A4AI ALLIANCE FOR AFFORDABLE INTERNET

IMPROVING MOBILE BROADBAND QUALITY OF SERVICE IN LOW- AND MIDDLE-INCOME COUNTRIES

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CONTENTS

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INTRODUCTION

Almost half the world today is online — a milestone that highlights the incredible global transformation we've seen in the relatively short history of the internet, but one that also underscores the long road to connecting the approximately four billion people still offline. Ensuring everyone, everywhere has the opportunity to come online will require us to accelerate our work to tackle the challenges that prevent people from accessing and using the internet, and implement the policies needed to reduce the cost to connect and realise affordable, universal access.

At the same time, we must also consider the quality of service that online populations encounter when they connect to the internet. Using the internet in a meaningful way requires a connection with sufficient and reliable bandwidth, and improving the mobile broadband user experience is critical to enable users to realise the many benefits of a free and open internet.

The quality of service offered through mobile broadband has significant economic and social impacts. The relationship between increased internet use and economic growth has been well documented, and increased broadband speeds (e.g., moving more of the population from a 2G to a 3G connection) have been linked to economic development across different country types, including low- and middle-income countries (LMICs). The social impacts of quality of service are similarly significant — a number of health services depend on reliable and good quality mobile broadband (e.g., where patient data is transmitted in real time to medical centres), as do most mobile financial services (e.g., where the ability to transfer funds and messages instantaneously is a critical component of building trust in the system).

In this brief report, we review the quality of mobile broadband service across LMICs and steps to improve the quality of service offered in these countries, based on both new and publicly available data on mobile connections speeds, as well as interviews with regulators, mobile network operators (MNOs) and civil society in four different countries: Peru, Colombia, Mozambique, and Bangladesh.[1] There are a range of technical factors to consider when examining quality of service, including in-network issues (e.g., availability of infrastructure and electricity) and out-of-network issues (e.g., quality of end-user devices) — many of these issues have been already examined by organisations such as the GSMA and ITU. Improving quality of service depends not only on these technical factors, but also on having the policies and regulatory framework in place that, for example, encourage MNOs to improve networks, promote competition in the market, and increase capacity to provide independent and accurate data on quality of service.

1 A total of 10 interviews were completed between mid 2017 to mid 2018. Informed consent was received in all cases.

This paper presents new data on existing levels of service in LMICs and the policy and regulatory steps that governments and their partners can employ to improve the quality of those services. It represents the first in a series of research designed to understand what constitutes meaningful access, i.e., the level of service quality needed for people to access the internet in a way to improve their lives. Further research on this issue will be published in 2019.

01

UNDERSTANDING QUALITY OF SERVICE (QoS)

In telecommunications, quality of service (QoS) refers to the range of factors — including mobile internet availability, connection speeds, and network latency[2] — that influence whether or not the service meets the user's needs. These factors are typically measured quantitatively. Quality of experience is a complementary measure, which looks at the overall performance of a service as perceived by the user (e.g., a study of mobile broadband in South Africa revealed that many users reported receiving speeds that were less than what was advertised by their MNOs). In this report, however, we will focus only on QoS metrics, while bearing in mind that more research (including user surveys) is required if we are to ensure that the user's mobile internet experience meets their needs and expectations.

2 See https://www.itu.int/dms_pub/itu-t/opb/tut/T-TUT-QOS-2013-PDF-E.pdf for additional information.

Measuring QoS

Assessing QoS in a given country requires robust and objective data; such data, however, is often expensive to obtain, out of date because it is not regularly collected, or otherwise not available to the public. To address this challenge, we have collaborated with New America's Open Technology Institute to leverage Measurement Lab (M-Lab) data, one of the few public and freely available datasets measuring actual mobile broadband speeds and latency in 54 low- and middle-income countries. This dataset examines a range of key QoS metrics, including median download and upload speeds (Mbps) and latency (the minimum time to transmit a packet of data from one point to another and back; here we refer to this as minimum round trip time or RTT).[3] (See Table 1 in the Annex for results by country.)

As Figure 1 illustrates, the slowest median download speeds were found in African countries (0.82 Mbps), followed by Latin America and the Caribbean (1.16 Mbps), and then Asia (2.11 Mbps). The figure also shows the gap between LMICs and countries in North America and Europe (which are included here for comparison) — median download speeds in the US & Canada were 4.76 Mbps, and 7.06 Mbps in Europe.[4]

