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# Reducing One Aspect of the Digital Divide – Connectivity

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Discussion Note (*draft*)

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***(Introducing the FiberAfrica Proposal – a Leapfrog Open Access Network)***[1]

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*This note is based on discussions with and a vision by several colleagues, notably Prof. Raj Reddy and Prof. V. S. Arunachalam, at Carnegie Mellon, and interactions with numerous other professionals, including those affiliated to the World Bank and the UN ICT Task Force. There are many assumptions made in this note that are not shown,[4] and no claim is made for the optimality or universality of the solutions or ideas. Nonetheless, the* FiberAfrica *proposal is an attempt that has been thought through at many levels by a number of professionals, and we hope that decision-makers will at the very least engage in a serious dialogue over proposals such as this one.*

The digital divide, however defined, is a stark divide and a challenge for development and technology professionals. Many groups and governments have recognized this, and the UN devoted a global conference on this issue, the World Summit on the Information Society.[5] It is actually a manifestation of other underlying divides, spanning economic, social, geographic, gender, and other divides.[6] This note focuses on connectivity for developing countries, especially Africa, even though there are divides within developed countries. Here, we introduce several ideas—some of which have also been postulated in variants by others—for how to end much of the digital divide (at least the connectivity aspect). In particular, we present a proposal, dubbed FiberAfrica, to bring affordable and sustainable broadband to Africa [details on FiberAfrica begin on page 13]. We show how for just about $1/person one-time capital costs, the majority of Africans could avail of (virtually) free data connectivity within walking or cycling distance.[7]

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[2] Dr. Tongia and his colleagues have more than an academic interest in connectivity, having been involved with the policy, design, and deregulation of telecom/ICT networks for many years, especially in India (e.g., Andhra Pradesh).

[3] A non-profit R&D center under incorporation in India.

[4] This note is not a business plan, and one shouldn't jump into building any such network. Rather, it is meant to promote open discussions on policy and design. For readability sake, academic levels of theory, details, referencing, and assumptions are not shown, even though many detailed calculations have, in fact, been done. This note is terse given each sub-topic deserves its own dissertation.

[5] The cover story of the March 10, 2005 issue of *The Economist* is titled: "The Real Digital Divide." This report emphasizes mobile telephony as the best means of bridging the divide, and how competition and regulatory liberalization are key for growth. As discussed later on (in section (2)b)(3)), mobile networks are important but should be viewed as complementary, not competitive.

[6] *Sustainable ICT for Emerging Economies: Mythology and Reality of the Digital Divide Problem – A Discussion Note (*2004). Raj Reddy, V. S. Arunachalam, Rahul Tongia, Eswaran Subrahmanian, and N. Balakrishnan.

[7] This excludes end-user equipment such as computers or wireless modems, which would be a distributed cost that scales with usage.

However, this leapfrog network requires a rethink in how networks are built, owned, operated, and utilized.

While any interventions or new technologies/networks will not end all facets of the digital divide, they would be a step in the right direction. However, bringing equality, even if just to information access, will remain a long-term task, not achievable quickly even with all the money and effort of all the nations in the world.

1) ***Access is a fundamental requirement.*** If we consider the desired end-goals of empowerment and opportunities, access leads to information, which can lead to knowledge, leading to empowerment and opportunities. Of course, it is not linear, and one requires complementary capabilities, especially to interpret information into usable knowledge.

   Access >>> Information >>> Knowledge >>> Opportunities and Empowerment

   If we consider the digital divide, it can be at four levels: Awareness, Availability, Accessibility, and Affordability.

   a) *Awareness*– People must know what can be done with ICT (information and communications technology); they must also be open to using ICT
   b) *Availability* – ICT must be offered within reasonable proximity, with appropriate hardware/software
   c) *Accessibility* – relates to the *ability* to use the ICT (spanning literacy, e-literacy, language, interfaces, etc.)
   d) *Affordability* – All ICT usage together should, ideally, be only a few percent of one's income (under 10% maximum); this involves life-cycle costs (total costs of ownership—TCO), spanning hardware, software, connectivity, education, etc.

   Reducing the divide requires improvements across all the dimensions of ICT [dubbed the 4C Framework]: Computing, Connectivity, Content, and (human) Capacity.

   a) *Computing* – PCs are prohibitively expensive for most people, and shared access (e.g., community centers or cybercafes) becomes inevitable. PCs today are very difficult to use, and even "experts" spend a lot of time maintaining their machines, worrying about upgrades, security, compatibility of hardware, etc. As a complementary technology, non-PC devices are an important option, e.g., mobile phones.
   b) *Connectivity* – While mobile telephony is improving worldwide (witness in Africa it is now twice the number of landlines), it remains expensive, limited in rural areas, and poor at providing data connectivity.
   c) *Content* – Meaningful content is lacking in many languages, and most content is not locally relevant. Today's systems tend to make people passive consumers of information, instead of enabling generation of local information. In addition, rich content demands multimedia (useful to overcome literacy issues), which, in turn, requires broadband connectivity.
   d) (human) *Capacity* – Users need to be aware, literate, and innovative to hardness the power of ICT. They also should be empowered to use ICT, societally and governmentally.

   Of course, ICT usage does not occur within a vacuum, rather within social and cultural norms that also shape the divide. In addition, ICT usage is based on policy and business models, especially regulation. In the long run, ICT must provide value and be sustainable from both a user and a provider perspective.

2) **Choosing the right technologies and design: don't look backwards or sideways – look forwards.** Choosing technologies based on what we or others have done or are doing now won't necessarily help us when we want to build an infrastructure that will last us decades

(though the electronics will, of course, be upgraded). An additional challenge is that technology is changing continually. Any solution should include modularity, flexibility, and upgradability, and it doesn't add too much to the costs (especially on a life-cycle basis) if these features are part of the design from the start. An example of a failure is how some digital transmission (broadcast) technologies are hard-wired to only use one particular encoding scheme, even though future compression technologies will clearly be superior.

If we accept digital information and content as the norm for ICT (though analog is still important, especially for TV and radio), then we first have to recognize virtually all services are just bits. The differences lie in their size (bandwidth), flow (patterns/directionality), and quality of service requirements. The so-called triple-play of services (voice, video, and data) is the holy grail for many operators, with attendant improvements in revenues and reduced churn of customers even in the face of customers.

