Chapter 4

Advancing the Development of Backbone Networks in Sub-Saharan Africa

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Expanding access to advanced information and communication technology (ICT) services will be a key factor in sub-Saharan Africa's economic and social development. Cross-country data show that ICT investment fosters higher long-term economic growth (Roller and Waverman 2001). Small businesses with access to mobile phones can generate sustained increases in the incomes of poor people in developing countries (Jensen 2007). The impact of broadband is harder to quantify because less data are available,[1] but emerging evidence suggests that access to advanced ICT services—such as those that require broadband for delivery—can also have positive economic and social effects (Goyal 2008).

As understanding of the benefits of ICT has grown, African governments have begun to give priority to it and to focus on providing affordable ICT services to as many people as possible. For example, in the introduction to Rwanda's 2006 ICT strategy, President Paul Kagame wrote: "We have high expectations of ICT and its transformative effects in all areas of the economy and society. Communications technology has fundamentally changed the way people live, work, and interact socially, and we in Rwanda have no intention of being left behind or standing still as the rest of the globe moves forward at an ever increasing pace" (Government of Rwanda 2006, foreword).

In response to the dramatic success of policy reforms in expanding access to mobile phone services in sub-Saharan Africa, policy makers and investors are exploring more advanced ICT services (Balancing Act 2007; Global Insight 2007; Telegeography 2008). Indeed, many policy makers in the region consider access to broadband a key driver of economic and social development. Yet broadband connectivity remains lower than in other parts of the world, and prices are high. For example, a basic DSL (digital subscriber line) package costs an average of $366 a month in sub-Saharan Africa,[2] compared with $6–$44 in India (ITU 2007; OECD 2006).[3] The average price of entry-level broadband in the OECD is $22 per month.[4]

The limited availability of low-cost backbone network capacity is one of the factors constraining sub-Saharan Africa's development of broadband connectivity. Backbone networks are the high-capacity links that carry communications traffic between fixed points in the networks and form a crucial component in the communications supply chain. This chapter explains why backbone networks are important for delivering broadband connectivity and describes the current pattern of backbone infrastructure development in sub-Saharan Africa and the market dynamics underlying it. This analysis provides the basis for the policy recommendations outlined at the end of the chapter. The potential benefits of broadband are analyzed in chapter 3 and so are not discussed here.

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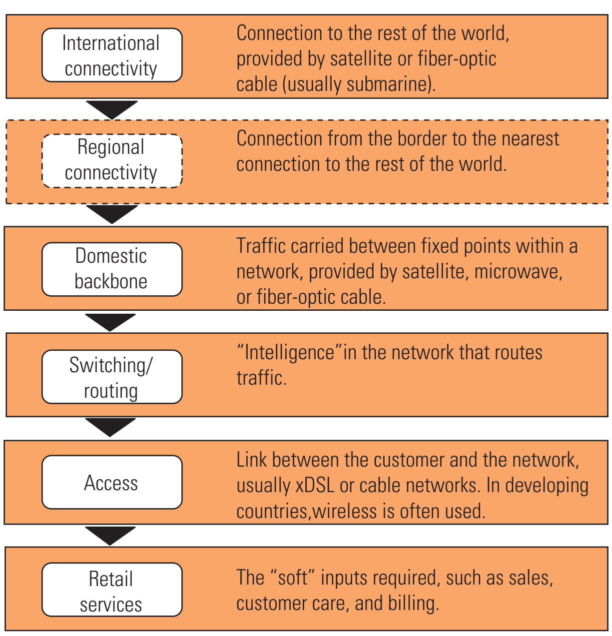
The Significance of Backbone Networks

The technical and economic characteristics of backbone networks place them at the heart of communications infrastructure and strongly affect the commercial viability of communications services, particularly broadband connectivity.

The Role of Backbone Networks in Delivering Telecommunications Services

The process of supplying communications services can be thought of as a supply chain (figure 4.1). At the top of the chain is the international connectivity that provides links to the rest of the world. At the second and third levels are the regional and domestic backbone networks that carry traffic from international communications infrastructure and within countries. The fourth level is the "intelligence" in the networks that route traffic. Below this are the access networks that link core networks to customers. Finally, there is a suite of retail services, including customer acquisition, billing, and customer care, that allows providers to function. The hierarchical nature of networks means that the volume of traffic carried by backbone networks can be relatively high even if the customer base is small.

Figure 4.1 The Supply Chain for Communications



Source: Author.

The Economic Impact of Backbone Networks

Backbone networks have a major impact on the commercial viability of ICT services, particularly broadband. In a typical mobile phone network, the backbone network accounts for 10–15 percent of total network costs.[5] The cost of backbone networks is much higher for operators providing broadband connectivity, particularly in small towns and rural areas. If an area does not have a backbone network offering low-cost network services, broadband connectivity is unlikely to be commercially viable.

Backbone networks have high fixed costs and low variable costs, which means that the average cost of capacity falls as traffic volumes increase. Figure 4.2a shows how average costs fall as traffic volume increases, while figure 4.2b shows how spreading traffic across more than one network raises average costs.

The picture presented in figure 4.2 is a static one that does not take into account the dynamic effects of competition. The cost advantage of aggregating traffic onto a single high-capacity network needs to be offset against the inefficiencies created by the lack of infrastructure competition. An illustration of this is the high price typically charged for backbone network services by incumbent operators, even where they have a monopoly in this market segment.

Competition among operators does not necessarily require each operator to have its own backbone network. Network interconnection enables one operator to use the backbone network of another, provided that it can access it on reasonable terms. This is achieved either through a competitive wholesale market for backbone services or through regulatory controls that allow open access to networks.