3 For a more detailed definition of these metrics see - https://www.measurementlab.net/learn/definitions/#metrics

4 The data included for Europe comes from the UK, Germany, Denmark, Finland, the Netherlands, Norway, and Estonia.

Figure 1 - Median Download and Upload Speeds (Mbps), by region 2017

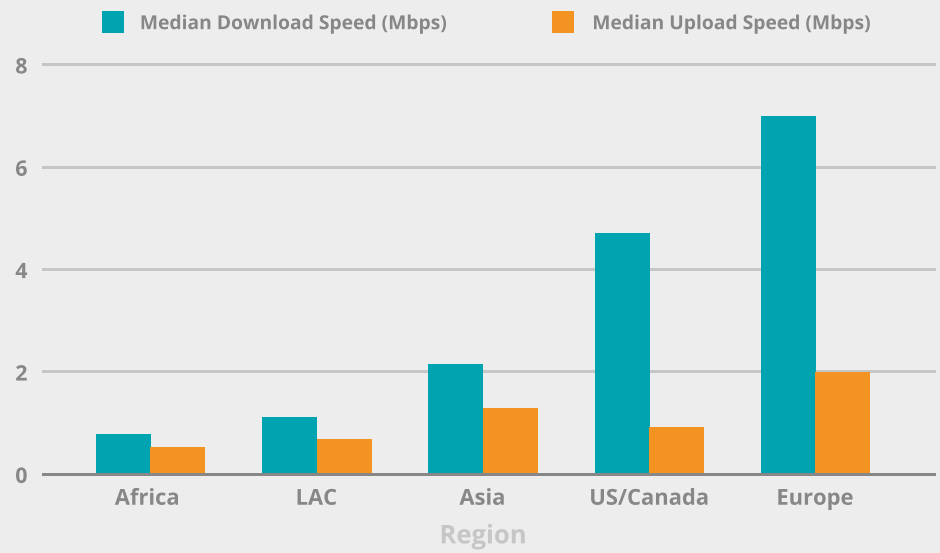
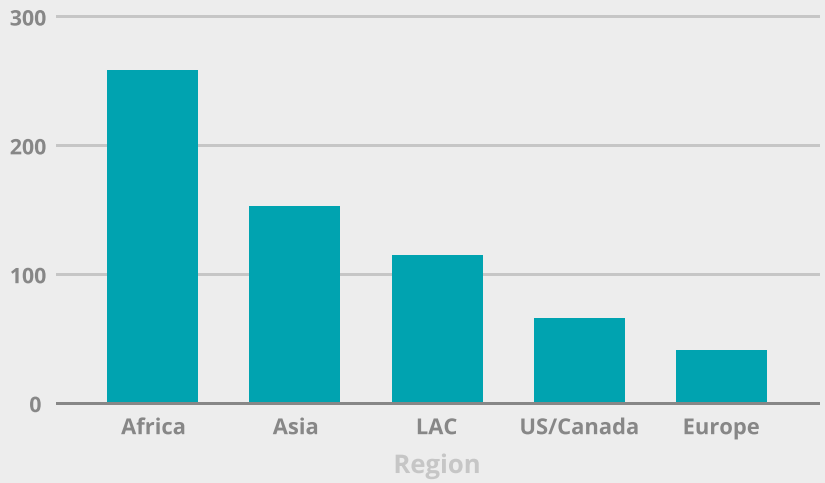


Figure 2 shows the median latency results for each region. Again, much like the results for median download/upload speeds, mobile internet users in Africa experience the longest delays — particularly when compared with Europe. With large populations that are offline, those that make it online also face connectivity options that are much lower in quality compared to other regions. In sum, users in many Global South contexts face a double barrier to meaningful internet access.

Figure 2 - Minimum Round Trip Time - RTT (millisecond), by region - 2017



The trends found between regions in terms of median mobile broadband speeds is similar to regional averages for mobile broadband affordability. In fact, we found a statistically significant correlation[5] between levels of QoS (e.g., median download/upload speeds and minimum RTT) and performance on the Affordability Drivers Index (a measure developed by A4AI to assess how well a country's policy and regulatory environment can lower industry costs and improve affordability). This suggests that many of the policy and regulatory changes required to lower industry costs and improve QoS will also improve affordability.

5 The correlations are moderate to weak: Median download speed: rho=0.33, p=0.01; Median upload speed: rho=0.4, p<0.01; Minimum RTT: rho=-0.29, p=0.03

02

POLICY INTERVENTIONS ON QUALITY OF SERVICE IN LOW- AND MIDDLE-INCOME COUNTIRES

While MNOs and other internet service providers can improve certain aspects of their network performance, policy remains a critical aspect of improving mobile broadband QoS and, ultimately, the beneficial impact of the internet. Through policy and regulatory reform, countries can positively affect the quality of service and average user experience with mobile broadband. This section summarises insights from four case studies – Bangladesh, Colombia, Mozambique, and Peru – and identifies three broad policy themes for attention: (1) the telecommunications regulator's internal capacity, (2) the institutional relationships within a country's telecommunications sector, and (3) the influential market dynamics of mobile broadband. These three areas intensify in rural and other underserved areas: this is discussed in further detail as a fourth theme, below.

01 Regulatory capacity

The regulators in this study varied in their internal compositions and capacities. Three factors emerged as influential to QoS within each country: the regulator's institutional position as a governing body, the regulator's internal resource to fulfill its mandate, and the regulatory functions in supporting a better QoS. These dynamics collectively defined the regulator's position to then engage with operators and civil society on this issue.

