ADVANCES IN REGULATORY COSTING AND PRICING STRATEGIES FOR DIGITAL SERVICES IN AFRICA

BACKGROUND PAPER

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This report was prepared for the International Telecommunication Union (ITU), by ITU Expert Ms Hilda Mutseyekwa, under the supervision of the ITU Regional Office for Africa and the Regulatory and Market Environment Division (RME) of Telecommunication Development Bureau (BDT). It *was prepared as a background discussion paper and presented during the ITU Regional Economic Dialogue for Africa (RED-AFR): Meaningful and Affordable Digital Connectivity for Africa* [1] *organized online from 11 to 12 November 2020.*

[1] ITU Regional Economic Dialogue for Africa (RED-AFR): https://www.itu.int/en/ITU-D/Regulatory-Market/Pages/Events2020/RED-AFR-2020.aspx

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ABBREVIATIONS

3G	Third-generation mobile telecommunication technology
4G	Fourth-generation mobile telecommunication technology
5G	Fifth-generation mobile telecommunication technology
A4AI	Alliance for Affordable Internet
B2B2C	Business to Business to Consumer
BEREC	Body of European Regulators for Electronic Communications
CAPEX	Capital expenditure
CDN	Content Delivery Network
CIS	Commonwealth of Independent States
GB	Gigabyte
GSMA	GSM Association
IoT	Internet of Things
IP	Internet Protocol
IPB	Internet Backbone Provider
IPvIC	Internet Protocol Voice Interconnection
ITU	International Telecommunication Union
IXPs	Internet Exchange Points
ISP	Internet Service Provider
MB	Megabyte
OTTs	Over-The-Tops
PPP	Public- Private Partnerships
RAN	Radio Access Network
RIXPs	Regional Internet Exchange Points

EXECUTIVE SUMMARY

This report explores the current situation and emerging trends pertaining to the provision and costing of digital services at both wholesale and retail levels. It also tracks emerging business models and pricing strategies by operators in order to remain viable, as well as policy and regulatory interventions by governments and regulators to ensure service availability and affordability at the global level, against what is happening in Africa. The report concludes by proposing a way forward for Africa to enhance the availability and affordability of digital services.

In terms of interconnection, the report establishes that the convergence of voice and data interconnection is yet to happen as many African countries remain with different interconnection regimes for data and voice services. Under this dichotomy, voice interconnection remains largely circuit switched based, with benchmarking and traditional Long Run Incremental Costing (LRIC) models for traditional voice interconnection as the most popular regulatory costing tools in use. This state of affairs is also prevalent in most developing countries across all regions. The story is different in more developed countries where interconnection regimes are evolving to become fully IP based, without ex-ante regulation, with the use of commercial agreements gaining traction. The report however notes that Africa is catching up fast with developments elsewhere as it scales up efforts to improve on its terrestrial fibre connectivity as well as the establishment and operationalisation of Internet Exchange Points (IXPs), construction of data centres and the coming on board of Content Delivery Networks (CDNs), to host content in Africa.

The report validates that Africa is yet to experiment with the costing of advanced services, including 5G services at both wholesale and retail levels, compared to more developed regions of the world. This is largely attributable to the relatively sluggish migration to Next Generation technologies, whereby Africa had the lowest 4G penetration rate of 10% compared to a range of 33-90% in other regions of the world, [2] whilst 5G deployment had only started in a few countries, with pilot launches done in South Africa and Lesotho only, as at end of November 2020.

Appertaining to emerging business models and pricing of digital services, the report notes that African operators are fast catching up with adopting new strategies, business models and new service offerings, including IoT, albeit not to the same extent and levels as in South Korea, China, Europe and the United States of America, that have fully deployed 4G networks and are already deploying 5G networks on a commercial basis. The report registers that pricing models for commercially launched 5G services are not very different from those of 4G services. There is no extra charge for 5G services [3]. This is largely attributable to the fact that current

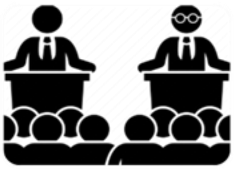
[2] https://www.itu.int/en/myitu/Publications/2020/08/31/08/38/Connecting-Humanity

[3] https://www.csgi.com/insights/5g-market-disruption-demands-pricing-innovation-from-the-get-go/

commercially launched 5G services are premised on a combination of heterogeneous technology types, incorporating all previous generations of cellular mobile systems, with some using existing fixed networks for wireless access and backhaul connectivity. In essence the launched 5G services are not from stand-alone 5G core networks. Going into the future, and with the deployment of 5G core networks, there is the possibility of pricing based on split 5G core infrastructure into end to end network slices for different use cases ranging from massive IoT, reliable low latency and enhanced mobile broadband, amongst others.

The report concludes by making recommendations for policy-makers, regulators and Network Service Providers, aimed at fostering investment in broadband infrastructure and service affordability to enable Africa to catch up with the rest of the world as illustrated below:

Way Forward for Africa:



Governments to:

Consider broadband as an industrial policy.

- Enhance ease of doing business for ICT investors.
- Create enabling tax, import tariffs regimes to attract foreign ICT investors and financiers.
- Adopt flexible and technology neutral spectrum policies.
- Facilitate cross border deployment of infrastructure, including carrier neutral data centres
- Operationalise RIXPs.
- Encourage and attract CDNs for local and international content hosting.
- Foster cross sector infrastructure sharing.
- Foster trust and collaboration amongst ICT stakeholders.
- Utilise USF to deploy broadband, as well as stimulating adoption and use of broadband in underserved areas.

Regulators should:

- Adopt dynamic, functionality-based regulation
- Avail additional spectrum at affordable prices.
- Encourage active network /spectrum sharing.
- Enhance open access interconnection regimes.
- Reduce regulatory costs i.e. spectrum and gradually adopt general authorisation.
- Prioritise migration to IPV6.
- Foster competition.
- Mandate Accounting separation of wholesale and retail businesses.
- Collaborative regulation.

Network Operators to:

- Invest in carrier neutral Data Centers.
- Aggregate as much traffic as possible within African Internet Exchange Points.
- Invest in last mile connectivity.
- Invest in network-based content delivery platforms (deep caching).
- Explore new revenue streams and business models.
- Upgrade and enhance revenue assurance systems.
- Automate processes to enhance agility in service provision.
- Consider mutualisation of non-differentiating assets when deploying Next Generation Networks.

1 INTRODUCTION

One of the immediate key outcomes of the COVID -19 pandemic is that it has brought many nations to realise that broadband connectivity is no longer a luxury but a necessity. This has brought with it the importance and urgency of rolling out ubiquitous broadband connectivity to address the upsurge in data traffic owing to tele commuting and restrictions on physical mobility due to social distancing measures. This is happening at a time when Network Service Providers (NSPs) are grappling with rising demand for data hungry services whilst Average Revenue per User (ARPU) is declining. This is constraining NSPs in their efforts to increase network capacities for them to cope with rising demand for high-speed broadband connectivity.

This report examines the current and emerging business models as well as the costing and pricing of digital services at both wholesale and retail level in Africa, against what is happening in other regions of the world. The scope of the report covers interconnection models in use, for both traditional and advanced services, including emerging trends and practices relating to the rising importance of Content Delivery Networks for local content hosting, as well as emerging business and pricing models related to IoT and 5G services. The report concludes with recommendations on what policy- makers, regulators and Network Service Providers (NSPs) in Africa need to do in order to take Africa to the next digitalisation level and catch up with the rest of the world.

2 BACKGROUND

Africa is no exception to the unfolding scenario amid the COVID-19 pandemic and could be in a worse predicament, as it is lagging behind in migrating to Next Generation Networks (NGNs) compared to other regions of the world. The World Bank [4] estimates that Sub-Saharan Africa economic growth stands to shrink by between 3.3% in 2020 compared to a 2.4% growth in 2019, due to reduced economic activity, tourist inflows and trade, owing to social distancing measures. Predictions are that Africa is set to register its first recession in a quarter of a century in 2020, receding progress towards poverty reduction by at least 5 years.

With the experience of the COVID-19 pandemic, many countries are already augmenting and fast- tracking their efforts on universalising broadband connectivity. This requires sizable amounts of offshore capital and is likely to trigger a scramble for offshore lines of credit and Foreign Direct Investment (FDI). According to the ITU report "Connecting Humanity: Assessing investment needs of connecting humanity to the Internet by 2030", [5] Africa needs an investment of about USD97 billion to universalise broadband connectivity at affordable prices, compared to $135 billion (South Asia); $83 billion (East Asia Pacific); $51 billion (Americas and Central Europe); $33 billion for Europe and Central Asia. Given this huge demand for funding,

[4] https://openknowledge.worldbank.org/bitstream/handle/10986/34587/9781464816482.pdf?sequence=41&isAllowed=y
[5] https://www.itu.int/en/myitu/Publications/2020/08/31/08/38/Connecting-Humanity

the expectation is that of reduced availability of FDI and offshore loans, which will be more expensive and difficult to attract, especially for African operators given the high-country risk stigma of most African countries.

The above state of affairs has far-reaching implications on migration to NGNs and the balancing of operator viability and service affordability in most African countries. According to a Policy Brief published by the ITU and the Alliance for Affordable Internet (A4AI) on the Affordability of ICT services in 2020,[6] the cost of broadband in Africa remains unaffordable to many, at 9.6% and 8.9% of per capita GNI for the mobile data and voice low usage basket, compared to a world average of 2.1% and 1.9% in 2019 and 2020 respectively.

At the global level, the roll out of 5G networks mostly in developed countries has been remarkable. According to the GSMA (2019),[7] 348 operators in 119 countries had invested in 5G technology, with 77 of them having deployed 5G technology, whilst 49 operators had launched 5G commercial services. In Africa, 5G commercial services were being offered on pilot basis in Lesotho and South Africa as at end of November 2020. Overall, the envisioned potential of 5G is yet to be realised, owing to the high capital requirements for its deployment as well as the uncertainty related to monetisation of the networks and return on investment.

In terms of 4G deployment, most developed countries had significant 4G coverage by end of 2019. According to estimates based on GSMA and UN population data, with Xalama analysis,[8] Africa had the lowest 4G penetration rate of 10% compared to other regions of the world as indicated in table 1 below:

Table 1: 4G broadband penetration in 2019 (based on unique users)

Ranking	Region	4G Penetration Rate
1	North America	90%
2	Europe and Central Asia	70%
3	East Asia/ Pacific	67%
4	South Asia	45%
5	Latin America and Caribbean	42%
6	Arab States	33%
7	Sub-Saharan Africa	10%

Source: Estimates based on GSMA and UN population data, with Xalama analysis: https://www.itu.int/en/myitu/Publications/2020/08/31/08/38/Connecting-Humanity

In terms of migration to NGNs, the ITU ICT Eye database (2019),[9] indicates that only Eswatini, Ethiopia, Gabon, Ghana, Kenya, Madagascar, Mauritius, Rwanda and South Africa have indicated that they have completed migration to NGN networks. The majority of African

[6] https://www.itu.int/en/ITUD/Statistics/Documents/publications/prices2020/ITU_A4AI_Price_Briefing_2020.pdf
[7] https://www.gsma.com/publicpolicy/wpcontent/uploads/2020/03/Realising_5Gs_full_potential_setting_policies_for_success_MARCH20.pdf
[8] https://www.itu.int/en/myitu/Publications/2020/08/31/08/38/Connecting-Humanity
[9] https://www.itu.int/net4/ITU-D/icteye#/

countries are still in the implementation stage whilst a handful are still in the planning stage. The slow pace of migration to NGN in Africa is largely attributable to the fact that mobile broadband is the leading technology and hence it is easier for operators to leverage on their 2G and 3G networks to achieve full migration to NGN. This is unlike the situation in most developed countries that have leveraged their extensive fixed networks to roll out NGNs.

The above state of affairs has implications on progress made towards the adoption of emerging interconnection models as well as business models and pricing of digital services. This points to the need for a thorough analysis of the current situation in Africa in order to come up with focused policy and regulatory interventions as well as business models for Africa to catch up with what is happening in other regions of the world.

