area, or because the area is newly built. If the government has a strategy to increase fixed broadband access, or if a company wishes to deploy fixed broadband in those regions, the standard today is to leap-frog directly to fiber to the home[20]. FTTH is future-proof, with enormous capacity, it is not prone to theft or degradation the way copper is, and essentially costs the same in civil works to deploy.

- *Mobile networks.* Mobile networks were first deployed for providing voice, and had a number of advantages over fixed networks, particularly where no fixed networks were deployed. Once a tower was installed, the mobile signal could reach anyone in range, saving significant deployment costs over fixed networks that must be deployed building by building, house by house. In addition, subscribers were no longer restricted to their residence or office, but could roam anywhere in the country where there was a signal.

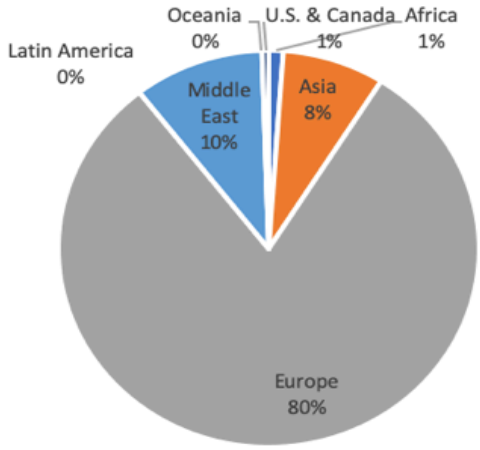


Figure 8: Middle East International Internet Bandwidth Connected to Regions (TeleGeography, 2019)

[20] For instance, the countries with significant FTTH in Figure 5, notably Qatar and UAE, replaced some existing copper with FTTH, and where there was no copper the operators built out directly with FTTH.

Given these advantages, mobile quickly covered large parts of many countries, with many having effectively 100% of the population covered with at least mobile voice services, also known as 2G. Then, when new generations of mobile technology were introduced, particularly those that offered Internet access, the existing networks could be relatively easily upgraded to offer mobile broadband. The cost of upgrading an existing mobile voice network to offer mobile broadband is a fraction of the original cost of deploying the whole network. This enabled mobile Internet to effectively leap-frog fixed access, which is much more costly to deploy.

The first true mobile broadband technology is known as 3G, and is still in widespread use today; its successor, 4G, is increasingly deployed, and offers greater speeds and bandwidth than 3G[21]. Early tests of 5G show speeds approaching or beating many fixed broadband connections, and thus can help countries with little fixed broadband to upgrade their offerings. Even in rural areas, using the appropriate low-band spectrum, 5G can provide good broadband coverage, although not at the speeds that are feasible in denser areas. 5G will be available as a fixed offering – serving a household – or as a mobile offering.

MENA boasts several early milestones. Qatar recently claimed the first 5G call in the world[22], and several countries in the region are running 5G trials or have plans to do so. The Telecommunications Regulatory Authority (TRA) of the UAE launched a comprehensive 5G strategy several years ago[23], and in May 2019 Etisalat launched the first commercial 5G service in MENA, followed closely by du.

For both fixed and mobile broadband, the cost and speed of the offering is important to realizing the goals of a digital economy. Moves to the latest technology, whether through upgrades or new deployments are in turn important to ensure the high bandwidth and low latency which many new services and applications will require.

[21] See Figure 4 for deployment levels for each country in the region.
[22] See https://www.thepeninsulaqatar.com/article/13/04/2019/Qatar-makes-world's-first-ever-5G-phone-call.
[23] See https://www.tra.gov.ae/en/uae-5g.aspx.

07 ISSUES AND RECOMMENDATIONS

A noticeable feature of the Internet is that much of the investment in the networks is from the private sector, investing in international, national, and last-mile connectivity. The same is true for the content infrastructure we will discuss in the next section, but there is a historical difference. At one time, in almost every country, the telecommunications network was owned and operated by the government. At this time, no competition was allowed, leaving no room for public investment in the networks.

Starting twenty years ago, policy and regulation began to allow competition in networks and provision of services, and thus private investment. In the MENA region, a number of governments have kept a partial or full stake in the fixed-line incumbent, impacting whether and how private investors enter the market, given the significant costs of investment in fixed networks. As a result, investors may build some parts of the network, and where regulations permit, buy access to the incumbent's network for other parts of the network. On the other hand, mobile competition was generally allowed as soon as mobile networks were introduced, resulting in multiple privately owned networks in most countries.

As a result, when fixed and then mobile broadband became feasible, in many countries in the region investment and competition was already possible, or soon became so. As we have seen above in Figure 4, the result is that in a number of countries in the region, mobile broadband using 3G is available to close to 100% of the population. Nonetheless, the more advanced countries in the region have seen significant investments in FTTH, as can be seen in Figure 5. It is worth noting that the countries with the highest level of FTTH are very urbanized, and thus the cost is lower than in the countries with less population density. However, 5G networks have speeds approaching FTTH levels, which may impact the framework for developing access infrastructure going forward.

In general we advocate a three-part approach to the issue, while noting that the countries in MENA are all at various stages in this process. This approach attempts to maximize the level of investment in the market, while accounting for regions of the country that are uneconomical to invest in because of high costs of deployment or low levels of demand.

1. Sector reform. These are reforms to the legacy telecommunications regulations, in order to enable competition and investment in the sector.

2. Remove barriers. After these sector reforms, other steps may still be needed to remove barriers to entry and deployment by operators, to maximize the possible level of investment.

3. National broadband plans. These should provide strategies to reach otherwise uneconomical regions, which can use government resources, and may also contain broader digital development plans to increase demand for Internet access.

We examine each of these three parts in turn.

[24] The World Bank's infoDev and the International Telecommunications Union have a toolkit on sector reform at: infoDev and International Telecommunications Union, "ICT Regulation Toolkit," ICT Regulation Toolkit, accessed October 15, 2019, http://www.ictregulationtoolkit.org/index. In addition, 82 Countries have accepted a set of telecommunications sector reforms which include commitments on competition, licensing, and having a separate regulator. See Negotiating Group on Basic Telecommunications, "Telecommunications Services Reference Paper" (World Trade Organisation, April 24, 1996), https://www.wto.org/english/tratop_e/serv_e/telecom_e/tel23_e.htm.

Telecommunications sector reform

In recognized best practice, sector reform consists of three steps[24].

1. *Status of incumbent*. If the incumbent is part of a Ministry, it should be corporatized, so that it is no longer directly part of the government, but rather a separate corporate entity, even if owned by the government. This will enable the company to be privatized, allowing for private sector investment in the incumbent. Where the government owns all or most of the incumbent, there may be concern that regulation will favor the incumbent.

2. *Competition*. Opening telecom markets enables competitors to enter and compete with the incumbent in fixed markets, or develop a mobile competitor. Entry should be enabled at all levels of the access infrastructure value chain, so that prices are set through market competition. Where entry may not be feasible, wholesale access to those parts of the incumbent's network may be required, at regulated rates.