1.1 Institutional position

Regulators hold varying degrees of political independence from other government ministries. In both Colombia and Mozambique, the regulator reports to the government ministry responsible for ICT, and ultimate authority for the regulator's decisions belongs to the government minister. Issues of regulatory independence are compounded by the fact that in both countries, the government has a financial stake in one mobile network operator. Commingled accountability such as this exposes the technical decision-making of the regulator to real and theoretical political influence, particularly where the profit interests of the state-owned operator clash with the public interest and the need for transparent and fair regulation on the QoS and enforcement of non-compliance.

Where regulators lack this autonomy, operators we spoke to regularly reported this lack of financial autonomy as a concern, noting that it may influence the regulator's capacity to intervene and enforce QoS requirements fairly among all operators.[6]

6 Interviews with MNOs in Colombia and Mozambique, February to March 2018.

Political and financial independence both have a significant impact on a regulator's position and ability. Without one or the other, the overall independence of the regulator is called into question and its institutional capacity to support positive market developments is reduced. For example, in Mozambique, the regulator holds budget autonomy but not political independence. Even though INCM, the Mozambican regulator (Instituto Nacional das Comunicações de Moçambique), is autonomous in all financial and administrative tasks, it is not completely independent of the government for the decision-making process and strategic choices because INCM reports to the Minister of Transport and Communication.

1.2 Internal resource

In surveying the studied countries for this report, access to resource and capacity defined the regulator's impact in supporting QoS. Limited institutional expertise impedes the Mozambican regulator's attempts to develop and enforce its regulations. In order to assure high qualitative mobile broadband service, INCM needs to attain internal expertise and build its institutional capacity in such a way that it is able to react to new laws and regulations in a timely manner. Currently, private operators feel that INCM does not have the capacity to review and adjust regulation that must be updated in accordance with the new telecommunication law.[7]

In addition, equipment and staff availability to support measurement and enforcement responsibilities influenced a regulator's ultimate ability to engage with QoS. From INCM's viewpoint, it does not possess the relevant means and equipment to monitor and control mobile broadband quality indicators (although there are plans to acquire relevant equipment soon) and therefore, it has to rely on reports provided by the operators.[8] Similarly in Bangladesh, the Bangladesh Telecommunication Regulatory Commission (BTRC) reports limited staff capacity to measure QoS. As a result, the regulator continues to rely on operators to self-report on the quality of service offered. The reliance on self-reporting mechanisms from operators can limit a regulator's capacity to engage confidently with operators.

1.3 Regulatory functions

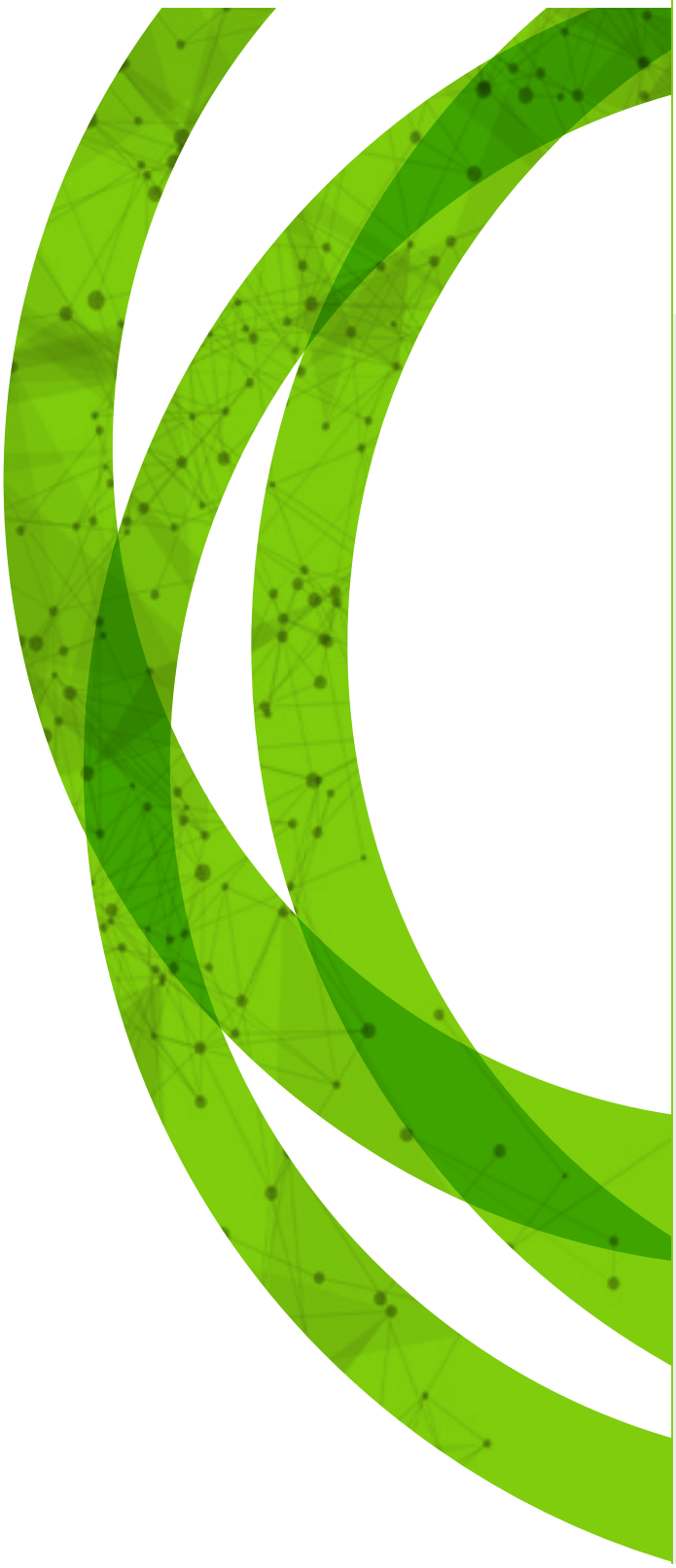
Some regulators have been able to dedicate resources to producing and publishing valuable data on QoS. The Colombian regulator — the Commission for Communications Regulation (CRC) — hired a third party to conduct periodic measurements using a regular smartphone and following a specific route in a specific city. The smartphone has access to all operators' networks, and measurements are made comparing the performance of different mobile networks at the same time. Data is compared, analysed and provided to the CRC. CRC then publishes this data with information on four cities (Bogotá, Medellín, Cali and Cartagena) and includes indicators of download speed, video streaming speed, web load time, and latency.