Too often, network designers do not think ahead when they are designing networks, especially greenfield developments. They cite a chicken-and-egg problem. They don't have many users for "high-end" (e.g., broadband) services, and thus they offer such services as a niche or limited-deployment service. For these, tariffs are quite high. But that leads to low demand! They build networks that don't utilize fiber (enough)—despite fiber being cheaper than copper for most greenfield deployments—and they also choose lower-speed and/or circuit-switched technologies for where robust high-speed IP (Internet Protocol) optimized networks would be more cost-effective.

Of course, connectivity is only one component of ICT systems, and the challenge is making ICT integrated into daily economic and personal life, and easy and robust for widespread use. Another issue is that the digital divide is really a moving target. When we offer people connectivity through a telephone, they then need Internet Access. Then, over time, the divide becomes between those who do and don't have broadband. This is certainly the case with rural America. Even addresses these issues, it then becomes a question of who has access to what *content* and who has what *skills*. The question we have to ask is can we design the technology such that we aren't faced with new and recurring sets of new divides?

a) *Nothing competes with fiber (ultimately).* The total bandwidth that fiber has is greater than all competing technologies. It is already the norm within the backbone and core of networks, and it is a matter of time before it becomes used for "last mile access" as well. The primary reason it has not yet been used more is cost, especially labor. If developing countries have inexpensive labor, they should harness it for installing fiber, especially in sub-ducted conduits. The US cites installation costs in the ten thousand dollar per km range (excluding rights of way) for "easy" unpopulated areas, and an order of magnitude higher for urban areas. We know, from experience, that it can be done for much lower. In India, inter-city and rural fiber is now being drawn and installed for on the order of $1,000/km or less. The capital cost of fiber itself is falling rapidly, and can be on the same order for dozens of strands of fiber.[8]

   One concept we propose is Fiber to the Village (FTTV). We don't necessarily need fiber to all the homes, but getting it close enough to population centers (a village or cluster of villages) would allow the use of inexpensive, off-the-shelf wireless technologies to provide high-speed data connectivity. In addition, wireless technologies can also be used at a district level, with two-tiers of wireless (one to the core fiber backbone, and another for local distribution) [FiberAfrica is one such model].

[8] These are actual numbers from Indian fiber manufacturers and network deployers; the figures quoted by leading global fiber suppliers will be higher.

b) *Wireless makes a lot of sense for low density access.* Wireless is inherently shared, and it has sufficient bandwidth for voice and data (though not necessarily video). When people think wireless broadband, they think of WiFi, which works well in some cases, but is not optimized for wide-area networking. An alternative upcoming technology based on similarly open standards is dubbed WiMax, and it might help significantly. In reality, WiMax is just one of several possible technologies for broadband wireless access

(1) *Wireless broadband technologies need truth in advertising*, else we will have a lot of hype and false expectations. A wireless technology may claim "Upto 70 Mbps and 50 km range." Well, I can run upto 20 miles per hour, and lift 70 kilos. But not at the same time! Wireless technologies as advertised are based on a number of assumptions, such as power levels, channel sizes (frequency bandwidth), line of sight, etc. The curvature of the earth itself dictates that 50 km propagation requires towers (or elevation) in the hundreds of feet.

(2) *The good news is that wireless technologies are still improving*, with better ability to filter out interference and noise. Innovations such as mesh networking, smart array antennae (Multiple Input, Multiple Output, or MIMO), and software defined radios (or, ultimately, cognitive radios) will truly provide us with almost all the bandwidth we need at very low prices. The question, of course, is when. In addition, will regulators allow such innovations to flourish? E.g., current regulations don't allow reuse or sharing of spectrum, even though most spectrum is under- or un-used.

(3) *Mobile wireless is complementary, not necessarily in competition.* Mobile telephony is doing very well, and helping human development across the developing world. But it doesn't have the capabilities of broadband. Most developing countries don't need the mobility for data access. In fact, mobility implies small devices, which hamper usability. Rather, data connectivity could be achieved as fixed wireless, or portable. Estimates indicate that a large fraction of mobile network costs are for the "soft handoffs" required between base stations, a cost that could be avoided for fixed or portable wireless [and fixed would be more capable and cheaper than portable]. While people advocate 2.5G or even 3G mobile telephony as solutions, the cost-effectiveness of such models is unclear (let alone having enough spectrum in mobile telephony bands per cell). In addition, mobile systems have not yet been well integrated into the Internet, especially not for *producing* information, instead of merely, say, receiving SMSes.

If one builds out a fiber network like FiberAfrica, there can be strong synergy for mobile telecommunications providers, who today have to either pay very high transport (uplink) costs, or rely on their own microwave-based backhaul, which limits their bandwidth for broadband data services. While one option would be to use the wireless links until they fill up, and then upgrade to fiber over time, such systems would operate as "closed" systems (likely owned by the mobile providers), making "open access" very difficult.

c) *Don't await "perfection" (such as the triple play).* Mobile wireless is a good step, but doesn't have the bandwidth, necessarily. On the other hand, we shouldn't wait for fiber to the home or triple play designs. Data connectivity is important enough for its own design, and can be used to offer voice services as a fringe benefit (unlike video, which needs higher bandwidth).

3) **What is the "best" model for ICT development? No one knows!** Telecommunications and computing have been growing rapidly, much more so than economic growth. Developing countries, in fact, show some of the highest growth rates as developed countries are somewhat saturated. What regulations and policies are required to help spur such growth? It turns out that very few policies in the domain matter as much as overall economic growth. This has been cited as the reason that China has had such an explosive growth of ICT (as well as electrification) in the last 15 years. What works in one country may not work in others. More specifically, the mantra of deregulation (and even privatization) means different things for developed versus developing countries. The former had reasonable penetration of services, profitability, and growth based on new technologies and services. In the latter, the base from which networks were being deployed was low, and many public services were barely profitable.

   If we consider most countries where there is high penetration for broadband, the dominant technologies are DSL and cable. All of these imply a solid revenue stream which helps justify an incremental investment for broadband. In the case of Africa, the number of land lines or cable subscriptions is low, so data may have to be thought of as a pure data play (assuming regulatory barriers against provision of voice services, which data networks could easily handle).