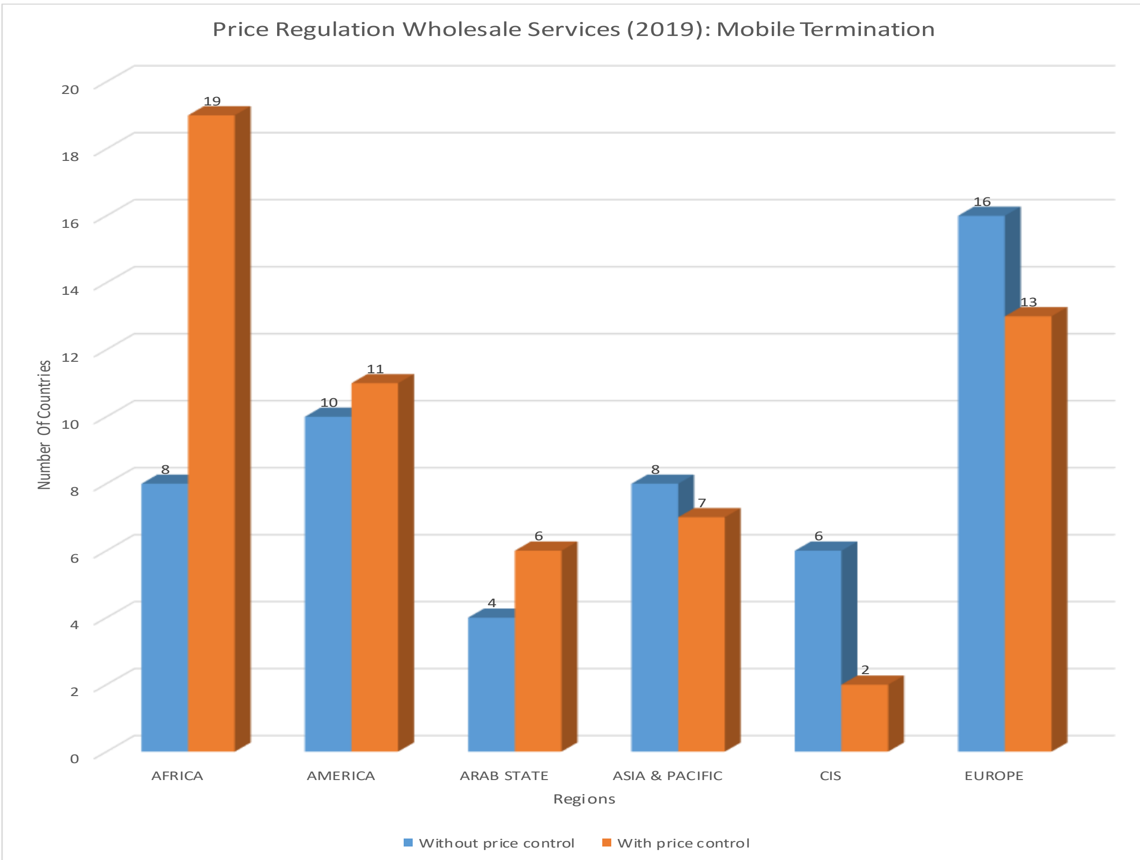
3 INTERCONNECTION MODELS IN USE

3.1 Traditional and advanced Wholesale Services

In Africa, the convergence of voice and data interconnection is yet to happen as many African countries remain with different interconnection regimes for data and voice services. The dichotomy of voice centric and data-centric interconnection regimes is largely attributable to slow pace of migration to NGNs. Under this dichotomy, voice interconnection remains largely circuit switched based and regulated.

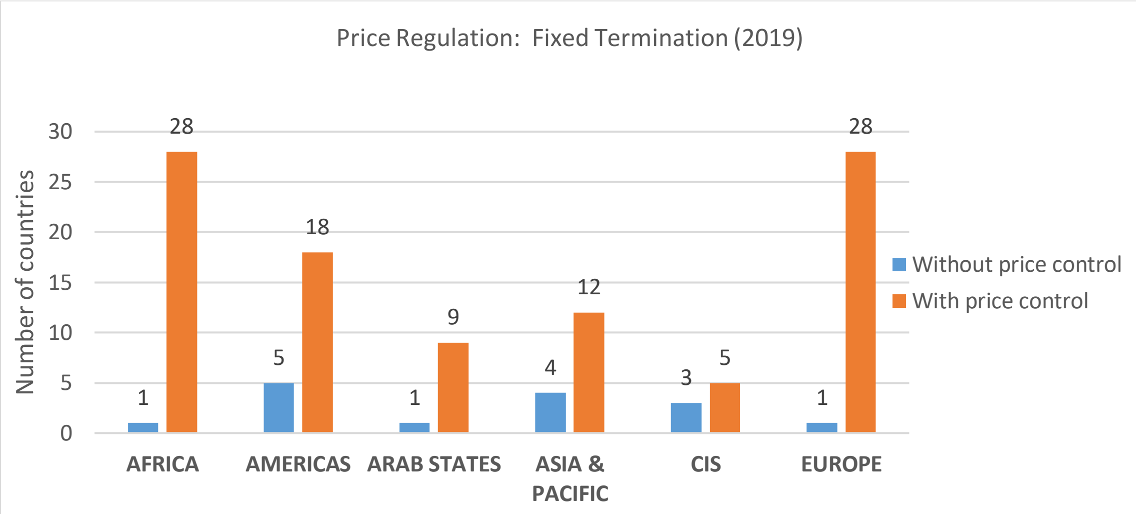
This scenario is also prevalent in most developing countries across all regions of the world including in Europe, Americas and Asia Pacific, where poorer countries are still regulating traditional wholesale services. Figures 1 and 2 below serve to show the number of countries by region that were regulating traditional wholesale services in 2019:

Figure 1: Price regulation Mobile Termination



Source: Author, using the ITU ICT Eye Database (2019) http://www.itu.int/icteye

Figure 2: Price Regulation of Fixed Termination by Region



Source: Author, using the ITU ICT Eye Database (2019) http://www.itu.int/icteye

Figure 2 above, shows that Europe and Africa registered the highest number of countries (28) that were still regulating fixed voice services voice in 2019. In Africa a majority of countries are still hanging on to traditional interconnection regimes owing to the slow migration to NGNs. In Europe, whilst notable progress has been registered towards migration to NGNs, mobile and fixed voice interconnection remain regulated in the majority of countries. The European electronic Communications Code (EECC) of December 2018,[10] requires a single maximum termination rate i.e. (Euro rate) effective from 31 December 2020.

The Euro rate is to be calculated based on a pure LRIC Bottom –Up cost model, using current costs, economic depreciation and an efficient operator with market share of at least 20%. This means cost orientation for voice termination rates is still relevant in the European region. However, interconnection regimes vary from country to country, with some European countries at advanced stages of adopting IP interconnection for all services. According to a BEREC publication, "*Study Report on Case Studies on IP –based Interconnection for Voice Services in the European Union"[11]*, covering 32 European countries, IP voice interconnection (IPvIC) has been implemented as indicated in table 2 below.

[10] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L1972 as per the following citation: 196) In order to reduce the regulatory burden in addressing the competition problems relating to wholesale voice call termination consistently across the Union, the Commission should establish, by means of a delegated act, a single maximum voice termination rate for mobile services and a single maximum voice termination rate for fixed services that apply Union-wide.

[11] *berec.europa.eu; Case Studies on IP –based Interconnection for Voice Services in the European Union: Document number: BoR (15) 196 dated 27/11/2015 BEREC*

Table 2: IP Voice Interconnection (IPvIC) in Europe

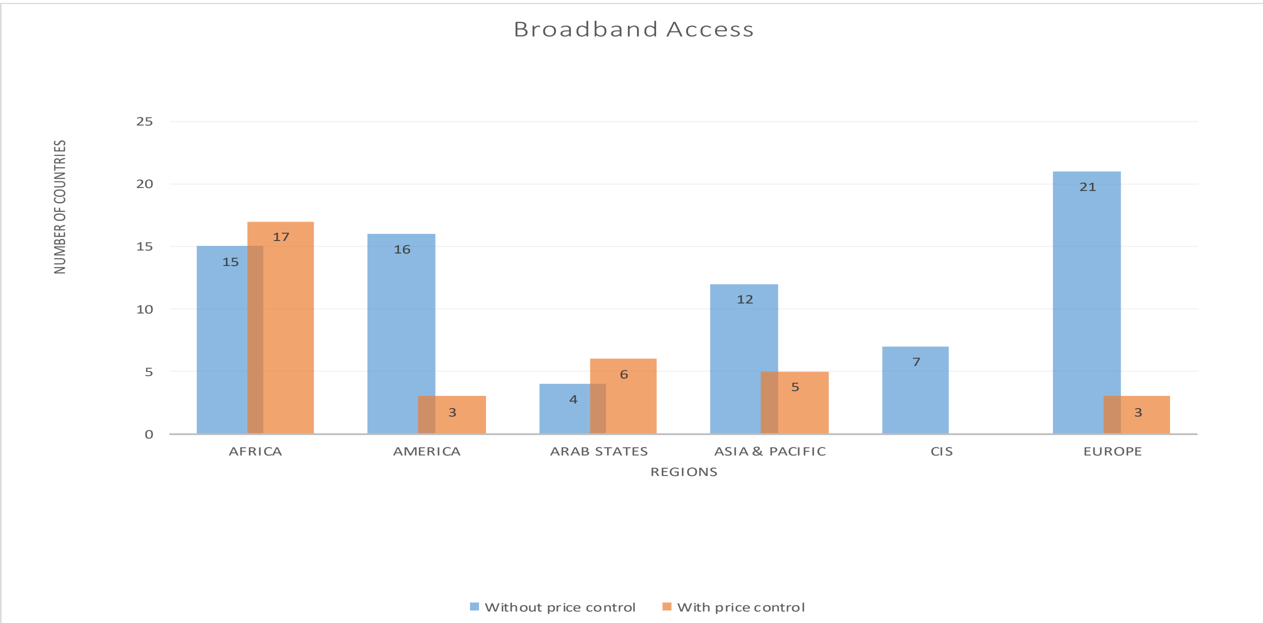
Type of operator	Countries with Mandatory IPvIC	Countries with Non -mandatory IPvIC
Fixed network incumbent	Germany, Denmark, France, Italy, Sweden, Slovenia,	Former Yugoslavian Republic of Macedonia, Netherlands, Slovakia, United Kingdom
Other IP networks	Austria*, Belgium, Germany, France, Croatia*, Italy, Spain*	Serbia* Greece*, Netherlands*, Norway*, Romania*, Slovenia, Slovakia* United Kingdom* Turkey*
Mobile network operator	Austria*, France,	Finland, Serbia*, Turkey*, United Kingdom*

Source: Berec Report on Case Studies on IP –based Interconnection for Voice Services in the European Union: Document number: BoR (15) 196 dated 27/11/2015 BEREC, berec.europa.eu

The BEREC report further reveals that IP voice interconnection has been implemented on a voluntary basis in France, Belgium, Romania, Denmark, Hungary, Finland, Lithuania and Slovak Republic. In these countries, there is no differentiation between circuit (TDM) and IP based interconnection.