3. *Independent regulator*. A regulator can act to open up markets, allow for wholesale access to facilitate entry, and regulate retail prices where there is no competition. An independent regulator can act as a neutral referee between the incumbent and the entrants to provide regulatory certainty for investors and to operate at a remove from government, proviing stability when governments change.

The ITU has put together an *ICT Regulatory Tracker*[25] , which ranks countries' regulations based on four clusters, as follows:

- Regulatory Authority, focusing on the functioning of the regulator
- Regulatory Mandate, determining who regulates what
- Regulatory Regime, detailing the regulation in major areas
- Competitive Framework, assessing the level of competition in the main market segments

The indicators making up each cluster are contained in Annex B. The four clusters are added together to get an overall score, and a ranking among the 193 countries. The scores are also divided into ranges, and each range is assigned a generation of regulation. The definition of each of the generations of regulation is as follows:

- G: Regulated public monopolies, command & control approach
- 2G: Opening markets, partial liberalization and privatization across the layers
- G: Enabling investment, innovation and access; dual focus on stimulating competition in service and content delivery, and consumer protection
- 4G: Integrated regulation, led by economic and social policy goals

Country	Regulatory Authority	Regulatory Mandate	Regulatory Regime	Competition Framework	Overall	Rank	Generation
Algeria	18	16	16	12	62	147	2G
Bahrain	17	18	26	26	87	46	4G
Egypt	15	20.5	21	24	81	81	3G
Iraq	17	21.5	16	3	58	155	2G
Jordan	19	20	24	22	85	66	3G
Kuwait	20	19	12	12	63	138	2G
Lebanon	8	18	5	1	32	180	1G
Libya	2	2.5	0	0	5	192	1G
Morocco	18	19.5	24	27	89	36	4G
Oman	17	19	28	26	90	30	4G
Palestine	4	11.5	13	14	42	171	2G
Qatar	14	18	21	17	70	119	2G
Saudi Arabia	19	22	29	22	92	23	4G
Sudan	15	20	18	19	72	109	3G
Syria	19	15	15	6	55	158	2G
Tunisia	19	16	25	15	75	96	3G
UAE	19	21	27	16	83	69	3G
Yemen	0	3	4	4	11	188	1G
Max Score	**20**	**22**	**30**	**28**	**100**		

[25] https://www.itu.int/net4/itu-d/irt/#/tracker-by-country/regulatory-tracker/2018

As above, there is a wide range of outcomes among the countries in MENA, which are ranked from a high of 23 to a low of 192. The distribution of generations is even, with four countries at 4G, five at 3G, six at 2G, and three at 1G.

A number of countries can improve their score in one or more areas, for instance, ensuring that there is a high score on the competition framework, and within that in the key segments relating to the value chain of access infrastructure.

Remove barriers to entry and deployment

Having enabled competition, with an independent regulator as a neutral referee, the framework for encouraging investment in access infrastructure is in place. However, there still may be barriers to investment, which raise the price or increase the uncertainty behind investment.

First, we examine general barriers to investment:

- *Licensing*. In order to deploy infrastructure or offer services, a license is typically required. There may be a limit on the number of licenses or the cost of a license, both of which will limit entry. Further, licenses may be for specific services, requiring applications for each additional service which raise cost and uncertainty for the new operator. The time it takes for a license to be given raises cost and "time to market" which can slow-down investment.
    - o *Best practice*. Emerging best practice is to not limit the number of licenses, but rather to have broad unified licenses that enable the operator to provide a range of services, and to charge reasonable fees for licenses. Best practices also indicate that creating shorter "wait times" for licenses helps businesses deploy on time and within budget. Some countries even offer general authorisations, requiring an operator to notify that they are providing service, but not apply for a license, or even to not require a license at all for certain services.
    - o *Example*. Saudi Arabia recently changed their licensing regime from separate licenses to unified licenses, which enable the operators the flexibility to move into other markets, with infrastructure and/or services, and also to begin to offer new advanced services without additional licenses and with reduced wait times for companies.
- *Rights of way*. Permission is required to deploy infrastructure, whether to install a tower on land or a building, or authorization for the civil works to lay fiber. Often, each municipality has its own procedure, has its own fee, which may be significant, and sets its own deadlines. Even where there is a national procedure, such as for permission to deploy cellular towers, the procedure can be long, uncertain, and costly.
    - o *Best practice*. With respect to municipalities, one best practice has been to develop a standardized application form, set a common deadline for decisions, and use the same cost-based methodology, for all municipalities. For access to government land and any government permissions, such as for cellular towers, a streamlined process with clear criteria helps to reduce uncertainty.
    - o *Example*. As part of the European Union Digital Single Market, regulations are in place to facilitate access to rights of way. Authorities must have transparent and non-discriminatory procedures for granting access, decisions must be taken within a set time period, and the fees must again be transparent and non-discriminatory. Where there are existing facilities that could be used, such as utilities networks, the owners must meet reasonable requests for access at fair prices.
- *Spectrum assignment*. Making spectrum available in a transparent and easy to understand manner is essential. It is critical to the availability and quality of all services, and in particular mobile broadband. National allocations should be easy for businesses to understand and in recognized bands for equipment and devices; it should be allocated to allow sufficient bandwidth without congestion. It must also be made available for trials and availability of new services, and entrants, and new mobile generations, notably 5G. The cost of the spectrum can also raise barriers, particularly for new entrants.
    - o *Best practice*. Emerging practice is to allow flexibility, such that existing spectrum allocations can be used for upgraded networks, with-

[26] For examples of innovative approaches, see "Spectrum Approaches for Community Networks," Policy Brief (Internet Society, October 10, 2017), https://www.internetsociety.org/policybriefs/spectrum/.

out unduly stranding users of previous generations. Allowing spectrum sharing and secondary use also is an emerging trend that allows for increased competition and more effective and efficient use of spectrum.[26]

o *Example*. In 2015, Russia made existing spectrum licenses technology neutral, and applied this to new allocations going forward, to provide mobile operators with flexibility in deciding when and whether to upgrade technology.

Once the provider has the relevant license or authorization, access to the rights of way, infrastructure sharing permissions and spectrum (if relevant), then the provider has to deploy the network. Any steps to lower the cost of deployment will maximize the investment made.

- *Civil works*. The civil works for deploying a network can be significant, to the extent that roads need to be dug up, poles and towers need to be erected, and the network deployed. Two solutions to lower the cost of this are to use existing networks, where available, and share the cost of deploying new infrastructure, where there is none.

  o *Existing networks*. In addition to telecommunications, other sectors have significant networks that can be used for deployment, including railroads, highways, and the electric networks. Some utilities, such as electric companies, have already deployed their own fiber networks to use for operations, which may have spare capacity (often known as dark fiber).

    - *Best practice*. Rights of way can be made available to telecom operators, and existing fiber capacity can be shared.
    - *Example*. Morocco has licensed three fixed operators. The incumbent already has a national backbone network; one of the other operators is using the fiber network of the electric company; the third is using the fiber network of the railroad, and they have also made arrangements with the highway authority to use their rights of way. As a result, there are three competing national backbones.

  o *nfrastructure sharing*. Passive telecommunications infrastructure, such as towers and ducts, can be shared between operators. That is true for existing infrastructure, and that is true for new infrastructure that is deployed.