   The challenge is finding the right models that provide enough profitably to invest in expanding the network (as population penetration is a key goal, instead of just corporate profitability. Why should anyone, other than the government, build out what will be a "free" service? Of course, we have to be careful when we consider a "free" service. Even free email is not free – one has to have the computer, connectivity, etc.

   a) *Telecom policies need to strike a balance between "St. Marx and St. Market."* The debates over governmental control/guidance versus free markets are often misinformed, especially when it comes to infrastructure.[9] At one level, governments can be inefficient, bureaucratic, and slow to innovate. On the other hand, market mechanisms will not provide the right pricing signals or incentives to spread penetration into rural and other economically unattractive areas. This is not a desire to move to the era of government telecom provision. Rather, the government should be an *enabler* and *neutral regulator*, and intervene where there are market failures or societal imperatives. One solution has been to impose a universal service charge like a tax, while some countries, like Chile, have had enormous success with applying market mechanisms for universal service. The debate on public vs. private needs to be transparent and more informed. We have to remember that infrastructure projects require large investments, often beyond the capabilities of either source acting in isolation. Public projects often have a large private component, if not outright outsourcing, and private projects in turn are often beneficiaries of public policies and specialized funding, and are generally subject to public regulation.

      A benign dictator, if one exists, might choose the best design for cost-effective broadband connectivity. Using today's technology, how could one expand broadband to many more users at very low cost? One option would be by reusing and sharing connections, e.g., with WiFi. Every third house with an uplinking connection would then suffice, giving neighbors connectivity. However, this is expressly forbidden by almost all service providers. Thus, no society has optimized its ICT based on lowest-cost *universal* connectivity. Point (4) goes into more detail on such issues.

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[9] A modern twist is the debate between "property rights" vs. "commons" for spectrum.

b) *Cost, Price, and Value are not the same thing.* In general, the value of a good or service should be higher than what one pays for it (price), and this should be higher than the cost. Otherwise, there will be a disequilibrium, requiring subsidies (or there will be losses). At one end, the value of information transmission will vary dramatically based on what one is doing with it, or what alternatives there are. Even a single packet of information can be worth billions if it is used for stock market orders. Integrated assessment of the value of information is beyond the scope of this Discussion Note.

When we consider cost and price, one challenge is that the marginal cost of transmitting information on an existing network is close to zero. Even when we factor in the capital costs, and amortize these, the costs can vary dramatically based on number of users (which is driven by the price). E.g., a single optical fiber pair, installed, between two cities may have cost, say, $500,000. A large company may have justified this cost itself, and run 100 Mbps Ethernet services between two offices. However, this fiber could easily handle 100s of gigabits/sec of connectivity, at only modest incremental cost. That would bring the cost per Mbps down dramatically.

Providers, on the other hand, do not charge only based on cost per Mbps unless they are comparing apples to apples. Per bit, an SMS service costs much more per Mbps than telephony, which costs much more than broadband Internet access, which costs much more than cable or satellite TV. The differences are based on both the user value, and the cost of service. Personalized bi-directional services both cost and are worth more, in general.

One should not try and glean cost information from pricing. Sometimes, different technologies are used, and marketing pressures push one over the other. DSL can provide symmetric 1.5 Mbps connectivity, same as a T1. A service provider could reduce the oversubscription ratio (statistical multiplexing) used, making this suitable for business use instead of residential, but even then such a Business DSL would be much lower price than the T1 service they would rather sell you.

Examples of the cost vs. price disconnect abound. In the old days, IBM would sell systems with, say, 8 MB of memory at a certain price. If someone wanted 16 MB, they'd pay many thousands more. However, the entire memory would already be installed, and it would essentially take a screwdriver turn to enable or turn on the memory. Viola—a much more "expensive product." Even regular coca-cola has most of its caffeine added in – but the low-caffeine product is considered a premium product. Not all of the disconnects are due to market failures, some are architectural or design based. If someone owns a fiber between two locations, and has a single wavelength running between the points, it is cheaper to run wavelength level connectivity between the two points (at, say, 2.5 or 10 Gbps) than an E1 (2 Mbps) or T1 (1.5 Mbps); the latter would require additional add-drop multiplexors on either end. Of course, users can often only afford the smaller granularity offered by providers, and a single E1 is priced lower than a single wavelength. But, there are instances where *cost* of the higher bandwidth equipment is lower, even in an absolute sense (not normalized per Mbps). This is driven by standards and market volume, and the fact that optical fibers have much longer reach than copper. The disconnect between cost and pricing is heightened by the various architectural layers in networking, which can raise the costs, e.g., the unnecessary use of Asynchronous Transfer Mode (ATM – a technology at the data link layer) in many Internet Protocol (IP) networks.

In Africa today, satellite connectivity is the norm for many data connections, at prices typically $3-5/kbps/month (sometimes higher), which ends up being unaffordable for most users. Now, terrestrial (sometimes fiber-based) solutions providers are beginning to enter the market, but as a *premium* product. Arguing they have less latency and losses, want to be able to charge more! This is counter to the actual cost of delivering services.

c) *Competition is **very** useful in ICT.* Most developing countries had and many continue to have a national PTT, who may or may not continue to be a monopoly carrier. The 1990s saw a push for private players and privatization, and the greatest success has been for mobile telephony, where the private players often came first, with governments getting into the act sometimes as a 3rd or 4th operator. However, privatization has often been confused with effective competition, and one needs to be careful to first separate the effects of technology improvement from regulation and structure when one considers price-performance of the telecom industry. Meaningful competition[10] requires at least 3 players, and, ideally, an independent regulator. Competition has been especially useful in mobile telephony networks, where countries with more players have lower rates and higher penetrations.

   Regulators (and governments directly) face many challenges in guiding competition. The technology is rapidly moving, and many assumptions based on which we have built up decades of regulation are now becoming outdated. As an example, broadcast television in the US has been treated as "special" and "for the public," and was thus given for free many channels of spectrum (totaling hundreds of megahertz of very good quality spectrum). However, some 88% of US homes now receive their TV from cable or satellite, and the vast majority of that spectrum is unused.