As networks evolve from being voice –centric to being data centric, access regulation is still in practice, in particular in countries where public peering is still in its nascent stages. The figure below serves to corroborate the prevailing situation where broadband access regulation is mostly prevalent in Africa:

Figure 3: Regulation of Broadband Access by Region



Source ITU ICT EYE Database (2019)

The emerging trend is that countries are moving away from regulating interconnection to commercial agreements. The following cases serve to show the diversity of approaches:

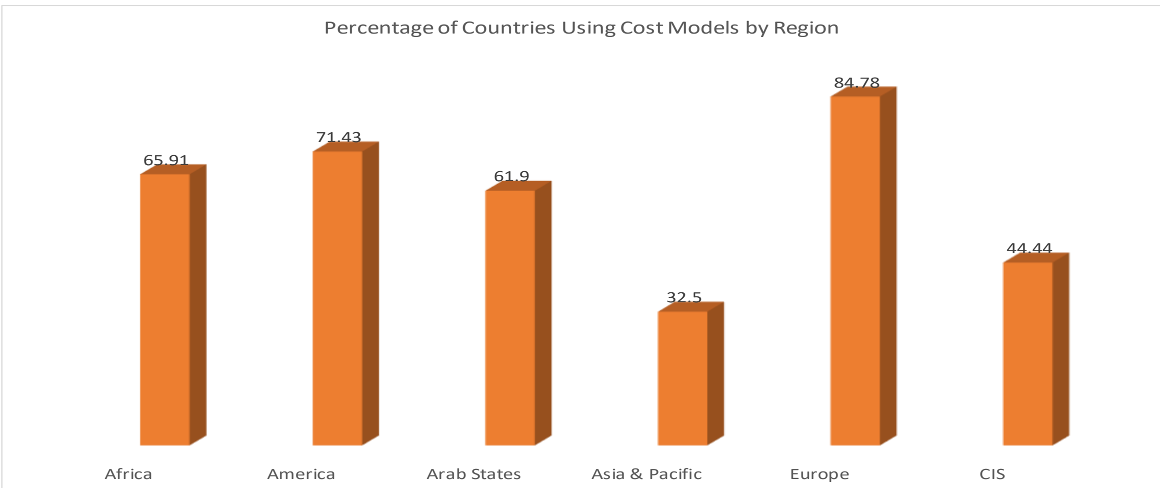
i. As early as April 2009, OFTA, the regulator in Hong Kong adopted hands off regulation of fixed and mobile termination rates, allowing operators to settle interconnection charges through commercial arrangements without ex-ante regulatory intervention.
ii. The United Arab Emirates (UAE) has migrated to using commercial agreements and benchmarks for wholesale services.
iii. In Latin America, countries such as Brazil, El Salvador and Guatemala no longer regulate termination rates; instead, market forces determine the levels of termination rates.

Some countries only regulate fixed to mobile interconnection rates, as is the case in Jamaica.

3.2 Interconnection Cost Models in Use

In terms of models used for determining costs of regulated services, the ITU World Tariff Policies Survey 2019 database [12] revealed that out of 176 countries of the world that participated in the survey, 122 are using cost models whilst 54 countries are not using cost models. In Africa, 65.91% of countries based on 44 responses, indicated that they were using cost models. In comparison, 84.78% of countries in Europe were using cost models for interconnection regulation as illustrated in Figure 4 below.

Figure 4: Percentage of Countries Using Cost Models by Region

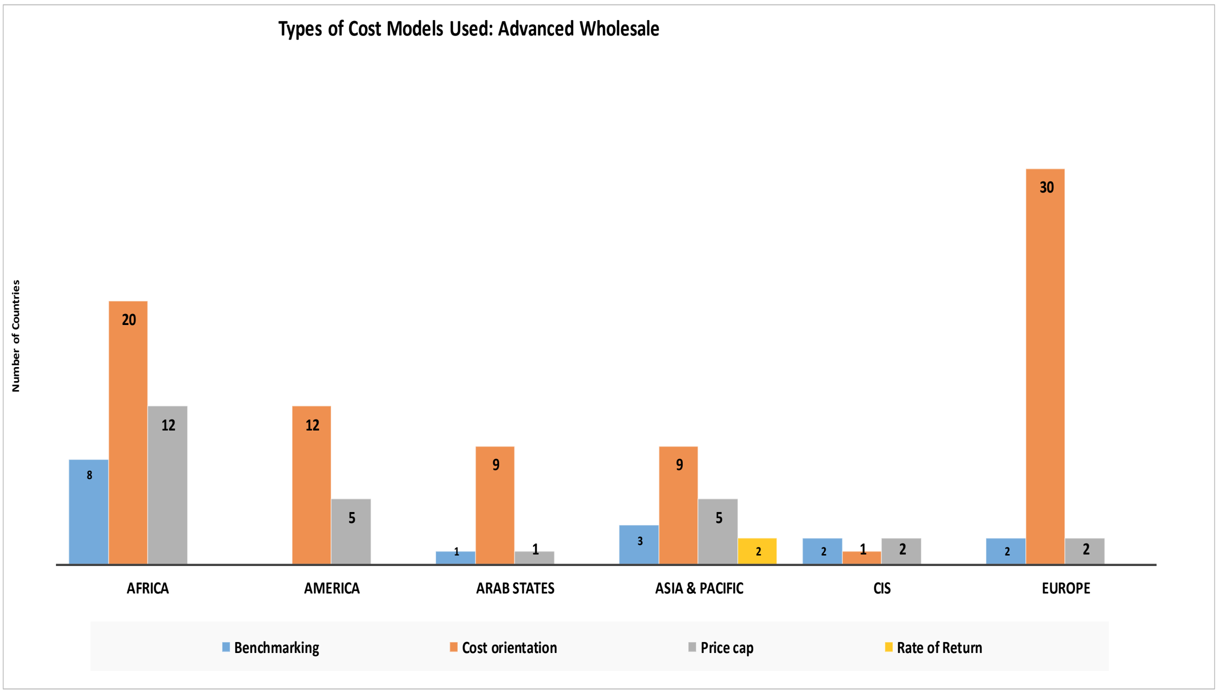


Source: ITU ICT Eye Database (2019)

[12] ITU ICT EYE Database Tariff Policies Survey (2019)

Figure 5 below, testifies the prevalence of cost orientation for regulation of advanced wholesale services in Europe, followed by Africa.

Figure 5: Types of cost models used by Region



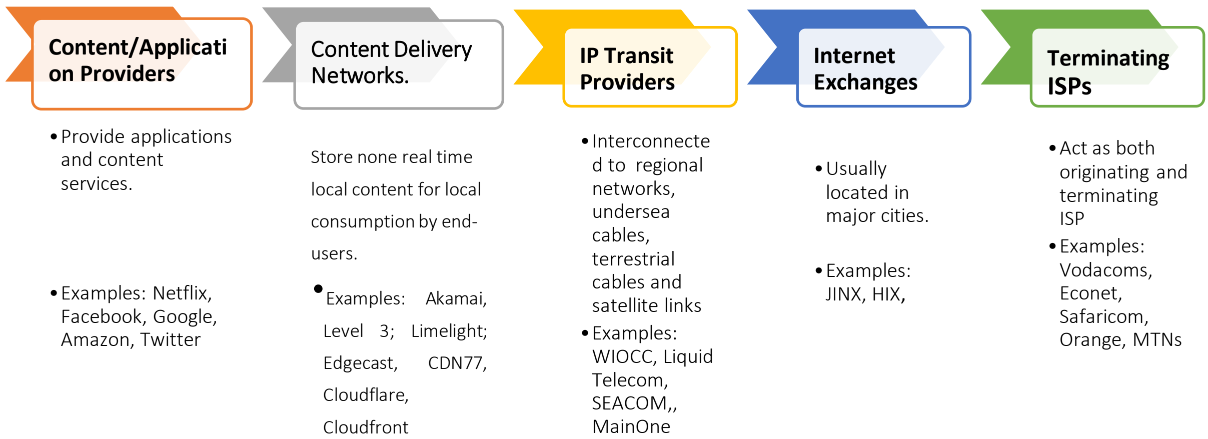
Source: Author, using ITU ICT EYE Database Tariff Policies Survey (2019)
***N.B** benchmarking countries are those countries that are relying on benchmarking only, without using any cost models.*

A majority of African countries have embraced the use of cost models for regulating advanced wholesale services with fewer countries still relying on benchmarking and price cap regulation. This is commendable, although more still needs to be done in terms of enhancing wholesale competition to facilitate cost-based competition at wholesale level in Africa.

4 PEERING ARRANGEMENTS IN THE DIGITAL ENVIRONMENT

IP services have evolved over the years from static data and text transfer to immersive content in particular video streaming. This has brought in a new set of digital players in the IP peering ecosystem to include Content Providers and Content Delivery Networks as illustrated below.

Figure 6: New IP Interconnection ecosystem



Source: Author

The surge in usage of data hungry and immersive video applications offered by OTT Content and Application Providers has accelerated the cross-over from a hierarchical to mesh IP interconnection formations, characterised by different types of players who can peer at all levels as illustrated in figure 7a and 7b below[13]:

Figure 7a: Hierarchical Peering

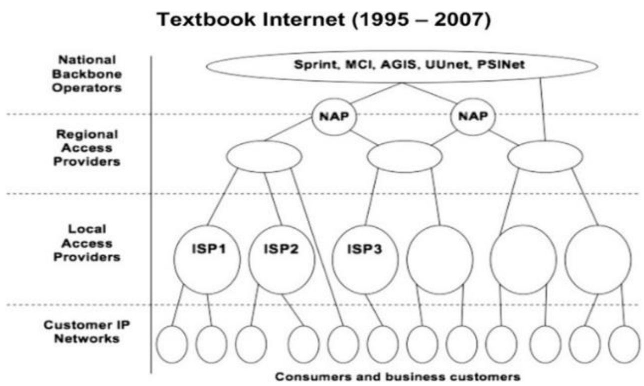
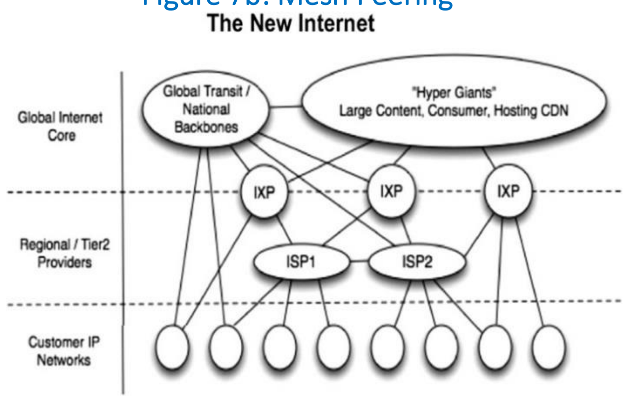


Figure 7b: Mesh Peering



*Source: **https://ssrn.com/abstract=2104323** or **http://dx.doi.org/10.2139/ssrn.2104323***

The mesh IP interconnection formation has given rise to a variety of IP interconnection business models ranging from private peering, IP transit to public peering and content driven

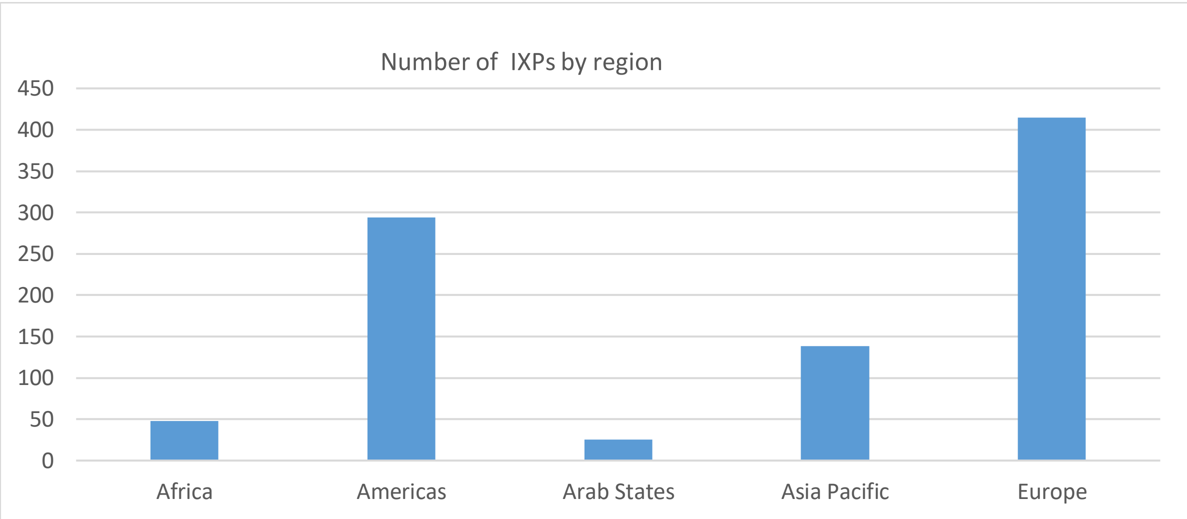
[13] Israel, Mark A. and Besen, Stanley M., The Evolution of Internet Interconnection from Hierarchy to 'Mesh': Implications for Government Regulation (July 11, 2012). Available at SSRN: https://ssrn.com/abstract=2104323 or http://dx.doi.org/10.2139/ssrn.2104323

peering arrangements across all players in the IP interconnection ecosystem. This is also happening in Africa where countries are increasingly adopting public peering through Internet Exchange Points and data centres as well as the coming on board of Content Delivery Networks.