    - *Best practice*. In some countries, it is common for an independent tower company (towerco) to buy or build a tower network and operate it on behalf of multiple operators; such arrangements should be encouraged. Likewise, some countries have a 'dig once' policy in which all operators are notified of civil works such as road construction, so that the operators have the opportunity to deploy equipment, such as a shared duct for all to use for their own fiber.
    - *Example*. The Oman Tower Company was setup in 2018 as an efficient way to deploy passive infrastructure, including towers for mobile services, on behalf of multiple operators. The government of Oman helped to establish the company, has an ownership stake, and has provided land for the infrastructure.[27]

- *Imports*. Many, if not most, countries must import the equipment needed to deploy the networks, and the devices for end-users. Tariffs and other duties on imports can raise the costs for operators and end-users, and non-tariff barriers, such as the need to test the equipment, or delays in process, can add time and uncertainty.

  o *Best practice*. Reasonable tariffs to lower the cost, and set times on passing equipment through customs, particularly if it has already been imported and has met recognized certification regimes. Recognizing certification from accredited test labs will also streamline the process.

  o *Example*. The UAE has a type approval plan to allow the import of devices that meet their technical requirements, and also a permanent customs release permit for approved equipment to allow for timely release of imports. Likewise, Oman has a type approval plan, allowing certification based on test reports from a recognized lab, with an eType Approval portal to enable equipment vendors to register.

National Broadband Plans

Having facilitated entry and deployment of access

[27] See https://www.omantowerco.om.

infrastructure to the furthest extent possible, there are still likely to be under- or un-served areas of the country. This could be because of the high cost of traditional network deployment, or a low level of demand, or both. In order to address this issue, many countries have issued national broadband plans that detail how to address the shortfalls. Some countries have broader digital development plans, which cover not just the infrastructure to supply broadband, but also means to increase demand for broadband. These are important to help close the gap between availability and adoption which we highlighted above in Figure 4, showing that mobile broadband availability is often higher than adoption.

Here we detail a number of aspects of national broadband plans.

- Overview of best practices
    - o *Targets*. Specific and achievable targets help to focus the efforts and measure the progress. The direct target is typically deployment, such as the number of homes passed with a new FTTH network, or kilometers of national backbone, but other more indirect targets are useful for ensuring that the broadband is used. These can include targets for adoption levels and broadband speeds, and some also include targets for training, adoption by SMEs, and jobs.
    - o *Example* Morocco has a long-standing plan to cover 100% of the population with fixed or mobile broadband with a minimum speed of 2 Mbps, but also as part of the more recent Digital Morocco 2020 plan, targets include lowering the digital divide by 50%, connecting 20% of SMEs, digitizing 50% of administrative tasks, and training 39,000 ICT professionals. [NOTE Egypt example]
    - o *Agency*. Further, designating one agency as the lead with the authority and responsibility for the plan is useful to ensure implementation and accountability. In some cases, existing agencies, such as the regulator or Ministry are responsible – in others, a new agency is developed as the lead.
    - o *Example*. The government of Morocco created the Agency of Digital Development to be responsible for implementing the Digital Morocco 2020 plan.
- Elements of broadband strategy.
    - o *Funding*. The plans must be funded, and the funding could come from general tax revenues, from telecom sector universal service obligation (USO) funds, or from industry through a public-private partnership (PPP).
    - o *Example* For instance, as part of the National Transformation Program, the Saudi Arabian Ministry of Communications and IT (MCIT) will create a 'Broadband Stimulation Fund' which includes SAR 2 billion from the Universal Service Fund to extend broadband service to 70% of remote households. It has awarded the contract to the incumbent, STC, to meet the goal.
    - o *Open access*. The funded infrastructure should be made available to other operators, directly if it is government funded, or indirectly through the private partner if it is funded through a PPP. The wholesale cost of accessing the network should be based on costs, so that competitors can compete with the owner of the network.
    - o *Example*. In Malaysia, the incumbent Telekom Malaysia built the High Speed Broadband (HSBB) network, created in a PPP with government, and must provide access at wholesale rates. At least three operators are accessing the HSBB wholesale to offer retail services.
    - o *Spectrum licensing*. An alternative to the government funding deployment would be to put coverage obligations for mobile broadband in existing or new spectrum licenses. Requiring operators to extend coverage may lower what they are willing to pay for the spectrum in an auction, for instance, but on the other hand they are well placed to efficiently invest the money to increase coverage, rather than the government using the money to increase coverage. At the same time, smaller networks, including community networks (described next) can benefit from innovative approaches such as unlicensed spectrum or shared licenses.[28]
    - o *Example*. In Portugal, coverage obligations were imposed as part of the spectrum rights for 4G, and also minimum mobile data speeds of 30 Mbps.
    - o *Community networks*. Finally, the government

[28] "Policy Brief."

can support community-based initiatives, which are networks deployed and operated by a local community, from the ground-up, for their own needs. This can include removing start-up barriers that result from registration and permitting requirements, and from high taxes and import fees for equipment. Lowering these costs, while also providing access to sources of funding, including Universal Service Funds, can help to make community networks viable. In addition, as noted in the previous point, as these networks are only economical if they are wireless, affordable access to spectrum is critical for community networks[29]. It is important to ensure that this is done in countries with limited coverage today, such as Sudan or Syria, and only where it is unlikely to crowd out a licensed mobile operator.

o *Example*. In Mexico, the regulator has set aside a small amount of spectrum for 'social purpose use' by communities of less than 2,500 people. One organization, Rhizomatica, has used the band to create networks in more than 10 communities in the Oaxaca region.

- Demand-side initiatives.

o *Affordability*. Many of the actions described here, including increasing competition, infrastructure sharing, reducing the cost of importing devices and equipment, and others will help to lower the cost of broadband, making it more affordable.

o *Example*. When Kenya exempted handsets from VAT in 2009, purchases increased by 200% and penetration rose 20 percentage points. More directly, as part of its initiative to promote technology parks, the Egyptian government provided support for a domestic company, SICO, to develop a factory to produce the low-cost Nile X smartphone in Egypt, which is targeted at low-income users.[30]

o *Digital skills training*. This can take place at three levels: first, to ensure that users have the skills to go online for meaningful interactions; second, engineering talent to be able to deploy and operate networks and develop and maintain software and services; and finally, for entrepreneurs not just to develop their innovations but be able to turn them into growing companies.

o *Example*. The United Kingdom Digital Strategy 2017 is a comprehensive plan to give everyone access to digital skills, help businesses go online, and provide training opportunities to help people fill relevant vacant positions.

o *e*-Government *services*. Focusing on developing online government services has a number of benefits: first, it helps create demand for online services; second, it can help governments efficiently reach and interact with citizens; and third, it can provide local jobs to develop the services and demand for data centers to host the services.

o *Example*. Bahrain scores high on the UN e-Government Index, with a portal bringing together all government functions for easy access, a feature shared in all Gulf Cooperation Council (GCC) countries. UAE plans to adopt blockchain technology for government services, to securely store citizens' digital transactions online and save in time and expenditures.[31]

More broadly, a digital development plan can focus on developing and filling content infrastructure, including an IXP and data centers. This is the topic of the next section.