In a fully liberalized ICT market, the upstream elements (that is, the higher levels of the supply chain shown in figure 4.1) are typically consolidated into a few large companies with high-capacity networks, while the downstream components tend to be smaller and more geographically disaggregated. In the United States, for example, this vertical disaggregation results in a three-tier industry structure. The first tier is made up of Internet service providers (ISPs) with extensive international and domestic communications infrastructure. Second-tier ISPs are large national companies, also often with their own infrastructure, that have interconnection arrangements with ISPs at other tiers. Third-level ISPs provide services directly to users.

Thus, the economic significance of backbone networks is determined by two factors. The first is the reduction in

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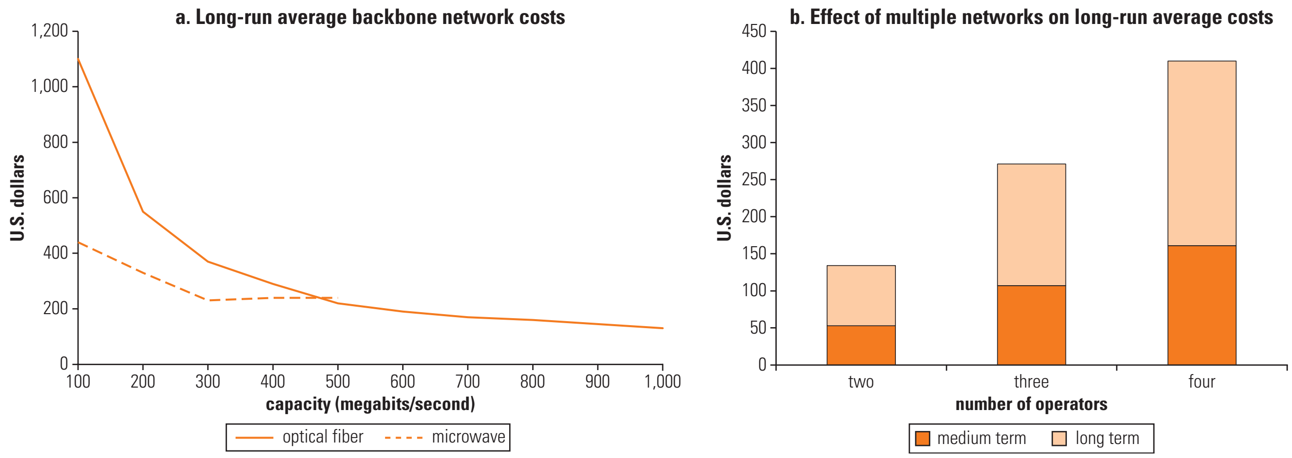
Figure 4.2 **Economic Impact of Backbone Networks**



Source: Ingénieurs Conseil et Economistes Associés 2008.

overall costs that occurs when traffic is channeled through high-capacity networks with lower average costs. The second is the opportunity for smaller players to enter the market by purchasing low-cost backbone network services without having to build their own network. These two factors are interrelated. By aggregating the traffic generated by smaller players onto higher-capacity backbone networks, average costs are reduced.

The Dynamics of Backbone Network Development

This section assesses the backbone network infrastructure in sub-Saharan Africa and describes the dynamics of the markets and regulatory systems that have influenced it. It focuses on three issues: the adequacy of backbone network infrastructure, network ownership, and geographic patterns of network development.

The Adequacy of Backbone Network Infrastructure

Contrary to common assumptions, there is extensive backbone network coverage in sub-Saharan Africa, with about 508,000 kilometers of terrestrial backbone infrastructure (microwave and fiber-optic cables) serving around three-quarters of communications users.[6] The remaining one-quarter of users connect to networks using backbone infrastructure based on satellite links.[7]

About a third of the terrestrial backbone in sub-Saharan Africa is owned by fixed operators, including both formerly and currently state-owned incumbents and new entrants. The other two-thirds of terrestrial backbone infrastructure and almost all satellite-based backbone infrastructure are owned by mobile operators. This setup is the opposite of that in Western Europe and North America, where mobile operators often focus on the wireless access layer of network infrastructure and lease backbone services from fixed network operators (Hanna and Ramarao 2006).

Most backbone infrastructure in sub-Saharan Africa is low-capacity wireless networks. Only 12 percent of terrestrial infrastructure in the region is fiber-optic cable; the rest is microwave. The share of fiber optics is even smaller when satellite-based infrastructure is taken into account.

The mix of wireline and wireless infrastructure varies considerably by type of operator. Among mobile operators in the region, some 99 percent of the length of backbone networks is made up of microwave technology; just 1 percent is fiber. Fixed operators have far more fiber in their networks—about 40 percent. Satellite capacity is generally used for transmission in thinly populated areas, between parts of networks where coverage is not contiguous, and during the early stages of network rollouts. This situation is also the opposite of that in more advanced markets, where fiber-optic backbone networks dominate and wireless technologies are used as backbone infrastructure primarily in remote and inaccessible areas.

Detailed technical information on the capacity of backbone networks in sub-Saharan Africa is confidential. But choices of basic network technology indicate likely capacity limits in the region. As shown in figure 4.2a, for a given length of network, capacity requirements determine the optimal choice of backbone network technology. Microwave networks are the cheapest option for low volumes of traffic, while fiber-optic networks are preferable for higher traffic. Satellites are the cheapest technology for backbone links connecting points that are far apart, but they typically carry low volumes of traffic. Thus, the predominance of wireless technologies—both microwave and satellite—indicates that backbone networks in sub-Saharan Africa are low capacity and generally incapable of carrying the large volumes of traffic generated by mass market broadband connectivity. Most of the backbone network infrastructure in the region was designed to carry voice traffic, which requires much lower bandwidth than the services offered to broadband customers. This is one reason the networks were built mainly using wireless technologies.