4.1 Internet Exchange Points (IXPs)

At the global level, public peering is increasingly the new mode of IP interconnection mostly through Internet Exchange Points and data centres. In Africa, thanks to the African Union (AU) AXIS project,[14] which contributed to the establishment of national and regional Internet Exchange Points (IXPs) in 30 countries, as well as providing technical assistance, policy and regulatory reform at regional levels. Figure 8 below illustrates the geographical spread of IXPs by region.

Figure 8: Number of IXPs by Region

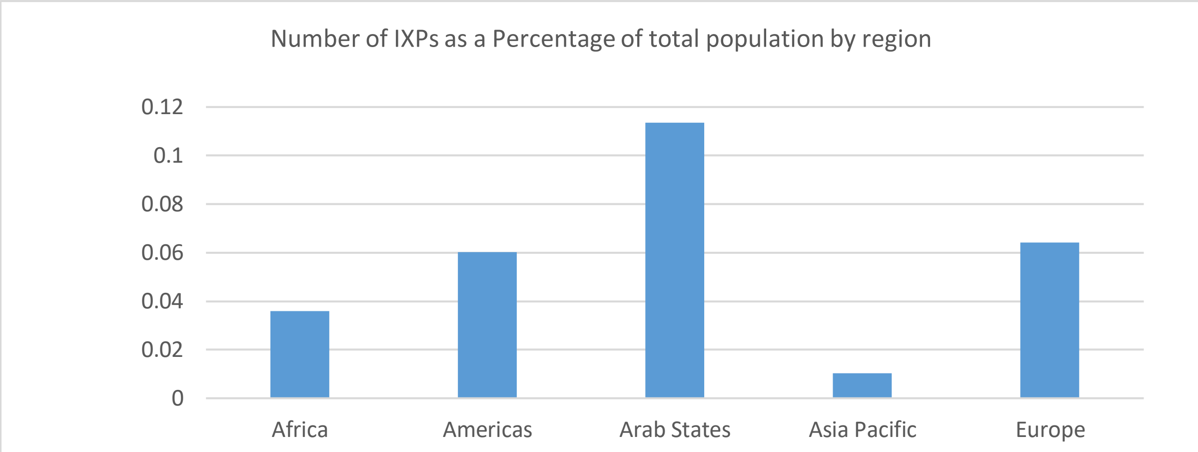


Source: Author using information on internetexchangemap.com website:
https://www.internetexchangemap.com/#/

Whilst significant progress has been registered in the establishment of IXPs in Africa; the region is still lagging behind in terms of IXP penetration with 48 IXPs compared to other regions as follows: Europe (415); Americas (294); Asia Pacific (138) and Arab States (25). [15]This means that some countries in Africa are yet to establish IXPs as some countries such as South Africa has eight IXPs, whilst Kenya, Tanzania, and Nigeria have more than three IXPs operating in their respective countries. Figure 9 below shows the number and penetration of IXPs by region:

[14] https://au.int/sites/default/files/documents/32508-doc-axis_project_information_as_of_feb_2016.pdf
[15] *https://www.internetexchangemap.com/#/*

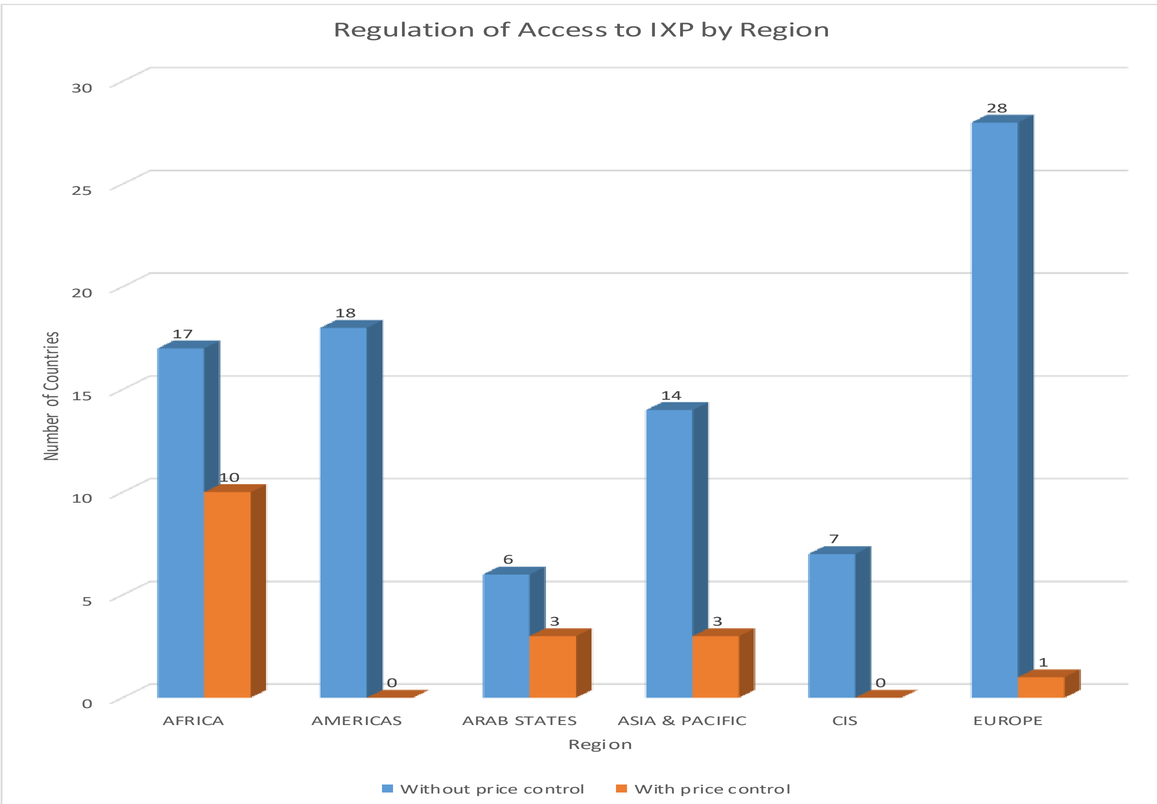
Figure 9: Number of IXPs as a Percentage of Total Population by Region



Source: Author, using information on internetexchangemap.com website: https://www.internetexchangemap.com/#/

IP peering in Africa is still developing and has not fully matured compared to other regions in the world. This could be the reason why access to Internet Exchange points remains significantly regulated in Africa compared to other regions as shown Figure 10 below:

Figure 10: Regulation of Access to IXP by Region

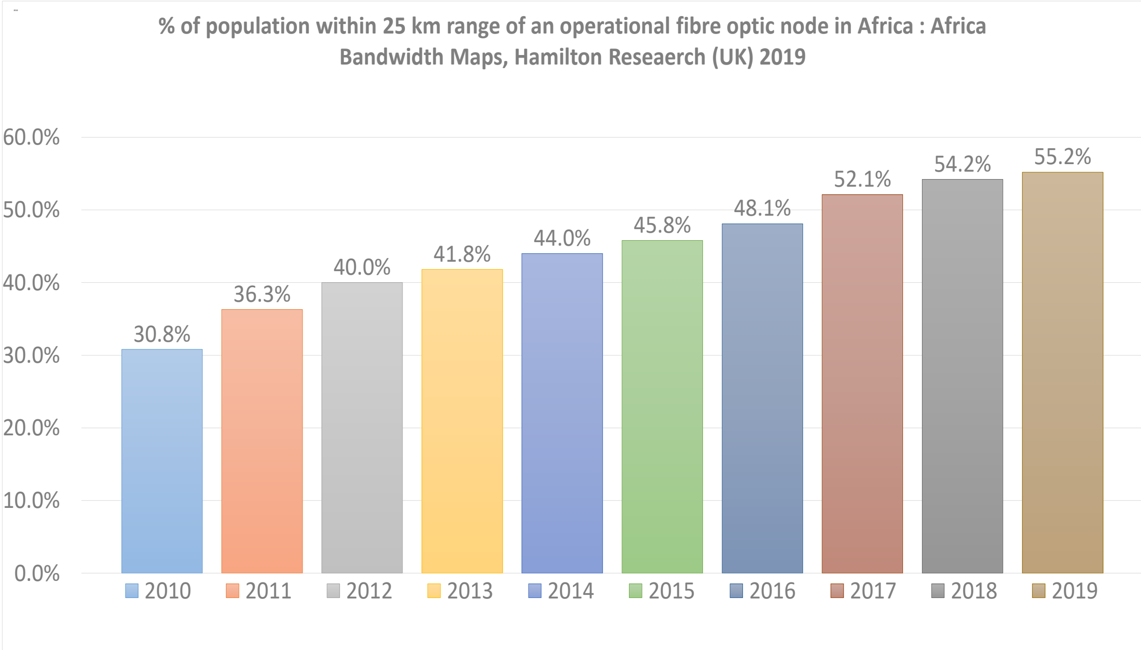


Source: ITU ICT Eye Database (2019)

4.2 Cross Border Connectivity

In terms of cross border connectivity, Africa has registered significant progress. According to a Report by Hamilton Research 2019,[16] Africa had 1,000,000 km of operational terrestrial fibre optic cables. Figure 11 below, shows the progression of operational terrestrial fibre in Africa since 2010:

Figure 11: Percentage of Population within 25 km Range of Operational Terrestrial Fibre in Africa



Source: Author, using information from Africa Bandwidth Map; Hamilton Research (2019)[17]

4.3 Data Centres

As at December 2020, Africa was host to 69 Data Centres in 13 African countries, in addition to Egypt which was host to 13 datacentres, compared to 135 data centres in 16 Countries in the Middle East; 1 257 in 23 countries in Europe and 1 974 in America.[18] This serves to show that a majority of the countries in Africa do not have operational third party data centre facilities. As at end of March 2021, the number of data centres had increased to 92 in 15 Countries, with South Africa, Egypt, Nigeria and Mauritius each hosting more than 10 data centre facilities as shown in the table 3 below.

[16] http://www.africabandwidthmaps.com
[17] http://www.africabandwidthmaps.com/

[18] https://enterprise.press/stories/2020/12/09/is-egypt-on-its-way-to-becoming-a-data-hub-part-1-the-data-center-landscape-26830/

Table 3: Distribution of Data Centres in Africa

	Country	Number of data centres
1	South Africa	25
2	Egypt	13
3	Nigeria	11
4	Mauritius	10
5	Kenya	9
6	Morocco	5
7	Angola	7
8	Algeria	3
9	Tunisia	2
10	Ghana	2
11	Cameroon	1
12	Democratic Republic of Congo	1
13	Reunion	1
14	Tanzania	1
15	Zimbabwe	1
Total		**92**

Source: https://www.datacentermap.com/africa/

According to a report titled "*The Cloud and Data Centre Revolution in Africa'* published in July 2020, [19] there are more Telco owned data centre facilities, constituting half of all raised floor space in Africa, whilst carrier neutral data centres accounted for just under 30% of the space. The report further forecasts that there is a huge potential demand for data centres in Africa because of its huge population of 1.3 billion people.

4.4 Content Delivery Networks (CDNS)

4.4.1 Peer-to-Peer CDNs: Where CDNs and their clients provide resources as well as use them, unlike the traditional client-server relationship arrangements where Content Providers pay CDNs to deliver content.

4.4.2 Private CDNs and Cloud based CDNs: Where content owners create their own CDN by having points of presence or caching servers around the world that only serve their content for distribution to end users via terminating networks. For example, Facebook has a network of servers dotted around the world connected by a backbone network called the Express backbone. Some of the CDNs are moving away from the traditional mode of using data centres to host their content, preferring the content delivery as a service model, using cloud resources such as storage and compute.

[19] https://datacentre.me/product/africa-data-centre-report-2021-2025/

4.4.3 Multi CDNs: A trend that is gaining popularity is that of Multi CDNs, a strategy which entails spreading a website's static content across servers of several CDN providers for the purposes of increasing global footprint, reduce website latency and improve redundancy.

4.4.4 Federated CDNs: CDNSs are also pooling their infrastructure resource together to create federated CDNs, which are interconnected CDNs with global footprints.