[29] "Policy Brief"; "Unleashing Community Networks: Innovative Licensing Approaches" (Internet Society, May 2018), https://www.internetsociety.org/wp-content/uploads/2018/05/Unleashing-Community-Networks_Innovative_Licensing_Approaches-2.pdf.
[30] See https://www.progrss.com/places/20171221/nile-x-egypt-smartphone-ict/.
[31] https://government.ae/en/about-the-uae/strategies-initiatives-and-awards/federal-governments-strategies-and-plans/emirates-blockchain-strategy-2021

08

SECTION 3. CONTENT INFRASTRUCTURE

Access infrastructure is necessary, but insufficient for developing a digital economy, for the simple reason that Internet access is a means to an end. The goal is to access content and services, and these are delivered through content infrastructure. We view two components to content infrastructure:

- Internet Exchange Point (IXP). This is a point where three or more Internet providers can connect and exchange traffic with one another over a shared platform. This includes notably ISPs, but content providers and CDNs, governments, and research networks may also connect directly to an IXP.
- Data Center. This is a location where Internet providers can store their data – be it content or cloud services – and deliver them. An IXP may be located in a data center.

The Internet is a network of networks that connect together to exchange traffic. An IXP is an efficient place to meet to exchange traffic, because with one connection to the IXP, each provider can exchange traffic with multiple other providers connected to the IXP.

In a country without an IXP, each ISP must use international connectivity to exchange traffic. For instance, many ISPs in MENA buy transit to an IXP in Marseilles, or further afield in one of the other large IXPs in Europe, where they can exchange traffic with other ISPs from the same country, or region, who have international transit going to the same location. As a result, an email written in a country without an IXP may go through Marseille and return to be delivered to a user across the street who has a different ISP. This process is sometimes called tromboning, as the traffic follows the outline of the musical instrument out and back.

The issues with using international transit are thus doubled – one ISP bears the cost, and latency, of sending it out, and another ISP bears the cost, and latency, of bringing the traffic back. If, instead, those ISPs are connected to a local IXP, they could use much cheaper local connections to exchange the traffic, and would save significant amounts in international transit costs. Likewise, the lower latency will increase Internet usage. This, then, is a win-win-win – lower cost, lower latency, more usage. We will calculate the benefits and savings below.

A significant source of Internet content today is high-bandwidth video. Again, getting such content from abroad is costly and can be slow. A data center can host content locally, where it can be distributed through the IXP, which itself may be hosted in the data center. At the simplest level, a popular video may be viewed thousands, or even millions of times. Stored locally in a cache, such as is the case for YouTube videos in many countries, the video must only be imported once into the country, and then can be accessed quickly and cheaply through the cache.

The Internet Society conducted a study in 2012 on the benefit of the IXPs in Kenya and Nigeria. In Kenya, we estimated that the IXP had reduced latency from 200-600ms for traffic exchange before the IXP to just 2-10ms after; the ISPs saved $1.5 million on international IP transit; and the ISPs also had increased usage as a result of the lower latency with an extra $6 million in data revenues as a result.[32] This increased usage came mainly from a local Google cache holding YouTube videos. These results are not specific to Kenya and Nigeria – they are true for any IXP that localizes traffic exchange and helps to attract content, and have motivated moves in Singapore and other countries to establish IXPs.

As a country moves towards developing a digital economy that will create local content, it is worth bearing in mind that all countries already are generating local content, whether it is coming from government, local

business or other organisations, or individuals developing websites or applications. However, the website is often hosted abroad. That may be because there is no suitable data center in the country, or because it is cheaper to host the data abroad. It may even be, in our experience, that the owner of the website is not aware that the website is hosted abroad, because they have left the hosting to the developer of the website.

Hosting local content abroad imposes two significant costs.

First, because of the latency of accessing content from abroad, usage of the website is not as high as it would be if it was hosted locally. Evidence shows that when a website or content is hosted locally, usage will quickly double or more as a result of the faster, and more pleasing, speed of access.

The Internet Society showed the benefits of local content hosting in a previous study, to show the benefits.[33] During that study, a CDN put a cache in a country, and the results showed that immediately, the speed of access to that data increased. Whereas 90% of users had throughput of less than 500 kbit/s accessing the content before the cache was in place, afterwards only 50% had such slow speeds, with everyone else experiencing speeds faster than that due to the local cache. The impact on usage was striking.

The cache was put in country in January 2013, and immediately the amount of traffic delivered from within the country spiked (dark blue line below), which is the purpose of the cache. Of course, not all content would be stored in the cache, but over time, the percentage continue to rise. At that time, the peak (green line) and average (light blue line) total traffic from the CDN had been relatively flat, but then began to rise steadily, as users experienced the faster throughput to the locally cached content, and began to use the content more. Just by putting the content locally, usage began to rise.

The second cost of hosting local content abroad is that, while the website owner may save a bit on the hosting cost, it is imposing a significant cost on all the ISPs that must spend on transit to bring the content into the country each time it is accessed. The cost imposed on the ISPs is far greater than the savings realized by the content provider.

During this set of studies, we highlighted the economics of local content hosting. We estimated that a content developer in Africa (in this case, Rwanda), might save just over $100 by hosting a website in the US, but that this website was generating enough traffic back to the US to cost the ISPs $13,500 in IP transit over the same time period. In addition, the latency was much worse bringing the content from the US, and thus usage was reduced. Bringing the website back to Rwanda lowered costs significantly, and increased usage and data revenues accordingly.[34]