The cost structures of different technologies are another reason for the predominance of wireless technologies in the region's backbone networks. Between 60 percent and 80 percent of the costs of fiber-optic networks come from the civil works associated with laying fibers (Hanna and Ramarao 2006). These fixed costs do not vary with the volume of traffic that a network carries. In fact, the only costs in fiber-optic networks affected by capacity are the costs of transmission equipment, which typically account for less than 10 percent of total network costs. The cost structure of wireless backbone networks is very different. A much smaller share of total costs is fixed relative to network capacity, so total costs are more directly affected by the volume of traffic carried. Thus, the initial cost of wireless networks is much lower, while the marginal cost of increasing network capacity is higher. This is an important reason why, in an uncertain market during the early stages of network development, operators are more likely to invest in wireless backbone networks than fiber-optic networks—even if, in retrospect, it might have been cheaper to use fiber in the long run.

A consequence of this preference for wireless networks is that operators are less likely to have excess backbone network capacity than might have been the case had they invested in fiber-optic networks.[8] This has implications for the market in backbone services. Operators that have a fiber backbone network with spare capacity have a strong commercial incentive to sell that capacity and, because its marginal cost is low, competition among operators could be expected to lower prices. By contrast, an operator with a predominantly microwave backbone network is likely to install the amount of capacity that it needs to meet its own requirements. If it were to decide to sell backbone capacity wholesale, additional capacity would have to be installed. Thus, a microwave-based operator has less incentive to enter this market and, if it did, competition with other operators would be less likely to drive down prices as quickly or as far.

Backbone Network Ownership Structure

Telecommunications markets in most countries in sub-Saharan Africa have developed as a series of vertically integrated businesses operating in parallel. Backbone networks are generally part of these vertically integrated businesses, and there is little wholesale trading of backbone services. In addition, there are few examples of joint ventures to build and operate terrestrial backbone networks and there is little sharing of backbone network facilities. This situation stands in contrast to that in countries with more advanced telecommunications markets, where there is extensive vertical disaggregation of networks and network operators can choose to own only certain parts of the network supply chain and buy network components from other operators.

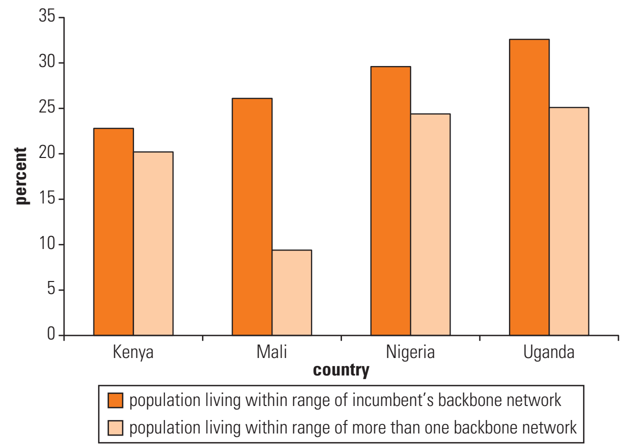
The few sub-Saharan African countries that have encouraged full infrastructure competition at the backbone level provide an instructive contrast to this general assessment of the situation in the region. Kenya and Nigeria, for example, have both allowed carrier networks to enter the market, while Uganda and Zambia have allowed their electricity transmission companies to operate as wholesale backbone network operators.

Regulatory frameworks often help maintain vertically integrated networks and discourage the development of wholesale markets for backbone services. For example, countries such as Burkina Faso have allowed mobile phone operators to build backbone networks to provide services to their retail customers but not to other operators on a wholesale basis. Such restrictions limit opportunities to exploit economies of scale in network infrastructure and reduce incentives to invest in high-capacity backbone networks.

Moreover, some countries—such as Botswana before its recent revision of sector legislation (Ovum 2005)—have given incumbent operators legal monopolies on backbone network services. Such regulations do force the market into vertical separation because competing operators are prevented from building their own backbone networks. But they also prevent the development of a market in backbone network services and so limit overall investment, often resulting in low capacity and poor quality of service.

The development of wholesale markets for backbone services is also constrained by the dynamics of markets in their early stages of development. When operators are competing to roll out networks in a country, they may not have an incentive to provide backbone services to their competitors because doing so could reduce their competitive advantage. In Uganda, the ISP Infocom was unable to negotiate interconnection agreements to use the backbone networks of MTN and UTL, the country's two biggest network operators. Although Infocom does not offer mobile voice services, the offering by data service providers of voice-over-Internet protocol (VoIP) services and the presence of MTN and UTL in the data services market mean that these operators may have considered Infocom a competitor and so could not reach an agreement to sell backbone services. Infocom, however, was ultimately able to reach an agreement to buy capacity on the electricity transmission network, which operates as a wholesale backbone services provider in Uganda.

Figure 4.3 Population Covered by Incumbent and Competing Networks in Four African Countries, 2007



Source: Hamilton 2007.

Geographic Patterns of Backbone Network Infrastructure

Fiber-optic backbone networks in sub-Saharan Africa have mainly been developed in and between major urban areas and on international routes. Fixed operator backbone networks, which account for most high-capacity fiber-optic networks in the region, cover only about a fifth of the population.[9] The focus of backbone network infrastructure in specific parts of the country is further concentrated by infrastructure competition in the few countries with fully liberalized markets. Entrants in these countries have focused their backbone network construction in areas where incumbent operators already have networks. This is illustrated for four sub-Saharan African countries in figure 4.3.

This pattern of network development shares some features with that of countries in other regions. A 2004 review of the U.K. leased line market (the market for capacity on backbone networks) by the regulator, the Office of Communications (Ofcom), found that the backbone market was highly competitive on intra- and interurban routes, particularly for high-bandwidth services. In areas with competition among networks, the former state-owned monopoly operator, BT, retained around three-quarters of the market share for low-bandwidth leased line services (64 kilobits per second to 8 megabits per second) but less than 10 percent of the market for high-bandwidth services (155 megabits per second and faster). In India, market liberalization has resulted in multiple backbone network operators entering the market and competing across the full range of services, but only on a limited set of routes. Reliance, for example, has 67,000 kilometers of fiber-optic network and competes with more than 10 other fixed-line operators, primarily on major interurban routes (TRAI 2006).