4.4.5 Telco CDNs: Network Service Providers are also deploying proprietary CDNs within their networks. They are offering CDN services to OTT content providers in order to reduce the demand on the network backbone and reduce investment requirements as well as enhance on quality of service and experience for their customers. This is achieved through deep caching of identified popular content and deployment of streamers in their networks. This allows them to earn additional income from content. This also has the advantage of cutting transportation costs as it bypasses traditional CDNs and facilitates better content management.

In Africa the majority of Internet traffic is routed through data centres, CDNs are becoming popular with several countries hosting more than one CDN. However, in a majority of countries, colocation data centres, cloud servers and IP transit facilities are still in the developmental stage. According to CDNPlanet,[20] as at June 2020, South Africa was host to 16 CDNs compared to leading hosting countries such as USA, Germany and Singapore, which each hosted 24 CDNs. Table 4 below shows the countries in Africa that were hosting CDNs as at June 2020.

Table 4: CDNs hosted in Africa (as at June 2020)

Country	*Number of CDNs*	*CDNs in operation*
Djibouti	3	CDNetworks; CDNvideo; Cloudflare
Egypt	3	CDNetworks; CDNvideo; Cloudflare
Kenya	5	Century Link; Cloudfront; Cloudflare; QUANTIL; Verizon Media
Liberia	1	Cloudflare
Madagascar	3	CDNvideo; Cloudflare; QUANTIL
Mauritius	4	Limelight; CDNvideo; Cloudflare; QUANTIL
Morocco	1	Cloudflare
Mozambique	1	Cloudflare
Nigeria	5	Cloudflare; G-coreLabs; Limelight; Medianova; Swiftserve
Rwanda	1	Cloudflare
Senegal	1	Cloudflare
South Africa	16	Century Link; Cloudfront; Cloudflare; QUANTIL; Verizon Media, Imperva; G-coreLabs; Limelight; Medianova; Firstly; Cachefly, CDNetworks; CDNvideo; CDN77; Bunny CD; Baishan cloud
Tanzania	4	CDNetworks; CDNvideo; Cloudflare, ChinaCache

Source: CDNPlanet: https://cdnplanet.com/geo

17 https://cdnplanet.com/geo

4.5 Pricing Strategies for IP Interconnection

Several pricing strategies are employed in IP interconnection. These include the following:

i. *Capacity based charging with pre-booking:* Charges for wholesale access arise on ordered network capacity, usually based on number of dedicated links. The number of interconnection links or ports are used as the charging unit. This is mostly used between CDNs and Internet Backbone Providers (IPBs).

ii. *Capacity based charging without pre-booking:* based on the actual used network capacities in a defined period, for example, peak time. The charging unit is the transmission capacity required in the peak time, which can be Kbit/s, Mbit/s or Gbit/s. It is mainly used where capacity requirements are difficult to forecast.

iii. *Volume/Usage based:* charging is based on data volumes exchanged in terms of megabytes or Gigabytes. This is mostly used for paid peering between ISPs with unbalanced traffic.

iv. *Quality of Service based charging:* Charging is based on quality-of-service parameters such as jitter, delay and latency.

v. *Settlement Free Peering:* Traditional method used between Internet back bone Providers (IPBs) - no charges where traffic and geographic reach are balanced.

5 COSTING MODELS FOR 5G SERVICES

5.1 General Overview

So far, 5G networks that have been deployed, are premised on a combination of heterogeneous technology types, incorporating all previous generations of cellular mobile systems, with some using existing fixed networks for wireless access and backhaul connectivity.[21] Resultantly, 5G deployment is fraught with technological, economic and market uncertainties that make it difficult to do cost modelling. This could be the major reason why there has been slow traction on the development of cost models for 5G networks.

Going into the future, and with the deployment of 5G core networks, there is the possibility of splitting the 5G core infrastructure into end to end network slices for different use cases ranging from massive IoT, reliable low latency and enhanced mobile broadband, amongst others.[22] It is envisaged that this development will ease the complexity of costing 5G services, but will not fully address the challenges related to the dynamic and agile nature of 5G core networks and their capability to deliver multiple services with different bandwidth capacity requirements.

This is unlike the case with traditional circuit switched networks where dedicated networks are used to deliver specific services. Hence, cost drivers are clear and routing tables allocate costs based on utilisation of network resources. Uncertainties related to demand estimation, in turn present another challenge in terms of network planning and dimensioning. This makes it difficult to estimate network investment requirements.

Another key factor that differentiates the traditional cost modelling principles are the emerging various ownership models for 5G networks, that are characterised by network slicing in contrast to the traditional circuit switched stand-alone network ownership model. With 5G networks, software defined networks and network function virtualisation enable multiple tenancy on networks i.e., different operators can have access to a subset of network resources, while giving the illusion that they fully own the infrastructure. This makes it difficult to design and dimension a 5G network for cost modelling purposes that is applicable across all service areas.

Table 5 below, summarises some of the challenges encountered in developing cost models for 5G networks compared to circuit switched network cost modelling:

[21] https://www.csgi.com/insights/5g-market-disruption-demands-pricing-innovation-from-the-get-go/
[22] https://www.csgi.com/insights/5g-market-disruption-demands-pricing-innovation-from-the-get-go/

Table 5: Cost Modelling for Circuit Switched Networks Vs 5G Networks

Process	Circuit Switched Networks	5G Networks
Geotype segmentation	Straight-forward, based on population and geography	Based on population, area and site densification and depends on network densification and spectrum integration strategies employed.
Demand estimation	Well-defined volume-based service offerings, delivered over dedicated circuits, which make demand estimation easier.	Uncertainty on services that will need to be supported (voice, video, IPTV, data, voice), with different quality of service parameters, making it difficult to estimate demand.
Network dimensioning	Fewer and services with well - defined quality of service parameters making it easier to estimate busy hour traffic.	Dynamic quality of service; complex service offerings, with different QoS parameters, which make busy hour traffic estimation difficult for network dimensioning.
Cost Estimation	CAPEX and OPEX costs easily estimated using well-demarcated network segments i.e., switching, Access and transmission.	CAPEX and OPEX difficult to estimate owing to different capacity expansion strategies, which differ from place to place. Also, depends on other factors such as the network ownership model and network deployments, i.e. whether brownfield or greenfield
Cost Allocation	Straightforward Cost allocation using well-defined routing table, which defines network element usage.	None defined traffic routing. Traffic routed based on best effort, hence almost impossible to define routing table for cost allocation purposes.

Source: Author

5.2 Studies on 5G Costing

Despite the above challenges, several cost studies on 5G networks have been conducted. However, in Africa, there is not much work done on 5G cost modelling as only a few countries are rolling out 5G networks, with pilot launches done in South Africa and Lesotho only as at end of November 2020.

At the global level, 5G cost studies done have apparently focused more on quantification of cost saving from the use of Software defined networking and Network function virtualisation as well as Mobile traffic forecasting for maximizing 5G network slicing resource utilization. Other studies have focused on cost modelling for single network segments, i.e., the Radio Access Network (RAN), or backhaul, or the core network. Other studies focused on the Total Cost of Ownership (TCO) for non-infrastructure sharing 5G networks. This report focuses on three 5G costing studies done covering different perspectives in order to understand the complexity of costing 5G network services as follows.

i. **The cost, coverage and roll-out implications of 5G infrastructure in Britain by Edward J. Oughton, Zoraida Frias, (2016)**[23]

The study was conducted in Britain by Edward J Oughton of the University of Cambridge, England; and Zoraida Frias of the University of Madrid, Spain. The objective of the study was to inform the UK Government's 5G strategy. The study explored the dynamics of 5G roll out for different capacity expansion strategies using nine scenarios under which network capacity was calculated based on a per- user speed of 50Mbps. This entailed assessing the impact of different capital intensities, infrastructure sharing and end-user speeds on the Total Cost of Ownership for a non -virtualised ultra- fast 5G network, using current equipment costs.

Key assumptions for demand estimation were grounded on the minimum required user throughput of 50Mbps per user and population density assuming 100% broadband penetration. Capacity expansion principles used in the study entailed integrating new spectrum in the 700MHz and 3.4-3.6 GHz bands into existing brownfield sites to meet expected traffic demand. Any additional capacity requirements to meet remaining traffic was covered by network densification using small cell deployments. The modelling methodology used a hybrid approach whereby a Top-down approach using 9,000 post code sectors were segmented into seven geo-types based on population density was used for demand estimation, whilst network dimensioning was based on hypothetical 4G and LTE-Advanced networks.

Findings

The study established that there were still several uncertainties associated with 5G deployment and service uptake in terms of technical, economic and behavioural aspects. This arises from the non-availability of 5G equipment costs and the different roll out strategies that are employable by operators.

The study concluded that to achieve ubiquitous 50Mbps per user coverage is highly costly and unviable based on current revenues. However, in urban areas, the study concluded ubiquitous provision of 50Mbps per user coverage was viable, representing only 2% of the overall Capex cost. Achieving 50Mbps in rural areas was highly costly, representing 79% of Capex.

i. Network Slicing Cost Allocation Model, by Deutsch Telekom, Real Wireless and Telefonica1+D, (2016)[24]

The study was done by a consortium comprising Deutsch Telekom, Real Wireless and Telefonica1+D focused on 5G network slicing cost allocation model under a software defined network and network function virtualisation arrangement. The model focused on allocation of 5G network costs to different deployed network slices, which are then used to price different end to end services. The model uses a resource allocation algorithm and a 5G network function-dimensioning model to come up with the required inputs for the model.

Findings

The results of the cost modelling exercise indicate a significant reduction in costs where software defined networking and network function virtualisation are considered compared to corresponding costs for a traditional network architecture.

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[23] https://www.sciencedirect.com/science/article/pii/S0308596117302781

[24] https://core.ac.uk/download/pdf/326332835.pdf Chiha, A., Van der Wee, M., Colle, D. *et al.* Network Slicing Cost Allocation Model. *Network* System *Management* 28, 627–659 (2020).

i. Resource analysis and cost modelling for end-to-end 5G networks by University of Bristol, UK and the University of Post and Telecommunication 1000876, China (2017)[25]

This study, done by a consortium of researchers from the University of Bristol, UK and the University of Post and Telecommunication, China, studied the total cost of ownership for a non- sharing 5G network. The study focused on three geo-types covering the cities of Lucca, Bristol and London in the UK, which represent rural, urban and dense urban geo-type scenarios respectively. Key assumptions amongst others used in the study included the following:

- 10% population subscription to network
- 10Gbs data rate based on 5G requirements
- 50:50 wired to wireless backhaul deployment ratio
- Small and macro-cell radius of 200m and 2km

Findings

The main findings of the study were that fibre is more expensive to deploy compared to microwave for backhaul, with a 56% cost difference for Lucca compared to a difference of 16% and 21% for Bristol and London respectively. The calculation for the total cost of ownership established that London had the highest deployment cost, whilst Lucca, which constitutes 1% of the population of London had the lowest cost of deployment equivalent to 12% of the latter's deployment costs. Bristol had the lowest per user deployment costs.

The study concluded that geo-types were a key differentiating factor in cost of deployment for non- sharing 5G networks. In areas where there is low population density, using microwave for backhaul was a much cheaper option than fibre.

The above -cited studies point to a shift in cost modelling from being network centric to being service centric. This is attributable to the difficulties associated with costing services in an environment where networks are becoming more heterogeneous, with a variety of technologies at play and the increasing use of software-defined networking and network function virtualisation. Apparently, it is proving to be an onerous task to design and dimension an efficient 5G network. This is in view of the varied network architectures/deployments and network ownership / sharing models as well as other dynamics such as Software Defined Networks and Network Function Virtualisation that come into play. In addition, much also depends on the state of the network upon which a 5G network is deployed, for example, whether it is a brownfield or green field stand-alone 5G core network deployment.