Similarly, some regulators have engaged with the market and acted as a venue for knowledge exchange among the various actors. In receiving large amounts of information from various sources, such as operator reports, independent studies, and consumer complaints, regulators make consequential decisions on the availability of this information. The regulator in Bangladesh recognised this role and, through the development of the Public Consultation Center, which acts as a centerpoint for focus group consultation and consumer complaints, has come to fill the role of market mediator. However, as noted above, the composition and reputation of the regulator within the country has a large influence on the regulator's capacity to effectively serve this function.

7 Interviews with MNOs in Mozambique, February to March 2018.

8 Interview with regulator in Mozambique, February to March 2018.

02 Institutional relationships with regulators



Regulators hold a key position within the telecommunications sector and carry a natural capacity for sustaining fora for discussion on QoS, but vary in their effectiveness in carrying out this function and cultivating the appropriate relationships. In particular, regulators' relationships with **network operators** and with **civil society** illustrate different regulatory approaches and their effects on the mobile broadband market.

2.1 Engagement with network operators

The relationship between regulators and operators under its purview fit along a spectrum from conflicting to cooperative. Where regulators were able to develop relationships closer to cooperation with network operators, more favourable arrangements and outcomes were documented. An example from Colombia illustrates this.

The ICT Ministry in Colombia developed a plan to help operators identify their failures in meeting QoS targets and design an improvement plan. Previously, operators were fined immediately for QoS violations and were not allotted time to design corrective measures. Under the new strategy, operators now have one month to develop an improvement plan and present it to the ICT Ministry. Then, they are given nine months to evaluate and correct their service levels. Progress is monitored by the CRC, and, if the corrective measure is not implemented within the given period of time, the regulator can impose sanctions accordingly. According to the CRC, the strategy is working — sanctioning has decreased and QoS has improved with new incentives for operators to act.[9]

9 Interview with regulator in Colombia, February to March 2018.

This improvement plan process and transparency in the relationship between the regulator and operators can have a positive effect.

2.2 Public engagement strategies

In developing policies, regulators have leveraged their capacity to varying degrees to unite different actors in the sector with procedures that hold some degree of openness for public consultation and input. The variance of these practices have illustrative effects on policy outcomes.

- In Mozambique, the regulator reports that operators are kept in the loop during the definition process of the key performance indicators (KPIs) and stated that the KPIs are officially sent to the mobile broadband operators and operators are invited for discussions before any quality indicators are published.[10] However, operators have raised the concern that the regulator's defined KPIs are unrealistic with respect to the country's current mobile broadband market and infrastructure. Operators point to the indicator around customer issue calls and a 24-hour response time as an example of an overly ambitious target established without sufficient consultation to ensure its feasibility. Because of this perceived dissonance, operators have designed their own, independent QoS standards.

- In Peru, the regulator has had a positive experience aligning the interests and requirements of all different actors involved around the deployment of infrastructure to improve broadband.[11] This should include the development of alliances and partnerships with all relevant actors to reach the greater target. From the Peruvian perspective, this also includes working closely with other sectors, such as transport, regional and local governance, and electricity.

- In Colombia, the modifications to QoS regulations have been conducted in a participatory manner involving the government, operators, civic groups and consumers. The regulator shared proposed resolutions regarding QoS on their website and solicited public comment from different stakeholders; it then analysed the comments received and incorporated comments into the final version.

These stories confirm that investment of regulators is essential for opening regulatory processes for wider consultation. Human interactions can give colour to the institutional relationships in the mobile broadband market.