   In addition, determining what is or isn't abuse of market power, underpricing, predatory pricing, etc. is difficult. Almost any service relies on some extent of cross-subsidy, be it electricity, telephony, or postal. What rate structures should or shouldn't be allowed? Corporate profit and deeper (universal) service are naturally conflicting to some extent, but what about when a company lowers prices almost or even actually below cost, just to extend services. While they may do that only through-cross subsidies, critics could contend that it was being done only to garner market share.

d) *Competition for fiber networks themselves is difficult, if not unlikely, especially beyond core interconnections between major cities.* Optical fibers have enough bandwidth for all ICT needs, and one model would be for every home to have its own fiber connection.[11] Even in the developed world do we anticipate three fibers coming in to every home? With that in mind, we are unlikely to see true competition in the near term with fiber in much of the developing world, esp. for access solutions or underserved areas.[12] At very low penetrations, there are large economies of scale lost with multiple players; if we only have a few percent penetration for connectivity and $n$ providers, then each would face costs that are almost $n$ times higher than if they were the only provider.

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[10] Simply measuring how many firms exist, or even their market shares (and measures of market power like HHI) do not tell the whole picture – the quality of competition matters, especially since the telecom market is not really a fungible commodity. There are subtleties related to additional services and products that different providers may or may not offer, some relating outside the field in question and technical differences (e.g., an incumbent telephony company that is also an ISP could offer discounted local access charges, unless regulators step in). In addition, there are often bottlenecks that restrict effective competition by geography. E.g., an inter-exchange carrier (IXC) may have a point of present (POP) within a city with enormous bandwidth, but end-users have to rely on a local carrier for the local loop – creating delays and additional costs.

[11] A back of the envelope calculations shows that the money spent in the UK on 3G wireless licenses (let alone hardware and technology) would be enough to provide fiber-to-the-home (FTTH) for all its citizens.

[12] While the US, Europe, and parts of Asia have seen enormous competition in the core of the network, and corresponding drops in the price of inter-city transport of bits, many systems were built during the boom years of the mid to late 1990s.

Competition with economic viability is especially difficult for fiber systems (compared to other solutions) given the very long lifespans for the infrastructure. Fiber will last decades, even though the electronics on it will need to be amortized much sooner.[13] On top of this, if we want 3 or more players, then each will have a very small market share. This pushes costs up very high. One solution would be to treat the optical fiber as a platform for open access, with competition at higher layers [FiberAfrica model, amongst others].[14]

4) **A major challenge is one of boundaries and transactions – who pays vs. who benefits.** A universally accessible ICT infrastructure in rural areas could have enormous impact in many fields of rural life, ranging from agriculture to healthcare to education to governance. Individually, it is unlikely any one of the disciplines would be able to justify building out the ICT infrastructure. The challenge is how we could build out such an infrastructure, and collectively benefit from it.

   If one had ubiquitous connectivity with the appropriate features (bandwidth, quality of service, etc.), there would be many more applications that one could run on such an infrastructure, e.g., automated metering for electricity, water, gas, etc. Today, either each utility provider has to build their own network, or an incumbent often tries to extract economic rents for such services.

   If one considers open access or public networks, there are strong indications that such models lead to lower costs for consumers. Companies may lament this leads to taxpayer subsidies, but such networks can be designed without subsidies, and many such deployments are leading to lower costs and better services (and deeper penetration). Here, the issue is that a producer surplus is now converted to a consumer surplus. However, even from incumbent and traditional service providers' perspective, all is not lost. If they themselves use open access infrastructure, and provide much lower cost connectivity, they can make up for lower revenues per user through more users. There are multiple studies that have shown elasticity greater than one for telecom usage. The growth comes from not only greater usage by existing consumers (up to a point – depends on where you are in the demand curve) but also new users who were previously outside the system.

   a) *"Open access" is easy to want, not so easy to do well.* The capabilities of modern communications technologies are impressive, and rapidly becoming all-encompassing—witness the rise of almost all services over IP (Internet Protocol). Regulators want to ensure that any entity with a dominant or established position in one segment (or layer) of the market doesn't lead to monopolistic control or market power. However, properly accounting for costs is a challenge. The companies want to ensure they are not paying for their competitors, and that they themselves are able to recoup their investments. Some regulations restrict the ability to provide services in the guise of competition. However, if we want others to be able to compete, a given firm itself should be allowed to offer the whole spectrum of services as well. Truly, convergence is the duality of open access.

      The issue of open access relates to issues of public versus private. Asking a private entity to open up (to their competitors) reduces their willingness to invest. To that extent, public providers are more amenable to open access models. Competition could flourish on top of the open infrastructure to provide retail and value-added services. By keeping the infrastructure open and in the public domain, like suggest for FiberAfrica, we can achieve

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[13] This is an additional argument for public funding of fiber, which can manage a multi-decade horizon for amortization.

[14] Open Access models are analyzed by Anders Comstedt, Russell Southwood and Eric Osiakwan for InfoDev; http://www.openaccessforafrica.org has more information.

the benefits of competition at the higher layers as well as ensuring dominance in one layer doesn't spill over to unfair power for providing services.

The solution of structural separation of certain infrastructure and retail services has been suggested by many analysts. This certainly leads to some transaction costs, but it helps prevent monopolies and makes competition much easier. On the other hand, companies want to ensure they can be profitable, without which they will not extend their deployments.

The US grappled with Open Access after the 1996 Telecommunications Act, but most deployments ended up as failures, for a variety of reasons. By many (but not all) metrics, for data services there is now a greater stranglehold by incumbents (considering telcos and cable companies both as incumbents). A disturbing trend recently seen in parts of the US is the restriction of community and municipal (public) networks, as these would purportedly "hinder competition." A public network is merely an additional option, and, often, one that caters to all segments of the population.[15]

An additional difficulty is that fiber has so much capacity, so it might evolve into a "winner takes all" world. In the absence of true competition, the only other option would be to have a strong regulator in place. However, how would they incentive new builds? This would likely bring us back to the situation in the West of some years back, of regulated monopolies. Instead, open access models can combine competition with public (or even private) regulated infrastructure.