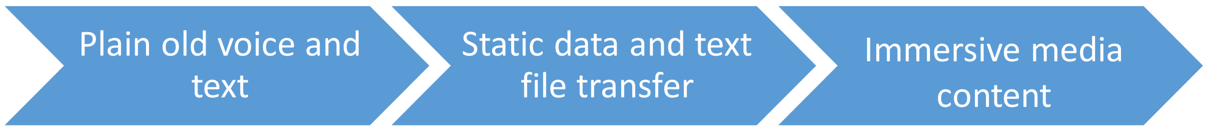
[25] Conference Paper: Cost Analysis of a 5G Network with Multi-Tenancy Options, https://www.econstor.eu/bitstream/10419/169495/1/Rendon-Schneir-et-al.pdf

6 EMERGING BUSINESS MODELS FOR DIGITAL SERVICES

6.1 Evolution of Digital Services

The ongoing digital transformation across the world has revolutionised service offerings from plain old voice telephony and text to IP driven static data and text file transfer to immersive media content mainly provided on OTT platforms, as well as other data hungry IoT applications. For most network services providers, it is not business as usual, as margins for traditional services such as voice and SMS take a plunge. The substitution effect of data hungry OTTs is taking a toll on traditional services and putting pressure on Network Service Providers to invest more in the data capability of their networks.

Figure 12: Evolution of Services



Source: Author

6.2 Evolution of Business Models

Network Service Providers are facing challenging times as they have to choose between being specialist connectivity providers or to go vertical by entering into partnerships with other businesses to support transactions with a wide range of other industries including transport and logistics, manufacturing, health, energy and financial services amongst others. Resultantly, we are witnessing the emergency of various business models that are thriving on the increased flexibility in service offerings and fuelled by new technologies such as virtual- reality, augmented reality and artificial intelligence. This in turn has intensified service-based competition across different types of service providers and has triggered the adoption of two-sided business models by Network service providers in a bid to monetise emerging digital media opportunities.

6.2.1 Utility/Connectivity Providers

Some network operators are opting to model themselves as utility providers only, focusing on providing high speed and quality connectivity services and cost efficiency to maximise on economies of scale. In so doing, they are exploring the use of Artificial Intelligence (AI) checklist cards that offer guidance from network equipment procurement, deployment up to the end of useful life. Operators are also exploiting their data generation and storage capabilities to improve customer experience.

An interesting case in point is that of Econet Wireless Zimbabwe, which demerged its Cassava Smartech arm from the parent mobile telecommunication Network Services Provider business.

Cassava Smartech specialises in development of applications leveraging on the high subscriptions on the Econet Wireless network, leaving the latter to focus on providing the connectivity for the applications to run. Cassava Smartech runs a diversified portfolio of applications that range from on-demand services such as transport and logistics, health e-commerce, Agritech, Edutech and Fintech amongst others.

South Korea Telecom (SKT) of Korea also operates several separate businesses from the MNO business in media, security, commerce and mobility, where it provides navigation services as well as an e-commerce platform. In addition, SKT operates separate businesses in digital health, media and AI robotics.[26]

Network Service Providers are also getting into the business of providing user-profiling services to media companies to help them understand their subscribers better in terms of their preferences and diversity. For example, Elisa, the Finnish operator invested EURO 70 million to acquire 100% of Polystar OSIX and all its affiliated companies. Polystar is in the business of providing analytics, assurance and monitoring software for mobile operators. The acquisition by Elisa signals the importance of data analytics going into the future of IoT.

6.2.2 Business to Consumer (B2C) Business Models

The shift in IP interconnection from hierarchical formation to mesh formation has also brought with it many business possibilities for Network Service Providers. Network Services Providers can enter into direct partnerships with content providers such as broadcasters, web service providers, advertisers and content aggregators to offer high quality content distribution services. By so doing, they are offering better quality of service compared to traditional data centres by facilitating accelerated delivery of content with guaranteed quality of service. The aim is to enhance user experience that is attractive enough for consumers to be willing to pay premium prices. A case in point is that of Korea (KT), a Telecom of South Korea that entered into a partnership with Discovery Networks Asia Pacific Pvt Ltd to form Studio Discovery in October 2020,[27] which specialises in media content development and distribution.

6.2.3 Business to Business to Consumer Relationships

Alternatively, Network service providers are going vertical by entering into partnerships with other businesses to support transactions with a wide range of other industries. The result is new innovative use cases that require connectivity for a wide range of devices and applications. Such cases include intelligent health, smart manufacturing, smart home, and municipal smart parking, amongst others. An interesting case is the partnership by Ericsson and Vodafone and in setting up dedicated connectivity using a private mobile 5G network to e.Go,[28] an electric vehicle manufacturing factory in Germany. Vodafone is also offering dedicated 5G connectivity

[26] https://www.sktelecom.com/index_en.html
[27] https://en.prnasia.com/releases/global/s-korea-s-kt-expands-media-business-with-discovery-networks-296495.shtml
[28] https://www.ericsson.com/en/news/2019/6/5g-car-manufacturng-with-ego-ericsson-and-vodafone

for running port facilities with guaranteed quality of service across the world where they have a footprint.

In the USA, AT&T has collaborated with Magic Leap[29], to develop solutions for various industries/sectors including manufacturing, health, retail and transportation amongst others. In Japan, NTT Docomo has gone into partnership with 3000 enterprises and SMEs covering transportation, communication and healthcare amongst others.[30]

6.2.4 Data Management services

Some operators are exploiting their vast knowledge and expertise on transactional data to provide data management services and solutions that facilitate the functioning of the Internet of Things (IoT). This entails collecting data from all sources, structuring, aggregating, alignment and fusion to vertical analytics such as connected car, home or factory, as well as facilitating its interoperability. Such services include:

i. *Carrier billing services* provided by NSPs, using their customer and billing relationships to provide billing services for digital platforms.
ii. *Data as a Service offering:* Which entails an enterprise offering data as a service to business entrepreneurs or marketers. Such data may include targeted lists, corporate data sheets used by sales people, customer demographics and competitive market analysis amongst other types of data. An example is that of Dun and Bradstreet that offers data as a service to various corporates across the world.

6.2.5 MNO-OTT Partnerships

Limited Free Access/Zero rating: OTT providers and network providers are going into arrangements where subscribers of a Network Service Provider can enjoy free access to a limited number of websites and services. Examples include MNO partnerships with entertainment content providers such as Netflix, Spotify and Deezer.

In the social media arena, Facebook has free basics partnerships with operators in developing countries such as Maldives, Mozambique and Cambodia. The partnerships relate to zero-rating of data for subscribers who access Facebook. This helps in attracting users, particularly in countries where connectivity is deemed unaffordable. Facebook is extending the scope of partnerships to venture into joint investment projects to expand Internet coverage as well.

[29] https://www.businessinsider.com/att-magic-leap-expand-partnership-2019-1
[30] https://www.gsma.com/publicpolicy/wp-content/uploads/2020/03/Realising_5Gs_full_potential_setting_policies_for_success_MARCH20.pdf

7 PRICING MODELS FOR DIGITAL SERVICES

7.1 5G Pricing Models

So far, there has not been any innovative pricing models for commercially launched 5G services. This is largely attributable to the fact that current commercially launched 5G services are premised on a combination of heterogeneous technology types, incorporating all previous generations of cellular mobile systems, with some using existing fixed networks for wireless access and backhaul connectivity.[31] In essence the services are not from stand-alone 5G core networks. Resultantly, pricing has not changed much from that of 4G networks. Some of the pricing models include the following:

i. Value added Service Bundling

Network Service Providers are entering into partnerships with OTT providers under which they include OTT music and video streaming services in their service bundles. A case in point is that of Verizon, a US based company, that is offering 5G service packages that come with streaming services for Disney, HULU and ESPN+ and apple music downloads as illustrated in the table 6 below.

Table 6: Verizon USA 5G Data Plans

Package	Plan Features	Plan Perks	Price per month USD
Start Unlimited	5G nationwide and 4G LTE data	Disney+ for 6 months; **Apple music for 6 months.**	$35
Play More Unlimited	Premium Network access (5G Ultra-wideband; 5G Nationwide); 4G LTE data; unlimited mobile hotspot **15 GB** of 5G/4G LTE data	Hulu, Disney+ ESPN+; **Apple music for 6 months**	$45
Do More Unlimited	Premium Network access (5G Ultra-wideband; 5G Nationwide); 4G LTE data; unlimited mobile hotspot **15 GB** of 5G/4G LTE data	• Hulu, Disney+ ESPN+; **Apple music for 6 months** • 600GB of Verizon cloud storage • 50% off unlimited connected device plans	$45
Get More Unlimited	Premium Network access (5G Ultra-wideband; 5G Nationwide); 4G LTE data; unlimited mobile hotspot **30 GB** of 5G/4G LTE data	• Hulu, Disney+ ESPN+; **Apple music Included** • 600GB of Verizon cloud storage • 50% off unlimited connected device plans	$55

Source: Verizon website: https://www.verizon.com/plans/unlimited/

[31] https://www.csgi.com/insights/5g-market-disruption-demands-pricing-innovation-from-the-get-go/

ii. Speed Based Tiers

Another pricing model that is also popular is the use of speed tiers for 5G pricing plans, where service packages that offer higher speeds are charged more than those offering lower speed. A case in point is that of Elisa, the leading operator in Finland with 4 million subscribers, which is offering 5G pricing plans based on speed tiers and not volume for its mobile and fixed wireless (FWA) broadband services, as shown in table 7 below:

Table 7: Elisa Mobile 5G Data Plans

Service package	Features	Perks	Price per month USD
5G 300M	300 Mbps unlimited 5G data	20GB per month roaming in Europe	**$ 35** for first 12 months to increase to **38.38** beyond the first year. Set-up fee: **$5.39**
5G 600M	600 Mbps unlimited 5G data	21GB per month roaming in Europe	**$ 43.88** for first 12 months to increase to **$49.38** beyond the first year. Set-up fee: **$5.39**
5G 1000M	1Gbps unlimited 5G data	23 GB per month roaming in Europe	**$ 54.88** for first 12 months and beyond the first year. Set-up fee: **$4.90**

Source: https://tarifica.com/elisa-finland-offers-cheaper-5g-subscriptions

iii. *Volume/Capacity Based Tiers*

This entails setting prices using volumes to differentiate data prices. Table 5 above show capacity-based pricing tiers offered by SKT. These come with additional benefits that are meant to increase customer willingness to pay. SKT offers zero-rated Virtual Reality and Augmented Reality as well as cloud gaming services that allow users to play video games anytime anywhere. Table 8 below, shows SKT's capacity-based tariff tiers.

Table 8: South Korea Telecom (SKT) 5G Data Plans

Service package	Features	Perks (zero rated services)	Price per month USD
Slim Plan	8GB of data	Virtual Reality and cloud gaming	$48
5GX standard Plan	150GB	Virtual Reality and cloud gaming	$66
5GX Prime Plan	200GB	Virtual Reality and cloud gaming	$84
5GX Platinum	300GB	Virtual Reality and cloud gaming	$110

Source: SKT website: sktelecom.com

Table 9 below, shows another capacity-based charging model by KT, offering unlimited access to 5G data with price differentials based on capacity of free tethering data allowance.

Table 9: Korea Telecom (KT) 5G Plans

Service package	Features	Perks	Price per month USD
5G Slim	8GB of 5G data	-	$49
5G super Plan Basic	Unlimited data access	5 GB tethering	$70
5G super Plan Special	Unlimited data access	50 GB tethering	$88
5G super Plan Premium	Unlimited data access	100 GB tethering	$115

Source: https://venturebeat.com/2019/04/02/korea-telecom-unlimited-5g-is-essential-plans-start-at-70-per-month/

Going into the future, and with the deployment of 5G core networks, there is the possibility of splitting the 5G core infrastructure into end-to-end network slices for different use cases ranging from massive IoT, reliable low latency and enhanced mobile broadband, amongst others. So far, most of the 5G packages on offer are focusing on speed and capacity-based tiers and additional value enhancing perks. In essence, 5G is being offered at no extra cost.