10 Interview with regulator in Mozambique, February to March 2018.

11 Interview with regulator in Peru, March 2017.

03 Market influences on quality of service

The high-level decisions of policymakers and regulators have cascading influences through the mobile market to individual purchases, and the options available to consumers at that purchasing moment can influence market pressures on operators. Market competition can influence operators' investment strategies. Consumers then make decisions based on the information available to them on quality of service and what value they derive from accessing the internet: the source of this information can have impact, and some regulators provide data to better inform this competition. When empowered with policies like mobile number portability, consumers can also more dynamically shift to a new operator for a better user experience. Together, these factors have an impact on the quality of service offered by mobile network operators.

3.1 Service coverage

Market composition has an impact on consumer experience with mobile internet. Houngbonon & Jeanjean (2016) find that the number of operators and intensity of market competition in the mobile market influences how much an operator is willing to invest further in their infrastructure.[12] This, in turn, can impact the network's capacity to support a higher quality of service for the operator's users. Consumers can only make market-influential decisions when there is more than one option for a mobile internet provider.

12 Houngbonon, Georges Vivien, and François Jeanjean. "What Level of Competition Intensity Maximises Investment in the Wireless Industry?" Telecommunications Policy 40, no. 8 (August 2016): 774-90. doi:10.1016/j.telpol.2016.04.001.

3.2 Transparent data

Some regulators have successfully taken steps to make more information available to consumers on operators' comparative QoS performance to enable market competition. In Peru, for example, the regulator OSIPTEL publishes the records of operators' compliance with the minimum speed and average speed requirements. In case an interruption of any of the services occurs, the operator must report this to OSIPTEL, regardless of the cause. The regulator supervises and verifies the information presented by the operators, as well as the methods and equipment used to measure QoS indicators. More recently, OSIPTEL published a ranking of districts in the country with the best QoS performance (based on a combination of several QoS metrics); this also included results comparing MNOs in each district.

Beyond just network performance metrics, the regulator in Colombia has made public the improvement plans settled with operators, giving another layer of public accountability on both the performance of the network as well as progress made on promised improvements. Consumers need access to market information to help make decisions about the best operator for their needs, including on QoS. The regulator has also recently launched an online portal, Post[data], with data on QoS, digital markets, and the impacts of digital technology on the country's economy, and with registration open to all.

3.3 Consumer power

Market pressures on quality of service hold best when consumers have power to switch between operators, and some regulatory decisions can affect that power. Mobile number portability (MNP) is such an example. Policies that allow consumers to port their number from one operator to another does not automatically improve QoS, but it does motivate operators to make network improvements to improve both quality of service and quality of experience to recruit and retain customers. Indeed, comparing the download speeds across 24 African countries within the data set developed in partnership with M-Lab, countries with MNP had a median download speed 319% faster (1.31Mbps) compared to countries without MNP (0.41 Mbps).[13] MNP is a practice that exists in all four countries surveyed,[14] having just launched in Bangladesh.[15]

13 Using a Mann-Whitney test, the difference is statistically significant at p=0.01

14 International Telecommunications Union. 'Number portability required from mobile operators (2017).' ICT-Eye. https://www.itu.int/net4/itu-d/icteye/Default.aspx.

15 https://www.dhakatribune.com/bangladesh/2018/03/15/mobile-operators-try-drag-number-portability-process/

04 Infrastructure for rural and other underserved areas

Quality of service is a particular challenge in rural communities and other underserved areas, where infrastructure is typically more limited and operators are less likely to invest resources in developing such infrastructure due to perceived low return on investment. In response, some regulators have adopted region-specific strategies to spur growth in these areas. In addition, regulatory barriers in rights-of-way and zoning permissions can create higher per capita costs in filing the documentation required for compliance with local authorities in network build-out. Policy decisions can affect these two dynamics and overall impact the quality of service available for mobile broadband users in these areas.

4.1 Region-specific strategies

Some regulators have taken steps to specifically encourage infrastructure development in rural and low-margin areas. In Peru, regulator OSIPTEL eliminated the requirement for operators to pay for the renewal of their licences, instead calling on them to invest money to improve services, deploying stronger networks and providing coverage to more district capitals within a specific period of time.[16] In addition, licensees were required to offer broadband services to public schools, health centres and police stations across the country for 10 years at no charge. For example, Telefónica del Peru's Movistar, the largest operator in the country, renewed its operating licences with obligations to extend mobile broadband coverage to 1,842 remote villages by the end of 2015, and provide more than 12,000 free mobile broadband connections aimed at improving the performance of essential state services in areas such as education, healthcare and security.

4.2 Regulatory harmonisation

16 Interview with regulator in Peru, March 2017.

Regulators can also play a role in simplifying the permissions process for operators looking to build their network infrastructure. This phenomenon is present in Colombia, where some municipalities impose taxes on mobile services, negatively impacting broadband usage and, therefore, future operator investment in QoS improvement.[17] Removing municipal barriers and ensuring a consistent regulatory environment across the country can encourage infrastructure deployment and therefore have a positive impact on QoS.