We have noted that building basic ICT infrastructure similar to FiberAfrica can be achieved for 1 to 2 orders of magnitude lower cost than other infrastructure, such as roads. Roads are a good example of an analogous system that allows open access on top of public infrastructure – we don't want ten highways in parallel under the aim of competition. But, there remains significant competition and private participation, ranging from hardware (e.g., cars) to maintenance (e.g., outsourcing or tendering for toll-booth operations or even building the roads) to services riding on the infrastructure (e.g., courier and delivery companies).

b) *How connectivity becomes more expensive.* A further distortion in transactions occurs when we consider how policies (especially governmental) lead to artificial increases in the cost of connectivity (or other ICT). If one starts with the equipment (hardware, software, and installation) for an ideal network (optimized for user conditions), there is an associated cost to end-users. Any policy decisions on top, for whatever reason, create additional costs, distortions, or rents. Below is a list of policies that make connectivity such as broadband more expensive for the end-user (not in any particular order):

   i) *High ISP license fees.* Some countries charge upfront for becoming a data service provider, in contrast to revenue-share models or zero/nominal charges. In addition to fees, there are often regulatory burdens that raise costs (point xvi).

   ii) *High spectrum license fees, and lack of unlicensed spectrum.* Setting spectrum "prices" right is a challenge; one only has to remember the 3G debacle in Europe. However, regardless of socially optimal economic pricing for spectrum, special cases and policies can be considered for rural broadband, including:

[15] Of course, one must be careful that such networks don't become a drag on public funds, and are efficient in operations.

(1) *Suggestion: Allow increased power levels for transmission (with gain allowed from antennae).* Lower densities of users means less issues of interference, and technology is improving to reduce issues of interference.

(2) *Suggestion: Allow use of spectrum allocated for but not used by television transmission (UHF band, upper channels).* Even developed countries have idle spectrum in this band, and these frequencies are ideal for rural broadband—longer ranges and better penetration through obstacles.

Many regulators in developing countries allow unlicensed spectrum, but only for "indoor, personal use." This precludes its use for interconnections or access, and certainly restricts offering Wireless ISP services. Developing countries need to recognize that unlicensed does not mean unregulated; there are controls on emissions, power levels, etc.

iii) *Right of Way charges.* While compensation for use of private land is to be expected, there are questions as to why public land should charge for rights of way for a public infrastructure built upon it (of course, private networks are a different story). This is not only for laying optical fibers underground, but utilizing poles that belong to public utilities for aerial links. One main challenge with free access is limiting multiple players from requesting access (which can be disruptive), or preventing market power for the few that have access. One solution would be the open access model as envisaged for FiberAfrica.

iv) *Import duties.* While governments certainly require revenues, a balance needs to be struck for infrastructure development (which some countries choose to exempt from import duties).

v) *High user taxes and surcharges.* Taxing telecom services can make sense to the extent all services can be taxed, higher taxes lead to underinvestment and underusage of telecom. The rationale for Universal Service levies is sound, but there are many disagreements on the best mechanisms for such programs. Very often such surcharges become absorbed in general government coffers, instead of being spent on helping targeted segments of the population with connectivity. Rural and underserved areas could perhaps be exempt from many or even all such surcharges. This, in effect, would create a cross-subsidy mechanism.

vi) *Uplinking and interconnection restrictions.* Many data (and even voice) service providers are not free to choose their interconnections (or have virtually no alternative providers to choose from). International connectivity (gateways) are often still under government control, and a major bottleneck (both high prices and limited performance). The "security" bogey is overstated, and even private companies can meet security norms and regulations.

vii) *Limits on usage or applications (includes limits on convergence).* Governments or regulators often limit what types of services different companies can provide, with sometimes arbitrary separation of services. This obviates the goal of converge, a useful benefit of modern communications protocols. Closely related to limits on services, different applications are restricted on different types of networks.

viii) *No Voice over Internet Protocol (VoIP).* This is a special case of restrictions on applications/services, singled out given the enormous revenues associated with voice telephony.

ix) *Treating voice as a special service.* While traditional voice services face higher regulatory burdens, and universal service obligations, data connectivity usually cannot benefit from these universal service funds, making access for the truly poor hard to supply.

From a developing country perspective, international voice connectivity is an especially valuable enterprise, since they earn significant money (in foreign exchange, no less) from voice call completion/termination charges. In contrast, for backbone Internet connectivity, they pay for the entire pipe—their uplinking is charged for both directions of traffic flow, unlike public, free, or bartered (private) peering by larger carriers in the US/Europe. Thus, it is only rational (under the existing system) developing country governments would prefer international circuit-switched voice instead of IP based voice.

x) *Limits on sharing connectivity.* Given the marginal cost of connectivity is very low (once the infrastructure is on place), and most people don't use their existing capacity to its full, sharing connectivity would be a cost-effective use of the facilities. However, service providers and, by extension, even some government regulations often limit reuse of a connection, or using one type of connection for a particular application. E.g., in the US, many other uses of special "educational connectivity" extended to remote areas (like through e-Rate) are expressly forbidden, even if there is spare capacity or during non-school hours.

xi) *Lack of regulatory clarity (or consistency) on "affiliate transactions".* Many data services have run on top of alternative services (e.g., DSL over voice, cable over video, [potentially] PowerLine Carrier over electricity wires, etc.). How regulators manage the interactions or separations between these services (some of which are regulated or regulated differently) leads to different costs for different providers. Instead of just raising costs, this can lead to artificially lower costs for competing technologies, e.g., if DSL can run over copper that was paid for by regulated voice users, and enjoyed special Rights of Way. Now, a new player putting in their own media for last mile broadband access faces much higher costs. Open access requirements complicate this issue much further.

xii) *Low density of target users.* A network built for ten times as many users will have per person costs multiple times lower. Of course, any technology should be optimized based on the number of target users, but this is likely to be a moving target, starting low and, hopefully, improving rapidly. One challenge becomes timing this right, with rapidly changing technology. Government policies play a role through their choices in what services they consider "elite" and then tax accordingly. E.g., some countries have treated local calls as worthy of subsidy, and overcharged long-distance or Internet connectivity.

xiii) *Design without scalability or upgrading possibilities.* Similar to the point above, optimizing for current demand instead of discounted future demand can lead to poor (and expensive) designs.

xiv) *Proprietary or National-only standards.* Many technologies have global differences in standards (e.g., electricity supply at 50 vs. 60 Hz and 220V vs. 110 V), but it is rare for a country to have individually unique standards. China is special given its size, market, and homegrown capabilities in proposing a new 3G wireless standard (called TD-SCDMA), but for most countries such approaches lead to higher equipment costs given their low market size. In fact, countries should not only try and choose existing standards, they should choose the best possible standard. An example is choosing US-FCC-style power emission levels for Wireless LAN (WiFi) technology for longer reaches instead of the more restrictive ETSI standards for power levels and antennae.