7.2 Pricing Models for IoT

In Africa, adoption of IoT is still nascent owing to limited connectivity, unaffordability of devices, and limited technology background. Mauritius, South Africa, Seychelles, Kenya and Rwanda are leading in the adoption of IoT. [32]

In general, IoT pricing trends indicate a shift from cost-based pricing to value-based pricing. Dr Imen Ben Chaabane, in his presentation on 'Business Models of IoT: From Suppliers to Customer; presented at the Regional Workshop for Africa on Developing the ICT ecosystem to harness the Internet of Things; 28-30 June 2017 in Mauritius,[33] identifies five IoT business models. These include purely transactional, cost savings sharing, revenue sharing, product sharing and performance as a service model. These go with different pricing mechanisms, which include the following:

i. Subscription based pricing

This follows the traditional practice where customers make payments to service providers at regular intervals i.e. monthly or annually. This is used most for transactional IoT services delivered to individuals. A case in point is that of OnStar, a subsidiary of General Motors in the USA, which provides vehicle owners with

[32] https://www.intelligentcio.com
[33] https://www.itu.int/en/ITU-D/Regional-Presence/Africa/Documents/business%20model%20of%20IoT.pdf

communications, in-vehicle security' remote diagnostics and turn by turn navigation.[34] As an example, T Mobile's Magenta IoT plan costs $6 per device per annum for up to 12MB of data.[35]

ii. Volume based Subscription pricing

Another example is that of Urban Mapping,[36] which provides geography data services mostly to real estate companies by allowing them to embed data into their own sites and applications, as shown in table 10 below.

Table 10: Volume based subscription pricing

Subscription Plan Description	Average Monthly Cost *	Maximum Monthly Hits
Departmental Monthly Subscription Up to 600 hits per month for all symbols.	$99.00	600
Corporate Monthly Subscription Up to 6,000 hits per month for all symbols.	$299.00	6,000
Enterprise Monthly Subscription Up to 60,000 hits per month for all symbols.	$589.00	60,000

Source: https://www.programmableweb.com/news/data-service-pricing-models-future-data/2010/08/26

iii. *Pay per Use Plans:* Where customers pay only for actual data usage, with no commitments. This is usually applied to B2B IoT services. For example, Google Maps charges hotels based on views made; car- tracking companies also charge based on number of assets tracked. Alternatively, customers get the option to choose the amount of data assigned to their SIM card(s), where payment is based on the data assigned, whether one uses it or not. Where assigned data is exceeded, overage charges apply. This may apply with data pooling or no pooling. The table below shows a data per SIM plan with data pooling for C-Mobile, an MVNO for Vodafone Australia.

[34] https://www.bcg.com/publications/2017/how-internet-of-things-change-pricing-of-things
[35] https://internetofbusiness.com/t-mobile-price-nb-iot-connectivity/
[36] https://www.programmableweb.com/news/data-service-pricing-models-future-data/2010/08/26

Table 11: C-mobile Australia

Plan	Included Data	Plan Price (ex-General Sales Tax) (AU$)
1MB data plan	1MB	$2.10
3MB data plan	3MB	$2.15
5MB data plan	5MB	$2.20
10MB data plan	10MB	$2.30
30MB data plan	30MB	$2.70
50MB data plan	50MB	$2.95
100MB data plan	100MB	$3.80
150MB data plan	150MB	$4.50
500MB data plan	500MB	$5.50
All services on the same plan on the same account have pooled data. e.g., an account with five SIMs on the 10MB plan will share a data pool of 50MB per month. Excess data usage charged at $0.05 per MB. Other charges: • SIM cards $4.00 per SIM or $3.50 per SIM for orders over 100 SIM cards • Standard voice calls charged at $0.60 per minute • Standard SMS charged at $0.15 per SMS *Source: https://www.cmobile.com.au/m2m-iot-plans/*		

Table 12: C-Mobile IoT and M2M Pricing Plan

Simplified IOT & M2M Pricing – Overage Data : 4 cents/MB, Text – 2 cents, Voice – 5 cents/min		
Monthly Charge	Data Included	Coverage Data
$1.75	1 MB	Data : 4 cents/MB Voice : 5 cents/min Text : 2 cents/text
$2.00	10MB	
$2.50	25MB	
$3.00	50MB	
$3.50	100MB	
$4.50	150MB	
$5.50	250MB	
$7.50	500MB	

Source: C-Mobile website: https://www.cmobile.com.au/m2m-iot-plans/

Additionally, pricing can be a mix of a once off payment to cover the cost of tracking hardware/devices combined with recurring monthly charges per device. An example is that of AT&T's high –Value Asset tracking product which comes with a once off payment to cover the cost of the AMOC asset tracking device and the connectivity thereof, over and above a monthly recurring fee of 7.50 per device per notification every 24 hours as shown in the table 13 below.

Table 13: AT&T High Value Asset Tracking Rates

Notification Rate	Once off charge	Recurrent charges per month	Life span
1 notification every 24 hours	$57.49	$7.50	24 months
1 notification every 12 hours	$59.74	$9.75	18 months
1 notification every 2 hours	$62.99	$13.00	3 months
1 notification every hour	$69.49	0	45 days

Source: https://marketplace.att.com/products/highvalue-asset-tracking-962762

iv. ***Data Type based Pricing:*** with data type-based pricing, data pricing comes with tiers that are based on data type or attributes in terms of number of fields returned in a query. A typical example is Urban Mapping Application Provider Interfaces (APIs), which offer geo-coordinates and zip codes in urban localities. Additional information associated with such services may include schools, post offices, or shops amongst others, which attract additional charges.

v. ***Value Sharing:*** Entails alignment of prices to the amount of value a service generates for the customer. Instead of volume, speed or time-based charging, the Service Provider takes a share of the benefit accruing to the customer, such that the higher the benefit derived from the service, the higher the reward for the Service Provider. The reward is calculated using a fixed percentage or an upfront amount combined with a sliding percentage scale. It is often applied to B2B IoT use cases.

8 STRATEGIES FOR AFFORDABLE AND MEANINGFUL DIGITAL SERVICES

8.1 Government Strategies

i. *Enhancing Institutional Capacity:* At the institutional level, the convergence of IT, Telecommunications and Broadcasting, cannot be leveraged in the absence of a Converged Regulatory Authority. Given that everything is gravitating towards service neutral IP networks, policy makers need to ensure that they have a converged regulator in place. This will facilitate the effective exploitation of economies of scope and scale, which in turn reduce cost of providing digital services.

ii. *Creating an enabling environment:* Broadband-led development requires substantial investment in the construction and modernization of digital infrastructure and systems. Given the unattractiveness of most African countries to Foreign Direct Investment, African countries need to improve on the ease of doing business in their respective countries. This calls for the creation of an enabling environment that attracts efficient investment, foster innovation and enhance competition in Broadband infrastructure and services. Hence, a modernized, technology and service neutral regulatory and licensing framework is a pre-requisite.

iii. *Enhancing ease of doing business:* To foster faster Broadband deployment, it is imperative to address administrative barriers faced in the deployment of Broadband infrastructure where operators have to obtain permits from various authorities. Hence, the need to coordinate such approvals through the establishment of a One-Stop-Shop for permits for Broadband deployment, as well as other strategies that reduce the cost of deployment such as the Dig Once Policy.

iv. *Promoting access to existing physical infrastructure:* Policy makers are promoting the use of existing physical infrastructure across all sectors of the economy to facilitate faster network roll out at reduced costs. Such infrastructure includes sewers, roads, electricity poles and railway lines amongst others.

Elsewhere, Governments have developed several initiatives to promote the use of existing physical infrastructure, including cross-sectoral policies to access rooftops, ducts, poles, electricity pylons, roads, sewers and railway lines to facilitate faster and cost effective roll out of broadband[37]. For example, in Singapore, the IMDA has

[37] https://www.marketlinks.org/sites/marketlinks.org/files/resource/files/SSG-Connectivity-Business-Model-Assessment-FOR_PRINT_00000003.pdf

mandated that all rooftop spaces that are suitable for mobile communication installations be provided to network service providers free of charge. In Japan, Network operators can install 5G base stations on traffic lights across the country and all cost of using the traffic lights are shared between the latter and local authorities. In the UK, network operators can access macro and small cell infrastructure on both private and public land.

v. *Public Sector Investment in connectivity:* In Africa, several governments have funded connectivity using direct National budgetary allocations. This has happened in Botswana, Tanzania and Malawi where the governments fully funded the roll out of backbone networks.
The Smart village Programme in India where the government is funding connectivity to villages under a Build, Operate and Maintain (BOM) approach, is also another innovative example where we see Government directly getting involved in investing in connectivity.

vi. *Pay or Play Strategy:* Vanuatu has adopted the Pay or Play strategy to facilitate infrastructure roll out to unserved and underserved areas. This entails inviting operators to choose between "playing," where they contribute towards the cost of infrastructure rollout to specific areas or "paying," where they contribute to the Universal Service Fund (USF).

vii. *Free Public Wi-Fi deployments:* Governments are increasingly supporting the deployment of free Public Wi-Fi in public areas including shopping malls, parks, and village centres, public health institutions, government offices, tertiary institutions and public transport terminals amongst others. Google, in partnership with Smart WIFI have deployed public Wi-Fi networks in several countries including Brazil, Mexico, India, Thailand and Nigeria. In the Philippines, more than 400 public Wi-Fi spots have been deployed, targeting high pedestrian traffic areas such as markets, malls, bus stations and airports.

viii. *Community Networks:* The establishment of community networks through public-private partnerships, using networking technologies to offer services in areas where there are no networks is also getting popular[38]. For example, Firechat can be used with blue tooth to facilitate peer-to-peer networking to send messages between users.

In Niger, for instance, the ITU Smart Villages project, launched in 2018, aims to provide broadband connectivity in rural areas based on a multi-stakeholder approach involving government, civic society, villagers, and development agencies, amongst others.

[38] https://www.marketlinks.org/sites/marketlinks.org/files/resource/files/SSG-Connectivity-Business-Model-Assessment-FOR_PRINT_00000003.pdf

8.2 Private Sector Strategies

Worldwide, operators are coming up with innovative strategies to reduce costs of service provision in order to stay afloat and retain subscribers. This ranges from shared infrastructure deployment strategies, to leasing of network resources amongst others. The following are some of the strategies adopted by operators:

i. Third Party Network ownership

Some network operators in Africa have entered into arrangements to out-source their networks, IT systems, call centres and other support functions to third parties[39]. In some instances, governments have rolled out networks for lease to network service providers. A case in point is that of Mexico whereby the government rolled out 4G networks across the country for leasing to network service providers. Operators are also selling their towers to Tower Companies and in turn renting Tower space from Tower Companies as is largely the case in USA, India, Pakistan and Malaysia. Cases in point include[40]:

- Bharti Airtel has an outsourcing arrangement with Huawei for 11 out of 15 of its networks in Africa.
- MTN, which sold 1,128 towers in South Africa, 524 towers in (Rwanda) and 704 towers in Zambia to HIS Holding. Under the arrangement, HIS holdings will roll out networks to suit and cater for all future needs of Towers to MTN.
- In the Democratic Republic of Congo, Millicom sold 729 towers to Helios Towers. Millicom and Helios have similar arrangements in Tanzania and Ghana41.
- Vodacom of Tanzania has an outsourcing agreement with Nokia Siemens.
- In 2018, Tele Pacific in the US sold and leased back metro fibre to Uniti Group, a telecom real estate investment trust.
- Altice of France sold a 49.99 percent minority stake in fibre-optic business SFR FTTH for $2.05 billion to Allianz, AXA and Omers Infrastructure.
- Cellnex has become a leader in infrastructure acquisition due to its European expansion.[42] Between 2015 and 2019, the company had a footprint in six European countries, and its market value has increased at each acquisition from EUR3.994 million to EUR8.658 million in the same period. Its acquisitions include:
    - In Italy, from Iliad and H3G, which then merged with Wind to form the third-largest operator in the country.
    - In France, from Bouygues Telecom and Free, which has allowed the independent TowerCo to consolidate national networks.