The concentration of backbone networks in urban areas and on interurban routes reflects the demand for and cost of providing services. In urban areas, residents have higher incomes and there are more businesses; both of these characteristics generate demand for advanced ICT services—and so there is more demand for backbone network capacity. At the same time, the fixed costs of networks mean that the average cost of providing services to people in urban areas is lower than in rural areas. Thus, there is a strong commercial incentive for networks to focus on urban areas and high-traffic routes between these areas.

There is one significant difference between the geographic pattern of backbone network development in sub-Saharan Africa and that in many other regions. Outside the region, incumbent operators (either currently or formerly state-owned) generally play a key role in providing backbone infrastructure in areas where infrastructure competition is absent. In the United Kingdom, BT is the sole supplier of backbone services in half of the market (Ofcom 2004). In India, despite Reliance's extensive investment in backbone network infrastructure, its fiber-optic network is still only 15 percent of the length of the incumbent operator's, which is more than 450,000 kilometers long. Such situations are not the case in most sub-Saharan African countries, where incumbent operators often have limited network coverage and do not provide backbone services of sufficient quality or affordability. Thus, these operators are not in a position to develop backbone network infrastructure in less profitable areas and be the "backbone provider of last resort."

Cross-border connectivity is another emerging feature of the geographic pattern of backbone infrastructure development in sub-Saharan Africa. Many communications networks in the region traditionally evolved as stand-alone networks without direct cross-border interconnection. Most international traffic has been carried by satellite, even where the destination was a neighboring country. But recently, cross-border terrestrial backbone infrastructure has started to develop. For example, fiber-optic networks on both sides of the Kenya-Uganda border are interconnected, and a link is being built across the Rwanda-Uganda border. Similar cross-border connections are being constructed across the region. Extensive cross-border connectivity is also occurring across Western Europe, where many pan-European networks connecting major urban areas have emerged since market liberalization.

Commercial factors are helping drive this emergence of cross-border connectivity in sub-Saharan Africa. First, a lot of international communications traffic is intraregional, since personal and business links are often within a region. One market response to this has been the development of retail packages in which customers pay local call charges when roaming within the region (Global Insight 2006). Such offers are likely to stimulate intraregional traffic, strengthening operators' incentives to interconnect their networks.

Second, demand for the Internet is becoming a major driver of network development. Most Internet traffic generated by sub-Saharan African customers is international because most content is hosted outside the region. Operators can route this traffic between countries where they operate to exploit economies of scale in international gateways. This effect will increase significantly when international submarine fiber-optic connectivity improves in the region. Such cables land at specific locations along the coast, and all traffic carried on them must be routed through these locations. Thus, operators in landlocked countries wishing to use submarine fiber-optic cables need regional connectivity to access them. Even operators in countries with direct access to such cables may wish to develop regional backbone networks to provide access to alternative locations for the cables as backup. Cross-border connectivity will become more profitable as broadband expands in the region and the data traffic carried by submarine fiber-optic cables grows. Thus, cross-border backbone network development will likely continue to develop.

Policies to Improve the Development of Backbone Networks

Sub-Saharan Africa has widespread but low-capacity backbone networks operating in parallel. Higher-capacity fiber-optic networks are concentrated in urban areas, between cities and, increasingly, on cross-border routes. These patterns have emerged because operators initially designed their networks to carry voice traffic, which requires lower-capacity backbone networks. Where high-capacity networks have been built, they have focused on the most profitable and populated areas. In addition, regulatory restrictions on infrastructure competition have often limited the development of high-capacity backbone networks, as have the considerable political and commercial risks associated with investing in fixed wireline infrastructure in the region.

Policy makers face two main challenges in developing backbone network infrastructure. The first is establishing and encouraging competitive markets in backbone infrastructure. The second is providing some form of financial support to encourage the development of high-capacity networks in commercially unattractive areas. Addressing these challenges will require a twin-track approach:

- Create an enabling environment for competition in infrastructure and services by fully liberalizing markets to encourage infrastructure competition and allow aggregation of traffic onto higher-capacity networks.
- Stimulate rollout in underserved areas, especially rural areas and small towns.[10]

Several policy options can be used to tackle these issues. These are summarized in table 4.1 and explained in more detail in the sections that follow.

Table 4.1 Policy Options for Expanding Backbone Networks

Create an enabling environment for competition in infrastructure and services	Stimulate rollout in underserved areas
Remove regulatory obstacles to investment and competition	**Share infrastructure**
Remove limits on the number of network licenses Encourage the entry of alternative infrastructure providers Remove constraints on the market for backbone services Improve regulation of backbone networks	Give operators incentives to cooperate in developing backbone infrastructure in areas where infrastructure competition is not commercially viable
Reduce investment costs	**Provide competitive subsidies**
Facilitate access to passive infrastructure Promote infrastructure sharing	Give operators subsidies to build and operate backbone networks in underserved areas, with services provided on a nondiscriminatory basis
Reduce political and commercial risks	**Reduce taxes and levies**
Provide risk guarantees and political risk insurance Aggregate demand	Give operators incentives to build networks in underserved areas by lowering sector levies or contributions to universal service funds
Promote competition in the downstream market	
Promote downstream competition through effective regulation	

Source: Author.

Create an Enabling Environment for Competition in Infrastructure and Services

Many sub-Saharan African countries do not provide incentives for private investment and competition in backbone networks—and, in some cases, discourage or obstruct it. Promoting private investment and competition among backbone networks allows market forces to aggregate traffic onto higher-capacity networks, lowering costs and stimulating downstream investment and competition among ISPs and other providers. Several policy initiatives are needed to create an enabling environment for infrastructure competition; they fall into four groups.