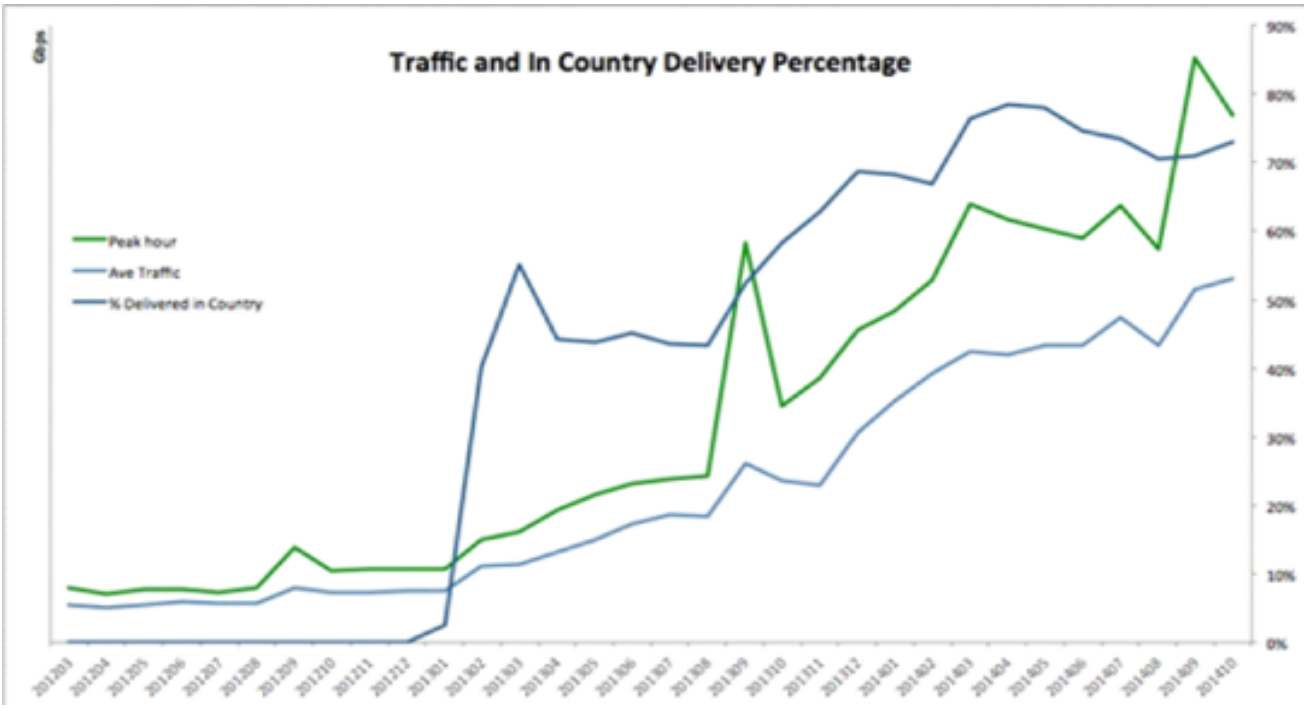


Figure 9: Impact on usage from local content hosting (Source: Akamai, 2016)

[32] Kende and Hurpy, "Assessment of the Impact of Internet Exchange Points – Empirical Study of Kenya and Nigeria."
[33] Kende and Rose, "Promoting Local Content Hosting to Develop the Internet Ecosystem."
[34] Kende and Rose.

09

IXPS IN MENA

The MENA region has a small number of active IXPs, and we have compiled a list based on a number of sources. Several of the IXPs listed were founded more than eight years ago, another group started in the past few years, and we understand other countries not on the list are planning their own IXPs for the next few years. Only four of them provide significant data on their websites; others list their members but not traffic data.

Country	IXP	Opening	Daily average traffic (Gbit/s)	Number of members
Bahrain	MN-IX	March 2019	n/a	n/a
Egypt	CAIX	June 2002	2.43	6
Kuwait	Ix.kw	Dec. 2018	5.33	12

Lebanon	A.IX	May 2017	n/a	32
	Beirut-IX	Dec. 2007	n/a	12
Palestine	PIX	June 2012	n/a	n/a
Saudi Arabia	SAIX	May 2017	15.55	6
	JEDIX	Dec. 2018	n/a	n/a
Sudan	SIXP	Oct. 2011	n/a	9
Tunisia	TunIXP	1996	n/a	24
UAE	UAE-IX	Feb 2012	58.6	66
	SmartHub	n/a	n/a	n/a

Table 3: IXPs in MENA (TeleGeography, Packet Clearing House, IXP websites, Internet Society, 2019)

For the three relevant IXPs that provide statistics on their website, we can determine the cost savings from having the IXP as follows.[35] Taking the average cost of international IP transit, the savings from using the IXP are in the millions for each country. For the six participants in CAIX, that is a savings of over $650,000 per year; somewhat more for the participants at SAIX, and somewhat less for Ix.kw.[36] These are significant savings while also lowering the latency of traffic exchange.

[35] As UAE-IX is mostly for international traffic, which would not have otherwise tromboned but for the IXP, we do not include it here in the calculations of the savings to the local ISPs from using the IXP to localize traffic exchange.

[36] These savings are calculated as follows. First, the average traffic through the IXP in Mbit/s is multiplied by two, because every Mbit/s of traffic that goes through the IXP represents one Mbit/s of traffic that one ISP would have delivered outside the country using international IP transit, and another Mbit/s of traffic that another ISP would have used to bring that traffic back into the country using international IP transit. The total Mbit/s that would have been sent and received is then multiplied by the cost of international IP transit (Mbit/s per month). This gives the average monthly savings, which is multiplied by 12 to get the yearly savings. This is then divided by the number of members of the ISP to determine the average yearly savings

	Egypt (CAIX)	Saudi Arabia (SAIX)	Kuwait (Ix.kw)
IXP daily average traffic (Mbit/s)	2,430	15,550	5,327
Total intl. Internet bandwidth (Mbit/s)	1,150,000	7,825,512	360,000
IXP traffic as a percent of total international traffic	0.211%	0.199%	1.944%
IP transit price for GigE ($ Mbit/s month)	$67.41	$14	$45
Yearly savings	$3,931,351	$5,224,800	$5,735,160
Average yearly savings per member	$655,225	$870,800	$479,430

Table 4: IXP cost savings (TeleGeography, ITU, IXP websites, Internet Society, 2019)

One salient point that emerges from this analysis is how little volume the IXP traffic is compared to total international traffic – in both Saudi Arabia and Egypt it is a fraction of one percent, in Kuwait just under two percent. This suggests a significant scope to increase the use of the IXP – the same is likely true in the other countries with an IXP that did not supply traffic levels; the benefits in countries without an IXP would be yet greater. As all the major ISPs in Egypt, Saudi Arabia, and Kuwait connect to their national IXP, it would appear that the main source of growth would be to increase the amount of traffic hosted locally, to also exchange that through the IXP.

10 DATA CENTERS AND HOSTING IN MENA

As shown in the table below, as of the third quarter of 2019, there are data centers in MENA, and there is international content hosted in MENA by CDNs. The data centers listed could be owned by carriers or carrier-neutral. Google has installed a number of caches around the region, holding static content such as YouTube videos, and in two countries has built out their network for a Google Edge. Three of the largest independent CDNs, Akamai, Cloudflare, and Limelight, also have a varying level of presence in twelve of the eighteen countries.

	Data Centers	Google Global Cache	Google Edge	Akamai	Cloudflare	Limelight
Algeria	1	9				
Bahrain	2	1		1	1	
Egypt	12	8		2	1	
Iraq	0	6		3	1	1
Jordan	6	1		1	1	
Kuwait	3	1		1	1	1
Lebanon	2	1			1	
Libya	1	3				
Morocco	5	4		2	1	
Oman	4	1	1	1	1	
Palestine	1	2			1	
Qatar	3	1		1	1	1
Saudi Arabia	19	3		3	1	Planned
Sudan	0	1				
Syria	0	0				
Tunisia	2	1		1		
UAE	9	3	1	3	1	1
Yemen	0	1				
Total	**70**	**47**	**2**	**19**	**12**	**4**

Table 5: Data Centers and CDNs in MENA (DataCenterMap, Google, Akamai, Cloudflare, Limelight, Internet Society, 2019)

Likewise, with respect to the large CDNs, Google has many caches in the region, in all but one country, with many having multiple caches. On the other hand, its edge network is only built into 2 countries. Akamai and Cloudflare are built into a number of countries in the region, but at least eight have no presence. In a country with no functioning IXP, however, it is likely that each CDN instance is only serving one ISP, as there is no established means to distribute content to the other ISPs. In countries with an IXP, it is efficient to put the cache in the IXP, where it can serve all members, and the cost of the IP transit to fill the cache can be shared among the members.