[39] https://www.marketlinks.org/sites/marketlinks.org/files/resource/files/SSG-Connectivity-Business-Model-Assessment-FOR_PRINT_00000003.pdf
[40] https://www2.deloitte.com/content/dam/Deloitte/fpc/Documents/secteurs/technologies-medias-et-telecommunications/deloitte_the-future-of-telecoms-in-africa_2014.pdf
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[42] https://www.lightreading.com/5g/cellnex-emerges-as-euro-mobile-tower-power-player/d/d-id/756581

- In Switzerland, from Sunrise and Salt, which has given it the opportunity to consolidate networks.
- In Spain, from Telefónica and Masmovil.

ii. Outsourced Managed Services Model

Network operators are also taking the route of outsourcing parts of their network operations to equipment vendors. This is widely practised in India where operators outsource their network operations to vendors such as Alcatel-Lucent and Ericsson. The advantage of outsourcing network operations is that it enables operators to focus more on market offerings and customer acquisition and not technology /software upgrades. Another interesting case is that of ViRural[43] a wholesale network access provider in Nigeria targeting rural remote areas with no grid power and mobile phone coverage. ViRural provides network connectivity solutions for single or several network operators, thereby enhancing their coverage without investing in building networks.

iii. Airborne Network Infrastructure

The world is witnessing interesting innovations around reducing connectivity costs, in particular for unserved and underserved areas. Case in point is the Google Loon Project launched in July 2020 in Kenya[44]. The project, which is in partnership with Telkom Kenya, is aimed at providing 4G Internet access in rural and remote using interconnected internet-enabled balloons that are connected to an earth station to provide connectivity.

iv. Cooperative Public Private Partnerships

Cooperative Public Private Partnerships for rolling out broadband connectivity are also gaining popularity in various forms. One interesting case is that of Gambia, where seven telecom operators teamed up with the government to form a cable management company to facilitate access to the ACE Submarine Cable System. Under the arrangement, operators are allocated capacity, based on their investment and charged at cost without a mark-up.

v. Network mutualisation

Network mutualisation is gaining traction in Africa, starting with the construction of undersea cables, which has now extended to the deployment of mobile access networks. An example is the construction of an open access 4G network in Rwanda[45], through a deal with Korean Telecom, which provides retail services to several fixed and mobile network operators in the East African country.

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[43] https://www.marketlinks.org/sites/marketlinks.org/files/resource/files/SSG-Connectivity-Business-Model-Assessment-FOR_PRINT_00000003.pdf
[44] https://www.marketlinks.org/sites/marketlinks.org/files/resource/files/SSG-Connectivity-Business-Model-Assessment-FOR_PRINT_00000003.pdf
[45] https://www.businesswire.com/news/home/20190618005819/en/Rwanda-Telecoms-Mobile-and-Broadband-Statistics-and-Analyses-2019-2023---ResearchAndMarkets.com

vi. Network sharing Arrangements

New innovative ways of sharing infrastructure are emerging. One such innovation which could revolutionise infrastructure sharing is the multicasting capability of fixed NGNs,[46] which entails simultaneous transmission of video to multiple consumers, carried as a single stream with much less bandwidth. With this approach, the resulting occupied bandwidth of multimedia linear content applications such as television, is equivalent to the demand of only one consumer Multicasting enables operators without access infrastructure to interconnect

Alternatively, telecommunication companies are coming up with innovative ways to roll out services, with the Norwegian fibre provider Lyse engaging prospective customers to dig last mile trenches for themselves in return for discounted service offerings.

vii. Nimble billing

Operators are adopting strategies to address the problem of service affordability to attain the critical usage mass for them to benefit from economies of scale arising therefrom. Accordingly, in Africa, we are witnessing the prevalence of more generous and flexible service offerings from Service Providers, who are allowing larger periods of validity for pre-paid credit, adopting per second billing, lower denomination recharge cards as well as promotional offerings, including graduated data bundles and various forms of pay per use plans.

8.3 Revenue Assurance Strategies

According to the Communications Fraud Control Association, telecom operators across the globe lose USD $29.2 billion to fraud annually. Revenue is mainly lost through poor planning and systems coordination as well as errors in call data records, and chargeable tariffs.

In Africa and other developing countries, the perception of fraud may slightly differ in that it can be broader to include issues such as OTT bypass, which are not recognised as fraud in the developed economies. This is of particular interest to developing countries as it affects their revenue earning potential in view of the fact that international termination revenue is a significant contributor to telecom revenues. The desperation on the part of developing countries emanates from the substitution effect of OTTs, which has reduced international incoming voice traffic over the years.

Regulators are responding by taking a role in fraud management at a national level by establishing Telecommunication Traffic Monitoring Systems (TTMSs), including enacting laws that make bypass calls illegal. In Africa, several regulatory bodies have established Telecommunication Traffic Monitoring Systems (TTMSs) as a way of addressing revenue

[46] https://pubdocs.worldbank.org/en/533261452529900341/WDR16-BP-Infrastructure-Mutualisation-Garcia.pdf

leakages through SIM boxing activities and traffic refiling. Countries that have established TTMs include Tanzania, Rwanda, Burundi, Zambia, Malawi, Mali, and Ghana amongst others.

In addition to the above, Network Service Providers are also enhancing and updating their revenue assurance strategies and systems in order to remain competitive and profitable. Owing to convergence, competition for Network Service Providers (NSPs) has increased significantly. NSPs are now venturing into media and digital services in direct competition with traditional media and digital service providers, whilst the latter are also investing in telecommunication networks. Overall, revenue assurance is shifting focus from plugging revenue leakages towards revenue generation, focusing on cost saving opportunities as well as customer acquisition, satisfaction and retention. These require precision and agility. The following are some of the strategies for revenue assurance and fraud management in the emerging digital environment:

i. *Enhancing capability to process multiple network topologies*

This entails integration of transactions from different types of networks such as 3G, 4G, 5G and IP to a single operations/business support system. Traditionally, revenue assurance systems were purpose designed for circuit switched networks for which use cases were based on batch processing of data. With convergence and the emerging B2B2C partnership relationships, there is increased need for Operations Support Systems (OSSs) or Business Support systems (BSSs) to have capability to process different network topologies and large amounts of data generated from different channels.

ii. *Ensuring Network Configurability*

Configurability of networks comes in various forms, of which the use of plug and play adapters is critical for end-to-end service activation from customer order to payment. The use of configurable data objects to define new service offerings is gaining popularity for ease of service activation. In terms of revenue generation, ensuring network agility and ease of integration with other systems regardless of vendor, is a critical success factor in the emerging digital environment. This is necessary for quick roll out of new service offerings and promotions. Configurable systems reduce time to market for new services, which is a critical success factor for customer acquisition and retention in a highly competitive environment.

iii. *Enhancing Real Time Capability of Revenue Assurance Systems*:

This entails the establishment of real time revenue assurance platforms capitalising on data analytics capabilities for quick response and more accuracy. Real time analytics enable operators to create and maintain network inventories, manage network faults and automate service provisioning. It also facilitates real time revenue monitoring analysing and monitoring usage trends for different services. This helps in reducing the lead-time between revenue leakage detection and revenue realisation.

iv. *Automation of Processes*

This entails enhancing customer management, aimed at knowing one's customers and enhancing customer assurance. This is achieved through automating processes such as device provisioning and service activation, creation of simple service portals for use by subscribers to view their account information and make purchases as well as automation of report generation for internal use and compliance purposes, amongst others. This is critical for customer retention and key success factor in view of the increasing importance of having a large customer database, which offers the opportunity to earn advertising revenues.

v. *Ensuring Network Standards Compliance*:

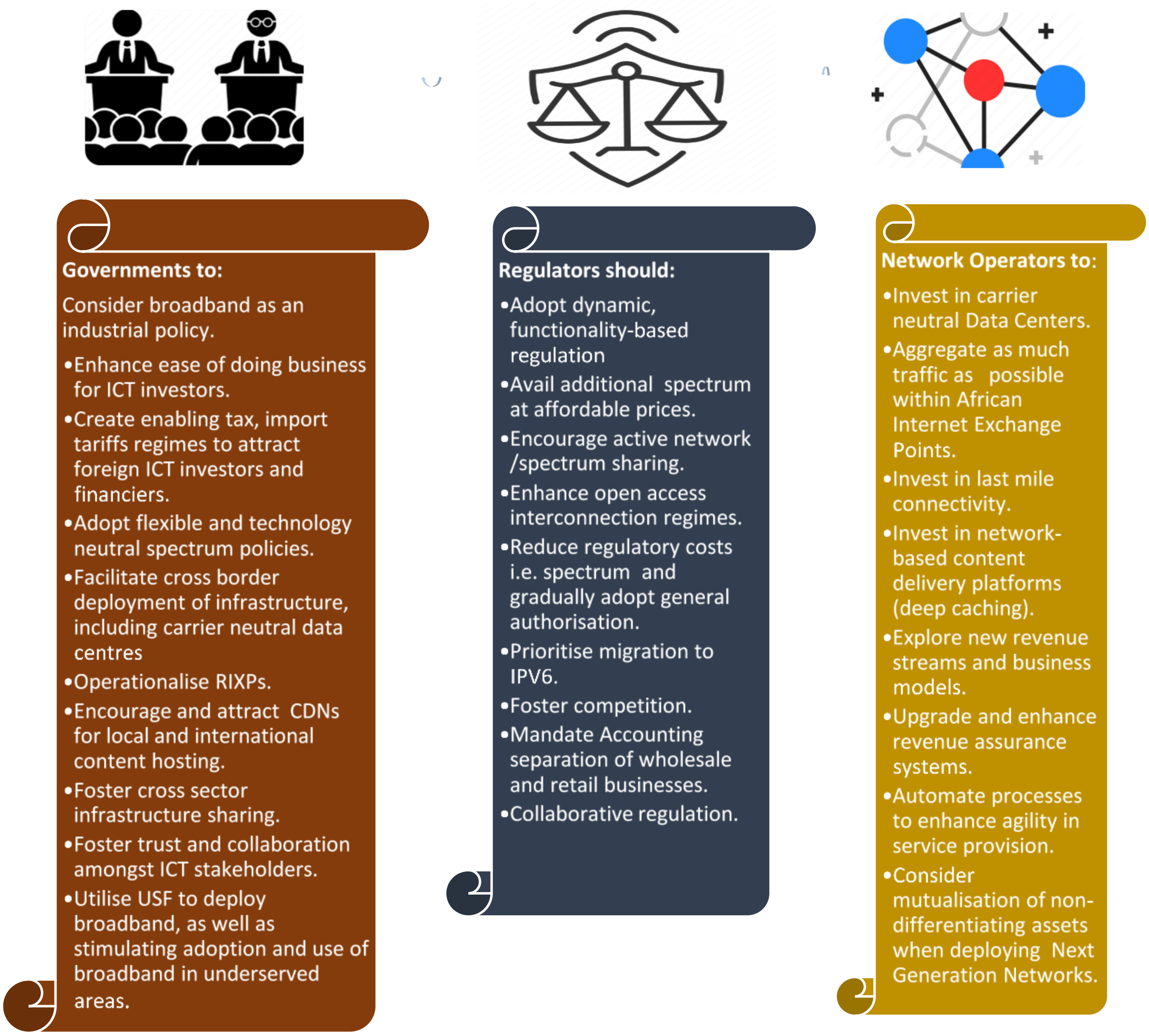
This is critical as it enables the network to integrate more easily with several vendors and it reduces data loss due to misalignment of systems. It enhances precision, which is required for order management, billing and collection for a wide range of services with different charging schemes.

9 WAY FORWARD FOR AFRICA

The contents of this report reflect the advances made so far concerning costing of 5G services, emerging IP interconnection models and the pricing models for OTTs; IoT and enhanced data services. Form the analysis, it is clear that Africa still has a lot of catching up to do in terms of migration to NGNs and adoption of IP interconnection models. Progress is however being registered with regards to establishment of data centres and investment by CDNs to facilitate local content hosting. The report also scanned various policy and regulatory initiatives as well as business models that are helping countries to accelerate the deployment of meaningful and affordable digital connectivity.

After assimilating the above, Figure 13 below, summarises what operators, regulators and governments need to focus on to catch up with the rest of the world in the digital race.

Figure 13: Way Forward for Africa



10 CONCLUSION

In conclusion, this report has highlighted key developments in the digital environment around the world in terms of regulatory costing and pricing models as well as upcoming strategies for the provision of digital services that Africa may explore. It is clear that Africa is still lagging behind on advanced broadband infrastructure and its support infrastructure, which includes IXPs, data centres and regional interconnection. This requires substantial capital layouts, which are not easy to get hold of. However, all hope is not lost for Africa as things seem to be heating up, largely driven by the surge in demand for data hungry services and growing consumption of data due to increased telecommuting owing to COVID-19 restrictions.

Africa has vast potential for broadband investment in view of its growing population, of which 60% are youths who seemingly have a penchant for data intensive digital services. Africa needs to adapt fast to the changing digital ecosystem. With political focus and capacity building, Africa is more than capable of crossing over to the new paradigm. Going forward, a collaborative spirit among all stakeholders is the key to success at national, regional and international levels.

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