xv) *Limited ability to deploy new services/upgrade.* Often, there are restrictions on what services can or cannot be offered by a provider. This also affects the choice of technology and the overall network design.

xvi) *High costs of regulatory compliance.* There are often burdensome requirements for service providers, which can relate to security (e.g., extra traffic logs, routing traffic through government servers or centers, etc.), inspections, mandatory use of domestic or preferred providers/vendors (including skewed interconnection policies), artificial market segmentation, onerous requirements to obtain licenses or clearance, etc.

xvii) *Higher failure rates and/or maintenance costs.* Decision-makers in developing countries have often not allocated enough investment for maintenance (or training, upgrades, etc.). In addition, some of the failures are due to poor enforcement, or problems with ancillary services (e.g., quality of electricity).

xviii) *High costs of capital.* Of course, a developing country government is usually not capable of directly lowering the "risk-premium" usually required for investments in developing countries, but it could create a better environment for investors to feel more secure (including transparency, independent judiciary/regulation, repatriation rights etc.). Governments could also offer tax or other incentives for rural connectivity.

5) **There is enough value in rural areas.** ICT investments required for rural developing communities are large, in the billions. But, they are an enabler for higher economic growth and efficiency. In addition, the investments are much lower than for many other infrastructures, such as energy or water, or even roads.

One mantra of many telecom projects (unlike, say, water) is that end-users should pay for the services, and, indeed, telecom is one infrastructure that has largely been profitable. However, rural areas have often required intervention or special pricing policies, including benefiting from Universal Service Funds. If we think of rural electrification, it usually came about from government intervention, even in free markets economies like the US.

If we consider ICT, rural areas in developing countries have enough "value" to justify the ICT investment. The 148 developing countries in the world (removing OECD and other hi-income countries) have a rural population of a little over 3 billion people. The agricultural output from these regions in 2003 was estimated at just under one trillion dollars.[16] Experience from rural ICT projects indicates efficiency and supply chain innovations can lead to very quick payback periods.[17] These also show that the transactions (goods and services) in rural services are a sizeable aggregate market, and can benefit from ICT for efficiency, increased competition, and improved choices (which is linked to end-user empowerment).

Related to value in rural areas is demand for ICT. The high prices people are willing to pay today indicate strong latent demand. The challenge is pricing it low enough, and getting the scale right.

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[16] Of course, not all the output came from "poor farmers"; commercial farming, especially in Latin America and East Asia, accounts for a sizeable fraction of the total economic yield.

[17] e-*Choupal*, the pioneering Indian project by agribusiness major ITC Ltd. that builds out rural kioks, is reported to have a payback period between 8 months and 2 years.

6) **Access is only one part of the challenge.** Giving people connectivity (and even a computer) will not improve food security or provide shelter. ICT is a means, not an end, and the Millennium Development Goals (MDGs) capture one roadmap for development. Many of the determinants for success of ICT depend on complementary development including but not limited to energy availability, education, enabling regulations and policies, etc. Carnegie Mellon academics, based on a pair of global workshops on ICT for Sustainable Development, will shortly be releasing a report/book defining the research challenge in ICT for SD.[18] This addresses the need to make ICT meaningful for the MDGs, and not just worry about the digital divide.

7) **FiberAfrica proposal – affordable, sustainable connectivity across Africa is possible if we have the political and social will (following pages).** There is a philosophy held by many across various fields, and it is amplified in the networking world: *incremental changes lead to incremental benefits*. FiberAfrica is presented as a continental scale network based on optical fiber and (fixed) broadband wireless that gives the majority of Africans virtually free basic broadband connectivity within walking or cycling distance. The network is sustained by small-scale payments and by commercial users who still benefit by dramatically lower costs for connectivity than not only today but also alternative designs as proposed elsewhere.

   The rationale for the FiberAfrica model as proposed is based on several realizations:

   a) *Small "Internet Size" of most countries requires unique scaling and design.* Most countries in Sub-Saharan Africa are very small in terms of "Internet Size," and even the obvious exceptions are themselves modest in the scheme of the Internet overall. The number of users, hosts, content, and present interconnections is proportionately much lower than even their GDP when compared to most other nations. Today, most countries are attempting to "reinvent the wheel" with their individual international fiber connected gateways, data centers, security centers, etc. Instead, they could save significant costs by sharing many of these features (with appropriate security mechanisms and sovereign control, of course). A single large-scale core router could handle all the traffic going in or out of Africa today with ease. But, we have countries with a few million people, and less bandwidth than a small city in the US, building out their own networks without optimizing them for the size or scale possible under a transnational network.

      Mobile telephony appears to be synergistic instead of purely competitive, and the question becomes what other sustainable models are there for fiber networks. In the US and other countries, most fiber deployments came from a double if not triple play, but Africa lacks the widespread use of wireline voice or cable TV. It is well accepted that a network designed for 1% of the population will be much more expensive per use and different from one designed for 50% of the population.

   b) *Domestic content and connectivity are required.* Without meaningful penetration within the country, building out international connectivity doesn't achieve much. Meaningful penetration will only be driven by content that meets domestic (local) needs, and such content is unlikely to be made available from abroad, especially not in local languages. To that end, while international connectivity via optical fiber can be justified, it should be the cart that follows the horse (local needs), and not the other way around. Using international connectivity as the backbone for interconnections is poor and expensive design[19] – domestic fibers will be much less expensive and easier to scale. We already have significant global fiber capacity (potentially, hundreds of Gbps) landing at multiple points

[18] Please contact me for further information, but do wait until May for this report (tentative date for publication).
[19] Even India had segments until the late 1990s where e-mail from one city to the other would go through the US!

in Africa (in multiple countries). However, has this done much for bringing down connectivity/uplinking costs in those countries?

c) *Big bang approaches can sometimes be more acceptable than small interventions that keep the underlying system (and divides) in place.* Envisioning any two neighboring countries cooperating might be more difficult in some cases than creating a common playing field at the continental level. In addition, the vision of FiberAfrica ensures that a new divide between African countries is not created – market-driven solutions would otherwise only connect a subset of countries in a meaningful manner. This also makes it more likely for donors to consider investing in such infrastructure.