17 Interview with private sector business association in Colombia, February to March 2018.

03

POLICY RECOMMENDATIONS

This report has focused on the policy dynamics that affect the quality of service available to users in low- and middle-income countries. Despite the theoretical portability of internet access to any node in the global network, infrastructural disparities and policy regimes have consequential impacts on users' experience with the internet. Large, continental gaps exist between the user experiences for someone in Europe compared to someone in Africa. This report presents data on this disparity and assembles a few case studies to compare regulatory regimes and their impacts. From this study, we present the following policy recommendations.

Regulatory capacity

The capacity of policy change starts in many ways with the constitution of the telecommunications regulator and its ability to effectively regulate the mobile broadband market.

Regulators need political independence and budget autonomy to isolate themselves from perceptions of bias and vulnerability to political agendas. Without it, the technical decision-making of the regulator are exposed to political influence, particularly where the profit interests of the state-owned operator clash with the public interest and the need for transparent and fair regulation on the QoS and enforcement of non-compliance. Political independence is fundamental to the regulator's ability to maintain fair and positive relationships that support market development towards a higher QoS. This political independence must also be supported with the financial resources required to develop, implement, and enforce the policies to support a fair and competitive market.

Internally, regulators must have sufficient financial and human resources to effectively engage with the market and ensure compliance with regulations. In surveying the studied countries for this report, the access to resource and capacity defined the regulator's impact in supporting QoS with its measurement and enforcement responsibilities. With this access to sufficient resources, regulators can undertake more comprehensive actions that sustain sector-wide collaboration towards a stronger mobile market.

Regulators can support QoS by engaging with the market and acting as a venue for knowledge exchange among the various actors. They can receive large amounts of information from various sources, such as operator reports and consumer complaints, and typically hold the political authority to act on this information to improve QoS. Leveraging the regulator's position and publishing this information publicly can encourage positive collaboration on QoS.

Institutional relationships

In addition to its own institutional capacity, a regulator should also focus on cultivating trusting, cooperative relationships with operators and civil society groups active within the sector. Regulator-operator collaboration opens scope for alternative enforcement and development strategies that can ultimately deliver benefits for consumers. Open and consultative processes can lend confidence to regulator's decisions in supporting market competition.

In developing its policies, regulators should leverage their capacity to unite different actors in the sector to establish inclusive, open procedures that give all actors an opportunity to consult and give input. There is no exact science to nurturing these relationships and developing the market, but the importance of the regulator-operator relationship is stressed in the development of a number of QoS policies across countries studied.

Early stage strategies that encourage operator enhancement rather than penalise underperformance can and have had a positive impact on QoS. Key evidence can be drawn from the two countries studied in Latin America — Colombia and Peru — where the regulators have engaged with operators to develop alternative arrangements to support QoS.

Yielding enforcement powers does not weaken the capacity of the regulator to motivate operators to act in the market. On the contrary, using sanctions on a graduated approach after continued failures gives actors an opportunity to devote resources first on developing networks and improving QoS rather than caching funds for potential sanction payments. Much of this success depends on regular and healthy interaction between the regulator and operators.

With the right resources and relationships, a country's regulator can have a healthy influence on the market dynamics in supporting QoS. Internally, regulators need political independence, budget autonomy, and sufficient capacity to undertake this work. Exposure to external influence or a lack of internal expertise can severely limit a regulator's capacity to grow legitimacy as a convener within the market. When it can convene actors across the sector, the regulator should leverage that opportunity with long-term relationships built on aligning political interests and open and fair consultation procedures that allow policy development to be a cooperative rather than competitive effort. Ultimately, the regulator's role is to positively influence the market, whose own dynamics must be noted.

Market influences

Competitive markets give consumers the power to motivate investment through operator competition. To leverage the benefits of a competitive market towards higher QoS, consumers need: (1) service coverage from multiple operators, (2) open data to compare that service, and (3) consumer power to act on that information. Competitive markets correlate with a better QoS, but that reality must be true in a consumer's local community to be able to gain that advantage. Accurate, publicly available data on QoS allows consumers to quantitatively assess operators and define their best value. With information and infrastructure, consumers also should be free from potential barriers that deny them the power to switch to a new operator that provides a better service. Market competition cannot be a superficial phenomenon to be valuable in QoS debates: it must be real, informed, and actionable at the consumer level to have the greatest impact.

Effective market engagement requires transparent and publicly available data for all actors to reference. Consumers need access to market information to help make decisions about the best operator for their needs, including on QoS. Regulators have successfully taken steps to make more information available to consumers on operators' comparative QoS performance to enable market competition. Further steps in this direction continue to support positive market developments that spur competition and competitive innovation.

In addition to access to information, consumers need adequate power to easily transition between operators. Using mobile number portability (MNP) as a benchmark for this policy strategy, we saw a positive correlation for faster user speeds in the countries examined in this report. Looking beyond the immediate scope of QoS and the infrastructure demands required, policymakers can make such changes that would spur market innovations by operators to retain and attract new customers. This distributes the motivations for network improvements among more actors and gives consumers a particular force in supporting their own interests.