1. Remove regulatory obstacles to investment and competition

Remove limits on the number of network licenses. Many sub-Saharan African countries that have nominally liberalized their network markets still have formal or informal limits on the number of licenses that they issue (World Bank 2008). There is little economic justification for such limits.

Encourage the entry of alternative infrastructure providers in the backbone network market. Electricity transmission networks, oil and gas pipelines, and railway networks can provide major cost advantages in the development of fiber-optic backbone networks. By encouraging these (usually state-owned) networks to establish operating companies that run fiber-optic assets and by licensing them, countries can bring them into the telecommunications market as providers of backbone capacity. This practice has been successful in other regions (box 4.1) and in sub-Saharan African countries such as Uganda and Zambia (though not in others, such as Ghana).

Lift constraints on the market for backbone services. Many sub-Saharan African countries impose constraints on operators with backbone networks and those that use them. These constraints include restrictions on the sale of network services and requirements to buy backbone network services from specific operators—usually state-owned incumbent operators. Removing these restrictions would allow operators to buy and sell backbone services to and from whatever operator they wished. Such an environment would consolidate traffic, providing an incentive to upgrade backbone networks to fiber-optic technology and so lowering average costs.

Improve regulation of backbone networks. Difficulties in enforcing contracts and service agreements have been a major constraint to the development of markets for backbone network services. In the short term, the ability to enforce legal contracts in commercial courts is unlikely to improve much in most sub-Saharan African countries. Still, regulators can improve the situation by establishing clear regulations on interconnection and access to backbone networks, amending licenses (if necessary) to increase the enforceability of such rules, establishing effective quality controls and clear procedures for resolving disputes, collecting accurate data

Box 4.1 Alternative Infrastructure Providers in Morocco

Morocco has three main backbone network operators: the incumbent Maroc Telecom, Meditel (a major mobile phone provider), and Maroc Connect (an Internet service provider recently awarded a general telecommunications license). In 2005, Meditel was given a license to develop a fixed-line network (including backbone) and Maroc Connect was given a global network and service license. However, rather than building full backbone networks, both operators obtain some backbone network capacity from two alternative infrastructure operators: the Office National des Chemins de Fer (the national railway carrier, which has a nationwide backbone network infrastructure of about 1,100 kilometers) and the Office National d'Electricité (the national power company, which has a nationwide infrastructure of aerial fibers of about 4,000 kilometers). In addition, a company called Marais entered the Moroccan backbone network market in 2007. The market liberalization and the presence of alternative network operators have allowed the new entrants to decide whether to build their own backbone networks or purchase backbone services from other operators. The entry of Marais into the backbone network market indicates that there is further scope for network development and competition.

Source: Ingénieurs Conseil et Economistes Associés 2008.

on service quality, and sharing knowledge and experiences with regulators from other countries. Regional approaches to regulating backbone network infrastructure, through participating in regional organizations, may also provide a way of improving the quality of regulation.

2. Reduce investment costs

Facilitate access to passive infrastructure. Civil works account for most of the cost of constructing fiber-optic cable networks (Hanna and Ramarao 2006). These major fixed and sunk costs increase the risks for network investors. By lowering these costs and the associated risks, governments can significantly increase incentives for private investment. Such changes can be made in a number of ways—for example, by providing open access to existing infrastructure and including passive communications infrastructure in the design of other forms of public infrastructure (such as roads, railways, and electricity transmission lines; box 4.2).

Promote infrastructure sharing where it does not undermine competition. By sharing backbone network infrastructure, builders of backbone networks can reduce costs and so make such investments more commercially viable. This is particularly relevant for fiber-optic networks in urban areas, where the costs of laying new fibers can be high, or in rural areas, where the revenues generated by such networks are low. However, caution may be needed in taking this approach. Infrastructure sharing arrangements are hard to enforce if the parties involved are not willing to do them on a commercial basis. Moreover, the sharing of facilities may help sustain collusive arrangements between competing operators (box 4.3).

3. Reduce political and commercial risks

Cut political and regulatory risks through risk guarantees and insurance. In uncertain political and regulatory environments, operators are likely to favor investments in scalable wireless networks instead of fiber-optic networks (which have high fixed, sunk costs). This uncertainty limits the extent to which operators are willing to invest in high-capacity infrastructure that could then be used to consolidate traffic and reduce average costs. These risks can be reduced by building confidence in the regulatory process, and mitigated by using instruments such as partial risk guarantees and political risk insurance (World Bank 2002).

Reduce commercial risk by aggregating demand. Governments can lower commercial risks and transactions costs for operators by acting as a central purchaser of services on behalf of all public institutions—including those at lower levels of government (such as schools, health centers, and local governments; box 4.4). But while there are potential advantages to this approach of demand aggregation, companies in sub-Saharan Africa often have a hard time

Box 4.2 Spain's Provision of Passive Infrastructure for Fiber-Optic Networks

In 2003, the government of Spain passed legislation requiring that the design and construction of new buildings include common communications passive infrastructure in elements such as ducting, building risers, and access points. Building managers are required to make this infrastructure available to any operator seeking to provide household access to fiber-optic networks.

This law directly affects the establishment of household access to fiber-optic networks and the construction of privately developed buildings. The same principle can be applied to the development of backbone networks in public infrastructure such as roads and railways.

Source: Ministerio de Ciencia y Tecnología 2003.

Box 4.3 Sharing Network Infrastructure in Uganda

Uganda's telecommunications market has five mobile operators and several Internet service providers. MTN and UTL are the two national wireline operators and are also significant mobile operators. Both companies also have operations in Rwanda. Thus, they have a common interest in establishing a communications link across the border from Uganda to Rwanda. In 2007, MTN constructed a fiber-optic cable from Kigali, Rwanda, to the border with Uganda. The company also recently announced a deal with its competitor UTL to jointly develop the fiber-optic network on the Uganda side—a good example of competing operators forming a cooperative arrangement to lower the costs of developing fiber-optic networks outside major urban areas. However, such an arrangement raises concerns for the market in Rwanda since the only fiber-optic connection to the country will be jointly controlled by the only two network operators in Rwanda. Such concerns may ease as more licenses are issued in Rwanda and competition develops.