As discussed, the benefits of data centers, and the content inside, are significant. Every Mbit/s of traffic that originates within the country, instead of from international sources, lowers the cost of transit from bringing the content in from abroad and lowers the latency of accessing the content, which in turn increases the usage of the content and the data revenues earned by the ISPs. Local content infrastructure is thus an important step on the road to a digital economy.

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Box: United Arab Emirates

The UAE, in many ways, stands out from the other countries in the region with respect to content infrastructure. It has the largest IXP, the UAE-IX, along with another, the SmartHUB. UAE has at least one instance of the listed CDNs, has a Microsoft Azure cloud data center, and the presence of several AWS locations.

However, there is a regulatory / commercial line between the international and domestic connectivity in the country, with UAE-IX in a Transit Zone in which international operators can exchange traffic without a license. Thus, UAE-IX advertises itself as a platform that connects global networks, particularly those in the GCC region, but it is not clear the extent to which national users and businesses benefit, given that traffic must pass through one of the two local ISPs to be delivered into the country.

We understand, for instance, that the cost of national connectivity is [10x] that of international connectivity coming into the country. Thus, implementing the full range of sector reform described above would improve the Internet environment in UAE, as opposed to UAE-IX providing benefits mostly for the rest of the region today.

11 ISSUES AND RECOMMENDATIONS

While they build on each other, we highlight the recommendations to promote physical infrastructure, such as IXPs and data centers, separately from the data policies needed to attract content and services to fill the data center and use the IXP.

Policies to promote an IXP and data centers

Many IXPs, including those among the largest in the world, were started by the Internet community, as a way to increase the efficiency of data exchange. This is true, for instance, of the LINX exchange in London, one of the largest in the world, which started when five British ISPs, including the incumbent British Telecom, agreed among themselves to establish a common peering point. This reflected the sustained ethos of the Internet, for stakeholders to work among themselves to develop, govern, and manage the IXP, the network of networks, an ethos which is a touchstone of the Internet Society's founding and mission.

The role of an IXP has expanded since the early days when LINX and other exchanges were founded in the 1990s. Now, they are also an efficient means to access content and services, which might be directly connected to the exchange, or indirectly via an ISP. This provides business continuity, in the case that international connections are severed, and increases the resilience of the local Internet.

Nonetheless, we recognize that in some cases, there may be policy barriers to the development of IXPs, and in other cases the government may be able to help launch a successful IXP. This is particularly true in those countries which have recently launched an IXP or are about to, where there was something holding back the industry to otherwise do it on its own. We reflect this reality in our recommendations.

Some recommendations are to countries without an IXP; others are meant to help level up an existing IXP.[37] While the government may help establish the IXP, the ideal model based on best practice is for the IXP to be owned and operated by an association of its members, on a non-profit basis.

- *Establish an IXP*. The government can take a number of steps to help establish and IXP and make sure it is healthy.
    - o *Resources*. The government can provide a location and other resources to establish an IXP, as has been the case with SAIX in Saudi Arabia, which was established by the Ministry, and hosted in a government data center. The government has plans to spin off the IXP as it grows.
    - o *Governance*: Governments can serve on a Board of Advisors or act as observers to the IXP vs being involved in day-to-day management of the IXP.
    - o *Government* services. To increase the incentive to connect to the IXP, the government can connect its own e-government services to the IXP, so that the ISPs have to connect to the IXP to enable their customers to reach the government services. For instance, one of the big participants in the KIXP exchange in Kenya is the government revenue authority, which benefits from direct connections to the ISPs.
    - o *Enabling environment*. IXPs are impacted by investment and tax constraints, high costs

[37] See "Internet Exchange Points (IXPs)," Internet Society, accessed August 7, 2019, https://www.internetsociety.org/issues/ixps/. And also "Internet Exchange Points: An Internet Society Public Policy Briefing" (Internet Society, October 30, 2015), https://www.internetsociety.org/policybriefs/ixps/.

of accessing local fiber, and network deployment regulations. The telecom sector reforms described above will help to keep the costs of accessing the IXP reasonable.

- *Avoid constraints through licensing or regulation on operators' ability to connect and peer at an IXP.* There are two potential constraints: first, operators without the appropriate license may be restricted from connecting to an IXP, and second, content providers may not be allowed to connect directly to an exchange.

Best practice. Separate the ability to exchange traffic from the ability to sell services in a country. Allow the maximal traffic exchange within the four walls of an IXP, without the requirement for a license that would allow an operator or content provider to fully operate in a country.

Example. Dozens of international operators and content providers have established a presence at the UAE-IX in the UAE to exchange traffic; indeed, the UAE-IX is in a Transit Zone established to enable the exchange of traffic by operators without a license for UAE. However, the benefits that UAE-IX brings to the region should be allowed to be fully felt inside the country.

- *Promote usage*. One of the significant early uses of an IXP is to help distribute content from caches. A CDN can establish one cache, connect it to the IXP, and thereby distribute the content to all the ISPs connected to the IXP. The issue is who pays for the transit to fill the cache. In spite of the significant savings to the ISPs from not each having to bring in the content multiple times, this has been a challenge.

Best practice. In some specific cases, the largest ISP – typically the incumbent – will agree to bear the cost of the transit; more often, the ISPs will find a way to share the cost of filling the cache. In other situations, the government, having established the IXP, will pay the cost of filling it for a set period, as a way to demonstrate the benefits of the IXP.

Example. The Internet Society, in partnership with Facebook, issued a Request for Proposal to help provide supplementary funding for the IP transit needed to fill any cache at five IXPs in Africa, based on a cost sharing template adopted by the African IXP Association (Af-IX) and already used by some IXPs in Africa.[38]

- *Level up an IXP.* In addition to steps to increase regional participation and promote usage, described above, there are other steps that can be taken to level up an IXP. It can increase its capacity to enable more interconnection, it can attract DNS root server mirrors, in order to increase the speed of resolving domain names, and it can ensure a sustainable funding and governance model. As demand in the country grows, the IXP can also expand within a city to have nodes in multiple data centers (also called a virtual IXP) or expand to other cities.

Example. The Internet Society helped a small IXP in the Philippines (PhOpenIX) as it grew to cover multiple cities and have 43 networks attached. It has now increased its capacity ten-fold, has six DNS root server mirrors, and Google and Akamai caches.[39]

The data center, which may serve as the host for the IXP, has a separate set of recommendations. We note that the preferred model of data center is carrier-neutral, that is one that is owned by an independent company, and not one of the ISPs. This avoids other ISPs having to rely on their competitor for data center services, and ensures for the content providers that there can be competing offers for backhaul services.