Infrastructure for rural and low-margin areas

Achieving a good QoS in rural and low-margin areas — comparable to that found in more urban or populated communities — requires specific attention and action. With lower population density and often more difficult terrain, rural communities require additional focus from regulators and investment from operators to improve service quality.

Regulators have a key role in motivating market factors to highlight rural regions for required coverage and, in turn, improve service quality. In addition to Universal Service and Access Funds, where the potential market base cannot justify the development of multiple, parallel networks, cooperative sharing arrangements can improve coverage and service quality in these target regions. Regulators can adopt a range of strategies to encourage operator investment in these areas, including non-enforcement tactics that support experimentation without leaving users in these areas with lower standards.

In addition, regulators can help build political will towards harmonisation or standardisation of local regulations that apply to operators. Where there is reduced returned investment in the number of customers covered by a potentially new and unique regulatory or tax setting, operators have even less incentive to provide coverage to rural communities compared to urban areas. Installation permits should follow a uniform process based on technical considerations and international good practices.

As actors consider the present circumstances in their country, geography and current service quality must contextualise their actions. The market dynamics for urban and rural areas are fundamentally different. Policymakers should give dedicated attention to service quality in rural communities in order to achieve genuinely inclusive internet access. In tandem, policymakers, operators, and other involved actors should work collaboratively and openly on setting ambitious, time-bound targets with intentionally incremental steps. These considerations alter the utility of the policy recommendations within this report for each country's context, and it is a common responsibility to all actors to mindfully consider policy development in that context.

SUMMARY AND CONCLUSIONS

Quality of service is a cross-cutting issue throughout the sector, and all actors have a potential role they can play in improving service quality. Operators make regular decisions in infrastructure investment that define the quality of coverage for communities. An effective regulator brings together actors, aligns interests, and supports positive policy development but must have sufficient capacity and independence, both political and financial, to serve this function. Consumers, when empowered in a competitive market, can drive the importance of this issue. While different perspectives emerge from different parts of the sector, some elements persist as contextual variables – geography and the pre-existing infrastructure and practices – that define the unique environment of each country. Recommendations in this report should be adapted to each country's context.

SUMMARY TABLE OF RECOMMENDATIONS, BY ACTOR	
POLICYMAKERS	• REDUCE POTENTIAL CONFLICTS OF INTEREST BETWEEN PUBLIC MNO OWNERSHIP AND FAIR, CONSUMER-FOCUSED MARKET REGULATION • GUARANTEE POLITICAL INDEPENDENCE AND BUDGET AUTONOMY TO REGULATOR • PROVIDE SUFFICIENT RESOURCE FOR REGULATOR TO BUILD INTERNAL CAPACITY IN HUMAN EXPERTISE AND PHYSICAL EQUIPMENT • ENFORCE MOBILE NUMBER PORTABILITY FOR MOBILE USERS • DEVELOP INVESTMENT-FRIENDLY POLICIES THAT ENCOURAGE OPERATORS AND REGULATORS TO MEET QOS STANDARDS
REGULATORS	• UNDERTAKE AN OPEN, CONSULTATIVE, AND EVIDENCE-DRIVEN PROCESS IN REGULATION • DEVOTE SUFFICIENT RESOURCES FROM BUDGET TO RECRUIT STAFF, DEVELOP EXPERTISE, AND PURCHASE EQUIPMENT TO PROMOTE QOS • EMBRACE ROLE AS A SOURCE OF TRANSPARENT AND OPEN DATA ON NETWORK PERFORMANCE AND QUALITY OF SERVICE FOR CONSUMERS • EMPLOY A SPECTRUM OF PUNITIVE AND NON-PUNITIVE STRATEGIES FOCUSED ON ENCOURAGING QOS INVESTMENT
OPERATORS	• VOLUNTARILY PARTICIPATE IN INFRASTRUCTURE SHARING ARRANGEMENTS • WORK WITH REGULATOR TO BUILD POSITIVE PRACTICES AROUND SETTING REGULATION, CONSULTATIONS, AND INFRASTRUCTURE SHARING • PROVIDE CONSUMERS WITH TRANSPARENCY IN SERVICE OFFERINGS

Improving quality of service is a consequential factor in the mobile sector's ability to support social and economic development. With poor or unreliable service, mobile internet users are left to the fringes of the internet, unable to harness the most valuable benefits it potentially offers. Consumers must be able to translate network access into meaningful use of the internet. This includes affordability and quality of service each as key components. We encourage actors working within this sector to maintain this focus across their policies and practices. In this alignment of interests, we believe the greatest potential for increases to quality of service are possible.