Source: Author.

collecting revenues from public institutions, even for utility services such as water and electricity. Thus, an issue to consider for this policy approach is the extent to which the credit risk associated with the public sector as a customer offsets the commercial advantages of the bulk purchase of backbone services. This credit risk can be reduced by using prepayment and escrow mechanisms.

4. Promote competition in downstream markets

Promote competition among downstream network operators and service providers. Network operators and service providers wishing to enter downstream markets—that is, those interested in building access networks and offering services to customers—will need either to build their own backbone networks or to access those of other companies. Governments can stimulate the development of backbone networks by promoting downstream competition and ensuring that operators have access to upstream backbone network infrastructure.

Stimulate Rollout in Underserved Areas

Incumbent operators in sub-Saharan Africa have found it difficult to build and operate backbone networks that meet the needs of the market. Relying on these operators to provide backbone networks outside the main urban areas—a model that has been adopted in other regions—would be difficult to replicate in sub-Saharan Africa. Instead, a partnership with the private sector is more likely to ensure that networks are built and operated efficiently. Three types of such partnerships are discussed here: shared infrastructure, competitive subsidies, and other incentive-based private sector models. While other models

Box 4.4 Developing Infrastructure by Aggregating Demand in the Republic of Korea

Korea's government provided financing to develop the country's broadband infrastructure in the form of a prepayment for the future provision of broadband services to public institutions. Between 1995 and 1997, the government provided $200 million toward the $2.2 billion cost of building a fiber-optic network. The remainder of the funding was provided by the private sector, mainly Korea Telecom. The second phase, between 1998 and 2000, focused on the access network, for which the government contributed $300 million of a total investment of $7.3 billion. The final phase, between 2001 and 2005, involved upgrading the entire network, and the government contributed $400 million of a total investment of $24 billion. In exchange for these upfront payments, operators were required to provide broadband services to public institutions over an extended period. Thus, the government's financing can be thought of as prepayment for services that, although representing only a small portion of total investment costs, provided the private sector with sufficient incentive to develop the networks and contribute their own resources. This initiative was undertaken in the context of an overall policy of promoting broadband that included full market liberalization.

Source: Author.

are available, these three basic models are representative of the broad scope of policy options, with their respective advantages and disadvantages. Hybrids of the models discussed here are also possible.

1. Shared infrastructure model

Under a shared infrastructure approach, existing private operators would form a consortium to build and operate backbone networks in underserved areas. The government would provide public resources to ensure that the network meets public policy goals such as focusing investment on underserved areas, achieving cost-oriented wholesale prices, and ensuring nondiscrimination between buyers of services. This regulatory protection can be written into the consortium structure through the leverage obtained by public support for the investment. But these policy goals run counter to the commercial interests of the consortium members who would benefit from charging above-cost prices and discrimination against users that are not consortium members. Thus, such an arrangement would require ongoing regulatory oversight.

The *advantages* of the shared infrastructure model are the following:

- The backbone network would be built and operated by private companies that already operate facilities in the country and so have experience likely to improve the chances of their success in operating the network.
- The operators would partially finance the network, reducing the cost to the government and ensuring that the operators have a financial stake in its success.
- The companies operating the network would also be its main customers, giving them an incentive to ensure that it is run efficiently and effectively.

The *disadvantages* are the following:

- A consortium in an otherwise competitive market could allow operators to collude and reduce competition.
- Any consortium is unlikely to include all players in the market, particularly as the market develops and new companies enter. Thus, members of the consortium have an incentive to raise prices and discriminate against nonmembers.
- Because this model does not have a competitive bidding process, it is difficult to assess the level of subsidy required for the network.

The shared infrastructure model has been used to develop the Eastern Africa Submarine Cable System (EASSy), a submarine cable project established by a consortium of operators from the region and partially financed by a group of international financial institutions. The involvement of the international financial institutions was used to establish an open access model to ensure that access to the cable is available to all operators in the region, regardless of whether they are members of the consortium (box 4.5).

2. Competitive subsidy model

A competitive subsidy approach uses a competitive process to award a license to build and operate a backbone network based on government specifications. The government provides resources to the licensee through in-kind or cash payments. The contract specifies the terms under which backbone network services are provided, including the type, quality, and price. These are key aspects of the contractual design because they determine the network's impact on downstream users and have a major impact on how much investors are willing to pay to obtain a license.

This model has a number of variations, based on the ownership structure of the network. At one end of the spectrum of options is a network entirely owned by a private company that receives a government subsidy to build a network that meets the government's policy goals. At the other end is one where the public and private sectors are joint owners of the backbone network. In all cases, the contract to build and operate the network, as well as the associated license, is awarded competitively through a minimum-subsidy auction (Wellenius, Foster, and Malmberg-Calvo 2004).

The *advantages* of the competitive subsidy model are the following:

- The government achieves its goals while leveraging the private sector's skills, expertise, and investment resources.
- The private operator has a commercial interest in operating the network as efficiently and effectively as possible.
- This approach is simpler than the consortium approach because fewer parties are involved. If it does not succeed initially, there is recourse to alternative operators or alternative models.
- Similar approaches have been used to promote the rollout of rural access networks in sub-Saharan Africa. There is also relevant experience with similar structures from other sectors that could provide useful benchmarks.

The *disadvantages* are the following:

- Government support to specific operators may undermine competition.
- It can be difficult to obtain accurate information on the performance of licensees and to impose penalties for failure to deliver.