- *Infrastructure*. A data center needs land to build, and a significant amount of power, which must be inexpensive and reliable. The government could help to provide the land and/or provide a subsidy on the power if it is particularly expensive.
- *Fiber*. As noted above, a data center needs fiber to bring and deliver data. A data center, in particular a carrier neutral one, seeks competitive, redundant, and resilient fiber connections. These result from the sector reforms described above.
- *Employees*. A data center requires engineers to develop and operate the data center. The government can assist by providing training opportunities for engineers, and in allowing foreign employees of the data center or its customers to enter the country to visit, or even help establish, the data center and assist in training.

[38] For the RFP see https://www.internetsociety.org/wp-content/uploads/2019/02/Cache-Fill-CFP-EN.pdf. For the general template for sharing the cost of IP transit, see https://www.af-ix.net/resources/2017/06/template-shared-cache-public-tender.
[39] Noelle Francesca De Guzman, "IXPs Level up in Emerging Asia-Pacific," Internet Society (blog), February 15, 2016, https://www.internetsociety.org/blog/2016/02/ixps-level-up-in-emerging-asia-pacific/.
[40] See https://www.borderlesscounsel.com/blog-news-and-updates/2019/5/23/bahrains-data-protection-law-what-you-need-to-know-to-comply.

Data policies to create trust

It is important not just to create content infrastructure, but also to fill it. There is a significant amount of international content that is popular, and that could benefit from local content hosting. Likewise, each country has its own local content, but often that content is hosted abroad as we have noted.

Content has its own regulatory sensitivities, as it can relate to politics, culture, religion, and other potentially sensitive subjects. Less sensitive topics include data protection, privacy, and cybersecurity issues.

- *Data residency.* A number of countries have implemented, or considered, data localization requirements to store local content locally. We recognize the benefits of local hosting of content, in terms not just of cost and latency, as described above, but also issues of sovereignty and resilience. However, we urge countries to create an enabling environment for hosting content locally, as we describe here, rather than mandating such hosting which can reduce incentives to invest.
- *Content restrictions*. Many countries have certain estrictions on content, whether to do with religion or cultural sensitivities. These restrictions typically exist outside the Internet's technical infrastructure, and countries attempt to apply them online. We only note that it is important to make these restrictions transparent and fairly applied, in order to provide content owners with the information needed to comply without creating undue uncertainty.
- *Intermediary liability*. The Internet has introduced a new category of provider, the platform. Platforms such as YouTube allow content to be uploaded by their creators and downloaded by viewers. Many countries recognize the challenge of screening and judging all content before it is uploaded, and instead shield the platform from liability, so long as they take down unlawful content within a set time of being notified. In turn, responsible platforms have terms and conditions regarding content, which may go beyond what is required by law, which they self-enforce.
- *Policies to generate trust*. At the same time, it is important to have laws and regulations regarding data protection and privacy, to provide a framework within which content providers can operate, and to help generate trust among users. Likewise, cybersecurity laws and practices, the subject of a separate Internet Society report for MENA, help to establish trust. As an example of the benefits of these laws, we understand that one factor that helped Bahrain to attract the AWS data center was passing a data protection law similar to the recently passed European General Data Protection Regulation (GDPR).[40]

Of course, it is important to fill the content infrastructure with new content and services, not existing ones, and to ensure that the access infrastructure is being used to produce content and services, not to just consume them. Developing a digital economy can assist in creating an enabling environment for development, which in turn creates the foundation for digital transformation of the rest of the economy.

[40] See https://www.borderlesscounsel.com/blog-news-and-updates/2019/5/23/bahrains-data-protection-law-what-you-need-to-know-to-comply.

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SECTION 4. DIGITAL ECONOMY

As noted previously, the digital economy must build upon access infrastructure, to develop content and services and to consume them, and the new content and services require content infrastructure to host and distribute them. The digital economy will help entrepreneurs to develop their innovations, while also helping existing companies to fully engage in the domestic and global online marketplaces.

The digital economy ensures that those best placed to identify gaps in the local market with innovative new ideas are also best placed to fill them. It also helps to grow local markets for those ideas by helping to create demand for the innovations.

A number of steps can be taken to create a digital economy, and to increase the market size for the resulting content and services.

- *Tech Hub*. Innovation requires its own enabling environment, and many countries have tech hubs to help innovators. These tech hubs host innovators and new companies, providing them with many key ingredients, including high quality Internet access, administrative resources, labs for IoT and other physical innovations, proximity to other innovators for networking, and other benefits.

Example. For instance, the UK Lebanon Tech Hub (https://www.uklebhub.com) is a joint venture of the Banque du Liban and the British Embassy in Beirut, and it helps grow local companies and connect them to global markets. It helped over 80 startups t, with a total valuation over $200 million, and generated at least 2000 local jobs. The UAE has a number of Tech Hubs, including Hub 71 (https://www.hub71.com/), created by Abu Dhabi's Mubadala Investment Company, Abu Dhabi Global Market ADGM, Microsoft and SoftBank. It is an initiative of the Ghadan 21 programme, a Dh50 billion package of reforms from the Abu Dhabi government to stimulate the local economy and to attract start-ups and support them with housing, office space, and access to venture capital.

- *Venture capital*. Innovation also requires capital to help develop and then market the content or service. Where traditional venture capital is limited, governments have supported venture capital funds, sometimes with assistance of international organisations such as the World Bank. In addition, the Internet itself provides access to capital through so-called crowd-funding platforms such as Indiegogo, for which governments should remove roadblocks, while ensuring trust in the new systems.

Example. One approach for governments to help stimulate innovation is to create a 'fund of funds' that can invest in venture capital funds, without itself becoming a venture capital fund. For instance, in Bahrain the Al Waha Fund of Funds was launched by the Bahrain Development Bank, with $100 million to invest in venture capital funds with a presence in the country. This fund will help to stimulate, among other sectors, the Bahrain FinTech Bay, a growing hub for FinTech (financial technologies).

- *Financial inclusion*. In order to turn innovation into income, new companies must be able to be paid,

either by the end-users or through advertising or other support, and this requires general financial inclusion as well as a means to be able to buy and sell online, such as through mobile money. Again, governments should remove any roadblocks to such instruments, while ensuring consumer protection.

Example. Financial inclusion has been a focus in Tunisia for a number of years. In 2015 Tunisia put in place a new banking law to help facilitate mobile money and allow distribution through agents, and it now has five providers, according to GSMA. Further, financial inclusion is also a focus of the Digital Tunisia 2020 initiative, and one result has been to enable interoperability between mobile money providers so that users can transfer money between providers, making the mobile money more useful.

Likewise Egypt has focused on mobile money for a number of years. In 2017 the government established the National Council for Payment to increase electronic payment, headed by the President and including the Prime Ministers and key Ministers. Interoperability between mobile money providers was established by the National Telecom Regulatory Authority (NTRA) and Central Bank of Egypt in 2017, and there are aggressive goals on increasing the number of subscribers and usage.