   There are certainly interim solutions and technologies that may be less expensive, with the tradeoff they are less scalable. FiberAfrica will not be built out at once, rather beginning in certain regions first. However, the vision and end-goal should be continental. Interim solutions will take enormous effort and cost to upgrade the solution down the road.

d) *There is no lower barrier to entry than free.* In addition to innovations in technology, FiberAfrica has a unique business model, whereby public users (schools, hospitals, libraries, etc.) can get free or nearly free broadband access, and end-users can also get free basic connectivity in community access points, distributed throughout Africa. Such access points would themselves receive either free or virtually free connectivity, and would charge for value-added services or assistance with transactions and fulfillment. Affordability is a key aspect of the digital divide. Mobile telephony could, in theory, be availed by well over 2/3 of Africans, even a non-trivial fraction of rural populations. However, they choose not, based on the value proposition (or lack thereof). In part, this is driven the by relatively high monthly average revenues per user (ARPU), which ITU data for 2003-04 indicate was more than double that of India. It is now falling, and we should indeed see greater mobile telephony penetration; that will not do as much for Internet connectivity.[20]

e) *The best model is one of public and private partnerships, on an Open Access model.* Optical fibers are a preferred technology for connectivity, but can we expect 3 or more independent fiber networks being deployed across Africa in the near term? If we treat optical fibers like a utility, built everywhere (or deeply enough) just once, then different players could compete to provide *services* on top of this infrastructure.[21] For rural or underserved areas, free or nearly free connectivity could be given for community access points. In urban areas, this could provide much cheaper uplinking bandwidth for service providers.

   The suggested use of donors is only one option, and private funds could also be used (leveraged through multilateral agencies, perhaps, who help reduce risks). It is worth emphasizing that donors would only pay for the lowest level of open infrastructure; the actual retail services would be provided by other public or private providers, whose total investment would be much larger in the long run.

Why should anyone build any such network in Africa, instead of such networks being built first in more well-to-do nations? This represents a leapfrog opportunity, with less legacy needs, and less regulatory hurdles (esp. compared to the US!) It might even be the one of the best methods for developing ICT in the continent—a combination of innovations in technology and in regulation/business models.

[20] Of course, complementary ICT can still have a significant impact, e.g., use of SMS messages for agricultural price discovery.

[21] This has parallels to the Utopia network model in the state of Utah, USA, and projects in Sweden.

In addition, the imperative for intervention in Africa is much higher given the stark differences in human development versus the rest of the world. Critics might believe that Africa's limited development is due to poor governance and corruption. The truth is that Africa has been burdened with several debilitating challenges. The rains are seasonal and erratic, and the overwhelming majority of agriculture is rain-based, instead of based on irrigation. The soil is also highly depleted, reducing productivity dramatically. On top of this, Africa also bears the burden of a triad of endemic diseases – HIV/AIDS, malaria, and tuberculosis. While ICT will not directly help with these, it can play a powerful supportive role in improving the efficiency and transparency of all development efforts.[22]

[22] Human development and ICT are no longer viewed as in competition, rather as complementary. "The issue is whether we accept that the poor should, in addition to the existing deprivation of income, food and health service, etc., also be further deprived of new opportunities to improve their livelihood." (Weigel, Gerof and Waldburger, Daniele (editors). "ICT4D – Connecting People for a Better World. Lessons, Innovations and Perspectives of ICT in Development." Swiss Agency for Development and Cooperation and Global Knowledge Partnership. Berne, Switzerland. 2004.)

# FiberAfrica Project *Executive Summary*

**The Project:** The purpose of FiberAfrica (FA) project is to accelerate the development process in Africa by building a 21st century Information and Communications Technology (ICT) infrastructure throughout the continent. The capital cost of this information superhighway will be under one billion dollars, or a one-time cost of roughly one dollar for each African. FA will involve a 70,000 km core optical fiber backbone network, 30,000 km of spur fibers to extend the backbone, and access networks based on broadband wireless, thereby integrating all African countries and major population centers to the Internet.

**What it does:** Low cost digital connectivity enables content to be brought to the doorstep of all Africans empowering them with information and knowledge to break out of the poverty trap. The low capital cost of connectivity, about $1 per African, will be paid by development partners and operating costs will be paid by private users; public users like schools, hospitals, and communities can get free access.

This design increases communications and enhances the impact of development projects. A major Health Network is just one of the likely spin off benefits, where doctors, paramedical personnel, and local officials can obtain updated information on disease control, demographics, efficacy, etc. Overall, by making data communications *available*, *accessible*, and *affordable*, the population will be empowered and find significant economic benefits based on greater market power, lower prices for goods and services, lower transaction costs, etc.

**How?:** FiberAfrica has multiple components, spanning a next-generation optical fiber backbone to broadband wireless access to ensure ubiquitous access to the backbone, combined with tens of thousands of community kiosks. (The kiosks can operate on solar or other renewable power, where electricity is unavailable). The business model is one of a public-private partnership, where private service providers and kiosk operators can compete for services over an open-access (low-cost) uplinking model – with the requirement that public users gain essentially free access. This solution is a powerful enabler for sustainable development, facilitating the creation of localized and tacit knowledge, urgently required to find African solutions to African needs.

While the network will built in several stages, beginning with certain regions, the aim is within 2-3 years of operation to span the entire continent. The benefits will be available immediately, without waiting for full deployment.

The unique model envisaged for FA ensures that African countries will not only be stakeholders in the project (in addition to being beneficiaries), they will also not have to finance the creation of the network. All they must do in return for a hundred-fold improvement in connectivity is facilitate the network through appropriate policies, e.g., allowing convergence technologies or making appropriate public spectrum available.