Box 4.5 A Shared Model for Backbone Infrastructure Development in East Africa

EASSy is a submarine fiber-optic cable from South Africa to Sudan, with connections to 10 countries along its route. The system's termination points will connect to the global communications network. The project has been developed by a consortium of more than 20 telecommunications operators, mostly from East and Southern Africa, with support from the International Finance Corporation, European Investment Bank, African Development Bank, Agence Française de Développement, and Kreditanstalt für Wiederaufbau.

The system has been designed to minimize the problems associated with the absence of effective competition and regulation. This is done through a special purpose vehicle that is a member of the consortium and owned by a group of smaller operators from the region. This special purpose vehicle is allowed to sell network capacity in any market in the region on an open-access, nondiscriminatory basis—providing competition to other members of the consortium. The agreements that established the special purpose vehicle require it to pass through to customers any cost savings arising from increased traffic volumes. These mechanisms for competition and pass-through of cost reductions are intended to lower prices and increase access.

Source: Author.

- If the backbone operator has any financial connection to downstream operators, it will have an incentive to discriminate in favor of them.
- It can be politically difficult to justify large public subsidies to private companies in which the government does not maintain an equity stake.

France provides an example of this type of public-private partnership used to develop backbone infrastructure (box 4.6).

3. Other incentive-based private sector models

All countries require operators to pay taxes and levies that typically consist of general taxes—applicable to all companies in the economy—and sector-specific taxes or levies. One common levy is a contribution to universal service or access funds. Such contributions are usually calculated as a percentage of revenues and are collected annually from operators. In most cases, these funds are intended to be used to subsidize access to services in rural areas. But in many countries they are not used effectively, often remaining undisbursed by the government and sometimes diverted for other uses.

Governments can give operators an incentive to develop backbone networks in commercially unattractive areas by offering to reduce these levies in exchange for the operators meeting specific targets. This can be done on a competitive basis—a limited number of companies are awarded the levy reduction and they have to compete for it, or it could be available to all. Such "pay-or-play" schemes are not common in the telecommunications sector but have recently been receiving increasing attention (box 4.7).

The *advantages* of other incentive-based private sector models are the following:

- Private companies own and operate the networks, increasing the likelihood that they will be managed efficiently and effectively.
- The government can specify the type of network that it requires and the terms on which services are sold.
- No cash changes hands between operators and the government.
- Government retains the option of penalizing any failure to meet obligations by removing the financial incentive (that is, making them pay, instead of play).

The *disadvantages* are the following:

- Any network built under such a scheme would be privately owned by operators competing in the market, and these operators would have strong incentives to discriminate against competitors. Thus, this option would require strong monitoring and regulation.

Box 4.6 A Public-Private Partnership for Backbone Infrastructure in France

Limousin is a rural region in central France with limited broadband services. To raise access to urban levels, the government launched the DORSAL project to develop a backbone network capable of delivering access to high-speed Internet. The project is structured as a public-private partnership with a 20-year concession to build and operate a backbone network and to construct a broadband wireless network using worldwide interoperability for microwave access (WiMAX) technology and capable of supporting high-speed, value added services. The project will cost 85 million euros, split between the public (45 percent) and private (55 percent) sectors. The fiber-optic backbone network was completed in mid-2007 and downstream competition has developed. Customers in the project area now have access to third-party service providers offering a wide range of broadband services, such as Internet protocol television (IPTV), voice-over-Internet protocol (VoIP), and high-speed data services, in competition with France Telecom.

Source: Ingénieurs Conseil et Economistes Associés 2008.

Box 4.7 Sweden's Incentive-Based Mechanisms for Developing Backbone Networks

Since it launched its first broadband policy in 1999, the Swedish government has provided subsidies for broadband rollout through several programs, including tax incentives for operators building networks in rural areas and grants to municipalities to build fiber-optic networks. The total value of these subsidies is an estimated $820 million. This policy has been quite successful and a government survey in 2007 found that, taking into account both wireless and wireline access, Sweden was coming close to 100 percent coverage of broadband. However, a government-appointed committee in 2008 determined that 145,000 people and 39,000 businesses still did not have access to wireline broadband (i.e., fiber, DSL, or cable) and recommended that government spend another $500 million on grants to municipalities and operators to invest in high-speed networks.

The financial incentives for infrastructure development provided by the government have been part of an overall package of policy measures used to promote broadband that includes stimulating competition, subsidizing network rollout in high-cost areas, encouraging municipalities to develop operator-neutral backbone networks, and promoting the use of state-owned businesses to develop fiber-optic infrastructure.

Source: Atkinson, Correa, and Hedlund. 2008.

- Pay-or-play schemes may sometimes limit competition in a particular area since the winner will be operating with a government subsidy.
- It can sometimes be difficult to ascertain precisely the amount of financial support that the government is implicitly giving operators through a pay-or-play scheme.

Conclusion

As the pace of broadband development accelerates globally and economies adapt to better and more widespread connectivity, the importance of broadband connectivity will continue to grow. Thus, the widening gap between sub-Saharan Africa and other developing countries is a major policy issue for many countries in the region. Most incumbent operators in sub-Saharan African countries are not strong enough to be an effective backbone network of last resort. Thus, the model of market liberalization and regulation of access to the incumbent's network—which has been successful in the European Union, North America, and increasingly in Asia and Latin America—is not directly relevant in the region. The main challenges facing policy makers in the region are ensuring that entrants have access to existing infrastructure developed by private operators and that networks are built in areas where commercial operators are not currently willing to invest. Both objectives have to be achieved without discouraging the private sector from investing in network infrastructure.

This chapter has outlined a market-based approach to policy for the development of backbone networks in sub-Saharan Africa. This approach harnesses both the investment resources and operational expertise of the private sector to help meet public policy goals, reducing financial and operational burdens on the public sector. It also builds on the model of infrastructure competition that has been very successful in other segments of the communications market in sub-Saharan Africa. Thus this chapter is consistent with the general approach to ICT that has been adopted in most countries in the region.