This report has summarised initial thematic areas of interest with case studies in four countries across the globe. More research must be completed to enrich this topic of study and to further the agenda on connecting mobile internet access into attaining the Sustainable Development Goals. A4AI aims to better understand what kind of connection a user really receives when they purchase 1GB of affordable data, and so will continue to work on this issue and will embed quality of service concerns in measuring the affordability of internet access. **As noted earlier, we will explore and develop policy recommendations on what constitutes meaningful access (i.e., what kind of QoS will allow people to use the internet is a way to improve their lives) in 2019. Affordable access cannot simply be defined by the market price but also by the user experience.**

	2017 MEDIAN DOWNLOAD SPEED (MBPS)	2017 MEDIAN UPLOAD SPEED (MBPS)	2017 MEDIAN MINIMUM ROUND TRIP TIME (MS)
ARGENTINA	1.5459	0.9272	200
BANGLADESH	0.9350	0.5531	154.5
BENIN	0.8225	0.4225	299
BOLIVIA	1.6497	0.8394	172.5
BOTSWANA	0.4750	0.6912	89
BRAZIL	0.9334	0.4462	380
BURKINA FASO	0.3233	0.2049	310
CAMBODIA	2.5021	1.3058	87
CAMEROON	1.1055	0.5464	281.75
CHINA	0.6120	1.4326	280
COLOMBIA	1.5722	0.7106	109.75
CONGO, DEMOCRATIC REPUBLIC	0.1517	0.5551	439.5
COSTA RICA	0.6882	0.6403	120
DOMINICAN REPUBLIC	0.9279	0.4193	83
ECUADOR	0.6054	1.1240	159
EGYPT	1.2795	0.4784	169
GAMBIA	3.7322	0.2197	259
GHANA	1.3555	0.4917	121
GUATEMALA	1.2988	0.7350	80
HONDURAS	5.6572	1.4520	70
INDIA	1.2863	0.9263	287
INDONESIA	1.2789	1.3638	59
JORDAN	2.2340	0.7351	155.5
KAZAKHSTAN	1.3110	1.2065	168
KENYA	4.6209	1.2065	13
LIBERIA	0.3683	0.3379	333
MALAWI	0.6458	0.4196	328.5

	2017 MEDIAN DOWNLOAD SPEED (MBPS)	2017 MEDIAN UPLOAD SPEED (MBPS)	2017 MEDIAN MINIMUM ROUND TRIP TIME (MS)
MALAYSIA	3.1715	1.5375	78
MAURITIUS	0.3371	0.4667	536.5
MEXICO	4.2338	2.4461	92
MOROCCO	3.2885	1.3112	110
MOZAMBIQUE	1.3593	0.9905	158
MYANMAR	4.4697	1.4797	115
NAMBIA	1.5423	1.1019	75
NEPAL	3.4380	1.4282	171
NICARAGUA	1.1656	0.6859	109
NIGERIA	1.4097	0.5376	157
PAKISTAN	0.4797	0.6709	336
PERU	0.8257	1.1253	144.75
PHILIPPINES	1.3385	0.8001	40
RWANDA	0.2573	0.6543	374.5
SENEGAL	1.1862	0.6151	259
SIERRA LEONE	0.3607	0.2538	289
SOUTH AFRICA	5.3518	1.7999	35
SRI LANKA	1.9910	0.8756	160
SUDAN	0.5576	0.5890	340
TANZANIA	0.8014	0.5754	371.5
THAILAND	3.5924	2.5684	32
TUNISIA	2.6875	1.8338	72
TURKEY	2.6875	1.8338	72
VENEZUELA	0.5671	0.5378	115.25
VIETNAM	3.1292	1.3338	152.5
ZAMBIA	0.6205	0.7947	395
ZIMBABWE	0.2330	0.2665	117.5

Methodology

1. To develop these policy recommendations we drew on interviews with regulators, mobile network operators (MNOs), academics, and civil society in four different countries: Peru, Colombia, Mozambique, and Bangladesh. A total of 10 interviews were completed between mid 2017 to mid 2018. Informed consent was received in all cases. The interviews focused on the existing challenges and approaches to improving QoS in each country from different points of view.

2. Developing a new data set on QoS for LMICs - *Contributed by Chris Ritzo and Nick Thieme, Measurement Lab.*

   A combination of two datasets was used to produce the aggregate upload and download speeds by country and mobile carrier for 2017. M-Lab's Network Diagnostic Tool (NDT) is a widely used, open source internet measurement test. Approximately 2 million NDT measurements are collected everyday from a diversity of locations and connection types, e.g. fixed and mobile. M-Lab NDT data is processed through an ETL pipeline and made accessible in BigQuery. To create the base dataset for this study, the full NDT data was filtered for only tests originating in the countries of interest. To separate fixed broadband NDT tests from those conducted via mobile networks, the IP address was checked against ipinfo.io, a data provider which offers detailed network operator information, e.g. mobile carrier details.

   Median values for upload and download speed, aggregated by country, were calculated using the statistics program, R. To account for variance in sample size per aggregation and potential sample bias in the number of tests per unique IP address, median values were first calculated by country, IP address, and by day. Final median values by country and carrier were then aggregated from these initial medians. Finally, to further contextualize each final aggregate value for upload and download speed by country and by carrier, the number of tests in the aggregation was counted, and the 99% confidence interval for the aggregation was calculated. The 99% confidence interval consists of two values, defining the range in which any subsequent calculations of the median will fall, with 99% confidence for the selected aggregation.

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