- *Capacity building*. Finally, new content and services require capacity building, preferably at three levels – all users being comfortable online to use the services, training to enable developers to create their content and services, and last but not least business training for entrepreneurs to be able to turn their small companies into bigger companies. While the Internet is the focus of much innovation, the Internet itself also enables capacity building, providing access to training courses as well as massive online open courses (MOOCs), and it allows more informal learning opportunities.

Example. WeMENA (Women Entrepreneurs for a Resilient Future), a program supported by the World Bank, provides opportunities for women entrepreneurs in MENA to have mentorship, training, and funding for their innovations. In turn, the supported innovations focus on building resilience in their communities while empowering women.[41]

Regional integration – countries lowering their digital barriers – can also help a country establish a prospering digital economy, in a number of ways. First, it can help to create economies of scale for infrastructure investments, such as cross-border connectivity through terrestrial fiber cables, where those cables can be used to support a larger market. The same is true for large data centers, which may cost up to USD 1 billion to build, and are more likely to be built, the larger the market they can easily serve. Finally, regional integration can create a larger market for new content and services coming from the digital economy.

Regional integration is particularly appealing for countries who share similarities in terms of language, history, religion, and culture, because the content and services created will have a larger market without making significant changes. The US, for instance, has a significant advantage in helping to foster large Internet companies, who can make their services available to the entire country in the same language without adapting their services to other countries' laws and regulations until they are ready for international expansion. Europe, of course, has been implementing a digital single market for a number of years as part of the broader single market goals of the European Union; other regions exploring this option include those in the East African Community, and those in ASEAN in East Asia.

Successful regional integration, in order to create a digital single market, must occur at three levels; first, at the access infrastructure level to allow content to flow between countries at low cost and latency; second to allow a free flow of data between the countries, so that regional data can be stored and analyzed in data centers in different countries in the region; and third to allow content and services to easily be sold across borders.

In MENA, this would ultimately create a market of 400 million population, with a combined GDP of USD 2.7 trillion, an attractive market for investment and growth. As a single digital market, it would have the fourth largest population (after China, India, and the European Union), and sixth largest economy, making it a more attractive market for investment and growth. This would help stimulate the digital economy in each country, while also providing more innovation and choice for users.

[41] See http://www.we-mena.org.

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SECTION 5. CONCLUSION

In this paper we focus on the Internet infrastructure, policies, and efforts needed to develop a digital economy. Internet infrastructure is not just the means to go online, but it is also the infrastructure to exchange traffic and host content. In turn, an ecosystem must be in place to develop content and services that will take advantage of the infrastructure, as follows.

- *Access infrastructure*. This is the entire value chain of infrastructure that carries traffic to and from international points, delivers the traffic throughout the country on a national basis, and connects users to the Internet. Users will connect to access relevant content and services. There are three steps to develop access infrastructure and make sure that it is accessible by all.
    - o *Sector reform*. These are reforms to the legacy telecommunications regulations, which enable competition and investment in the sector.
    - o *Remove barriers*. After these sector reforms, other steps may still be needed to remove barriers and maximize the possible level of investment.
    - o *National broadband plans*. These should provide strategies to reach otherwise uneconomical regions, which can use government resources, and may also contain broader digital development plans to increase demand for Internet access.
- *Content infrastructure*. This includes Internet Exchange Points (IXPs) where traffic can be exchanged on a local basis, and data centers, where content and applications can be hosted. Using local content infrastructure lowers the time needed to deliver traffic and access content, improves quality of service, strengthens capacity of local experts, and it lowers costs, which in turn helps to promote Internet adoption and usage. Governments must take two steps to help develop content infrastructure.
    - o Policies to promote an IXP and data center, including providing resources and an enabling environment to establish an IXP, and ensure that the inputs for a data center, namely land and power, competitive fiber connections, and trained engineers, are all readily available.
    - o Data policies that attract content and services to the data center and to utilize the IXP, including transparency on any content restrictions, limits on liability for intermediary platforms, and data protection and privacy regulations to generate trust.
- *Digital economy*. This is the ecosystem to create content and services to fully utilize the access and content infrastructure. A digital economy enables entrepreneurs to innovate while also providing consumers with the ability to use their new services, and it helps bring existing sectors online to trans-

form the entire economy.

The relevant policies to develop the digital economy include developing one or more tech hubs to host entrepreneurs while they innovate, supporting venture capital funds to provide resources, and ensuring financial inclusion to create a market for the content and services. Innovators need training to develop the services and build a business, while users need digital skills to go online and use the new services.

These policies will enable the more advanced countries in the region to grow their digital economies into regional and global hubs for advanced content and services, and the less developed countries to develop their infrastructure to build their own digital economy to begin to transform the rest of their economies. The policies are built on many years of experience by the Internet Society working around the world, which are now being applied to the MENA region through the newly established regional bureau.

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ANNEX B: ITU ICT REGULATORY TRACKER

The full set of indicators is showed in the table below.

ICT REGULATORY TRACKER

Cluster 1: Regulatory Authority

1. Separate telecom/ICT regulator
2. Autonomy in decision-making
3. Accountability
4. Percentage of diversified funding
5. Public consultations mandatory before decisions
6. Enforcement power
7. Sanctions or penalties imposed by regulator
8. Dispute resolution mechanism
9. Appeals to decisions
10. Existence of Competition authority

Cluster 2: Regulatory Mandate

Who is in charge of regulating the following?

11. Quality of Service obligations measures and service quality monitoring
12. Licensing
13. Interconnection rates and price regulation
14. Radio frequency allocation and assignment
15. Spectrum monitoring and enforcement
16. Universal service/access
17. Broadcasting (radio and TV transmission)
18. Broadcasting content
19. Internet content
20. IT

21. Consumer issues

Cluster 3: Regulatory Regime

22. Types of licenses
23. License exempt
24. Operators required to publish Reference Interconnection Offer
25. Interconnection prices made public
26. Quality of Service monitoring required
27. Infrastructure sharing for mobile operators permitted
28. Infrastructure sharing mandated
29. Co-location/site sharing mandated
30. Unbundled access to the local loop required
31. Secondary spectrum trading allowed
32. Band migration allowed
33. Number portability required from fixed-line operators
34. Number portability required from mobile operators
35. Individual users allowed to use VoIP
36. National plan that involves broadband

Cluster 4: Competition Framework

Competition exists in the following market segments:

37. Local and long distance (domestic and international) fixed line services
38. IMT (3G, 4G, etc.) services
39. Cable modem, DSL, fixed wireless broadband
40. Leased lines
41. International Gateways
42. Status of the main fixed line operator (public, partially or fully private)
43. Legal concept of dominance or SMP
44. Criteria used in determining dominance or SMP

Foreign participation/ownership in:

45. Facilities-based operators
46. Spectrum-based operators
47. Local service operators/long-distance service operators
48. International service operators
49. Internet Service Providers (ISPs)
50. Value-added service providers

Source: ITU.