Still, the detailed design and implementation of the public-private partnership models discussed here will require innovation by governments and regulators in the region. There are few clear, off-the-shelf examples from other parts of the world that can be directly transposed into the sub-Saharan African context. But this dearth of ready-made examples can be considered an opportunity rather than a problem. It provides policy makers with an opportunity to tailor policy solutions suited to their specific challenges.

Notes

1. Definitions of broadband vary, and no single definition is universally accepted. This chapter defines broadband as an Internet connection that is always on and provides a download speed of at least 256 kilobits per second.
2. Population-weighted average price of cheapest broadband package. World Bank staff calculations based on data from ITU (2007).
3. India's regulatory authority reported that the average cost of broadband was $12–$18 a month (assuming usage of three hours a day; TRAI 2006).
4. Simple average of monthly subscription prices in U.S. dollars in all OECD countries as of October 2007.
5. This estimate is based on discussions with operators.
6. This figure for terrestrial infrastructure is an underestimate because data were not available for some operators. In addition, the data in this section are for 47 sub-Saharan African countries but exclude South Africa because its backbone network infrastructure is highly developed and unrepresentative of countries in the region.
7. The key metrics used to measure the adequacy of terrestrial backbone network infrastructure are length (in kilometers) and capacity (in megabits per second). Satellite links are also measured in terms of capacity, but the distance between two nodes on the network is irrelevant.
8. This is changing, however. The commercial success of mobile operators in sub-Saharan Africa, increases in traffic arising from a growing customer base, and a shift in strategy toward more data services have led more operators to consider investing in fiber-optic networks that once were considered too financially risky.
9. Defined as the population living within 10 kilometers of a backbone network node.
10. This approach to backbone policy is analogous to the standard approach for analyzing telecommunications access in rural areas, where policies are designed to narrow two "gaps"—the market efficiency gap and the market access gap. The first gap is addressed by improving the functioning of the market; the second requires external financial support.

References

Atkinson, Robert D., Daniel K. Correa, and Julie A. Hedlund. 2008. "Explaining International Broadband Leadership." ITIF (Information Technology and Innovation Foundation), Washington, DC. http://www.itif.org/files/ExplainingBBLeadership.pdf.

Balancing Act. 2007. *Balancing Act News Update*, Issue 374. http://www.balancingact-africa.com/news/back/balancing-act_374.html.

Global Insight. 2006. "Sub-Saharan Africa: Celtel Launches 'One Network' in East Africa."

———. 2007. "The Shifting Geography of Broadband in Sub-Saharan Africa."

Government of Rwanda. 2006. "An Integrated ICT-Led Socio-Economic Development Plan for Rwanda 2006–2010. The NICI-2010 Plan." Kigali.

Goyal, Aparajita. 2008 "Information Technology and Rural Markets: Theory and Evidence from a Unique Intervention in Central India" Working paper. University of Maryland, College Park, MD.

Hamilton, Paul. 2007. "Analysis of the Extent of Development of Transmission Backbone Networks in Sub-Saharan Africa." Study commissioned by World Bank, Washington, DC.

Hanna, Milad, and Balaji Ramarao. 2006. "Cost Optimization for Transmission and Backhaul Technologies." Accenture. http://www.accenture.com/NR/rdonlyres/0000aae5/nwhotfp-pdswdgywuynxzagosezkmkgtr/acs_cost_opt_pov.pdf.

Ingénieurs Conseil et Economistes Associés (ICEA). 2008. "Strategies for the Promotion of Backbone Communications Networks in Sub-Saharan Africa." Study commissioned by World Bank, Washington, DC.

ITU (International Telecommunication Union). 2007. "Telecommunications/ICT Markets and Trends in Africa 2007." Geneva. http://www.itu.int/ITU-D/ict/statistics/material/af_report07.pdf.

Jensen, Robert. 2007. "The Digital Provide: Information (Technology), Market Performance and Welfare in the South Indian Fisheries Sector." *The Quarterly Journal of Economics* 122(3): 879–924.

Ministerio de Ciencia y Tecnología. 2003. "Por el que se aprueba el reglamento regulador de las infraestructuras comunes de telecomunicaciones para el acceso a los servicios de telecomunicación en el interior de los edificios y de la actividad de instalación de equipos y sistemas de telecomunicaciones." Madrid.

OECD (Organisation for Economic Co-operation and Development). 2006. "Internet Traffic Exchange: Market Developments and Measurement of Growth." Paris. http://www.oecd.org/dataoecd/25/54/36462170.pdf.

———. 2007. *OECD Broadband Portal.* Paris. http://www.oecd.org/ sti/ict/broadband.

Ofcom (Office of Communications). 2004. "Review of the Retail Leased Lines, Symmetric Broadband Origination and Wholesale Trunk Segments Markets." London.

Ovum. 2005. "Recommendations on Further Liberalization of the Telecommunications Industry of Botswana: A Final Report to the Botswana Telecommunications Authority." London.

Roller, Lars-Hendrik, and Leonard Waverman. 2001. "Telecommunications Infrastructure and Economic Development: A Simultaneous Approach." *The American Economic Review* 91 (4): 909–23.

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Telegeography. 2008. *Global Internet Geography.* http://www.telegeography.com/products/gig/.

TRAI (Telecom Regulatory Authority of India). 2006. "Study Paper on Analysis of Internet and Broadband Tariffs in India." Delhi.

Wellenius, Björn, Vivien Foster, and Christina Malmberg-Calvo. 2004. "Private Provision of Rural Infrastructure Services: Competing for Subsidies." Policy Research Working Paper 3365, World Bank, Washington, DC.

World Bank. 2002. "The World Bank Guarantee: Leveraging Private Finance for Emerging Markets." Project Finance and Guarantees Department Washington, DC.

———. 2008. *Africa Infrastructure Country Diagnostic for Sub-Saharan Africa, 2008.* Washington, DC.

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