**Synergies/Linkages with other existing projects:** There are several international fiber cables and networks connecting Africa, such as AFROLINQUE, SAT3/WASC/SAFE, etc., and these can provide international connectivity. These projects will be bolstered with FA, which enhanced access within the continent. Within specific countries, there are other projects for networking ongoing, but they lack the same scale/scope. Several networks are based on Satellite, e.g., Africa Virtual University (AVU), and face connectivity costs two orders of magnitude higher than FA would provide. This revolutionary network is a paradigm shift and important in not only bringing broadband connectivity within walking or cycling distance for the majority of Africans, but also for dramatically reducing costs. Some proposed networks focus on international connectivity, instead of meaningful penetration. Alternative incremental designs only offer incremental benefits. Given the billions being invested in Africa on ICT annually, the annualized capital expenditure for FA is only a small fraction of that (~2%). Other initiatives like Global Fund for HIV/AIDS, Cities Alliance (CA), Global Development Learning Network (GDLN), etc. would be strengthened and can piggyback on FA for stretching their connectivity dollars by two orders of magnitude.

**Who benefits?:** The beneficiaries are most citizens in Africa, especially public users such as schools, colleges, hospitals, libraries, government offices, etc, as well as NGOs, FBOs, and businesses. Private users shall be able to go to a community center and obtain basic access nearly for free, and they will have (paid) access to value-added services.

ICT is a valuable enabler to achieving the MDGs, though it doesn't achieve them directly. This powerful infrastructure can enable all ranges of communication and knowledge sharing, ranging from distance learning to telephony (through appropriate use of Voice over IP—VoIP). Reducing such infrastructure costs is a major priority for educational and economic growth (job creation). This also enhances empowerment as connectivity and content result in better governance and transparency of public expenditures resulting in equity and equitable service delivery to the poor.

**Suggested Collaboration:** NEPAD, Intelsat/pan-national telecom companies (potential operator), World Bank, Multilateral/private donors, Global Agencies (UN/ITU/etc.), academia and private sector.

Specific "champions" for the project might play a role to facilitate the creation of an independent entity by bringing all the development partners in tying up technical and financial details to assist (?)NEPAD in implementing its e-commission mandate of bridging the digital divide and using ICT for development.

Discussion Note (*draft*)

# Project Concept Note

## FiberAfrica Network
***The Network for Poverty Reduction Through Development and Empowerment***

## 1. Background and development indicators

Africa is a vast continent comprising of 53 countries with a population of about 820 million people. Africa is sparsely populated with about 28 people per square kilometer while the comparable number in South Asia is 293 and 116 in East Asia and Pacific. The annual per capita income is $664 overall, but excluding South Africa, Sub-Saharan Africa's (SSA's) is only $300 per year. The total output is only a little over 1% of the World's GDP. The continent's economy is growing at 2.7% per annum, just a little above the population growth of 2.5%, which leaves little per capita growth or margin for investment in development.

A number of factors contribute to the current state of the region. The digital divide has exacerbated the economic divide with the rest of the world, which benefited from the emerging role of knowledge as a major driver of economic development. Public and private investments have both been low. One facet of the poor prognosis is a limited understanding of prevention mechanisms of HIV/AIDS pandemic that has caused the erosion of economically active population, thus reversing the gains made during the past decade. Other factors include lower skill levels, poor infrastructure, high transaction costs, and poor governance.

On the positive side, Africa's rich natural resources, agricultural commodities, human and natural diversity offer potential for a better future. In order to harness the available resources, more regional collaboration and integration with the global economy are very important factors. Improvement in communications using information and communication technologies (ICT) is a key enabler for such a sustainable development.

## 2. Key sector issues and challenges

*Poor indicators:* Information and communication technologies (ICT) in Sub-Saharan Africa lag behind most countries, including other low-income countries. There are only 14 telephone mainlines per 1,000 people in Sub-Saharan Africa (7 per 1,000 excluding South Africa) while the average in low-income countries is 30. When it comes to Internet penetration, Sub-Saharan Africa accounts for about 1% of the world Internet users, and even this figure is skewed across regions. Access, especially to data networking, is very expensive, if not unavailable. As the ITU world telecom development report 2003 shows, in many countries, even limited basic access to the Internet can cost as much as several years worth of salary. Broadband access is yet more limited, even for colleges and universities who must rely on satellite connections that cost dozens if not hundreds of times higher than what their peers pay for connectivity in developed countries.

*Growth and current efforts:* Mobile telephones have seen a high growth rate within Africa, with penetrations twice that of mainlines. Much of this effort has come from the private sector, who have relatively low deployments in rural and economically unattractive areas. In addition, their network designs often do not have the capacity for broadband, and so such solutions also do little to enhance data (Internet) connectivity, and such investments might even limit the already scarce funding for data connectivity. Many countries have recognized the importance of ICT as part of their development planning, but most solutions have been one-off initiatives. In many cases, projects are centered on international linkage with some satellite connectivity as well and they focus mainly on urban areas or on areas serving elites. Nonetheless, the willingness to pay even today's high prices indicates latent demand for ICT in Africa.

## 3. Rationale for cooperative involvement

ICT's role in human development was extensively discussed at the World Summit on the Information Society (WSIS), phase I. The key resolutions from WSIS, presented in Appendix I, indicate that almost all of these targets depend on adequate infrastructure. This project facilitates freedom from illiteracy and freedom from illness, crucial to escaping poverty, a key goal for multilateral agencies. NEPAD has been created to effect the changes FA envisions, and its e-Commission has a mandate towards such development. The World Bank and/or other institutions can help raise capital for the project, including generating donor (grant) funding as appropriate – the business model below has more details.

*Big bang approach and inter-country/regional solutions:* Using new but robust fiber optic and fixed wireless technologies for a widespread deployment would enable critical mass and bring cost effectiveness on the whole. Without such a large scale approach, countries will have little choice other than a painful evolution of building infrastructure over a long time. Such a large scale approach might overcome inertia and resistance to change, and the proposed model can ensure the project helps the entire population, including rural areas who might be left out of alternative ICT projects. In addition, this allows significant economic benefits based on standardized designs and economies of scale. It is possible that a continental approach could allow the region to leapfrog and close the digital divide quickly. Without such a network, many countries will likely "reinvent the wheel" when it comes to building a network backbone.

*Proposed development partners can facilitate optimal public and private partnerships:* The business model for such an initiative should ensure African involvement and ownership for implementation, including the franchising of local operations and value added services. It is also expected that such a framework will enhance the regional integration process and it can act as an example for all other regional initiatives. Without a lead like NEPAD, a project like FiberAfrica (FA) has difficulty gaining political credibility. Preliminary analysis has identified other important participants and stakeholders as well, and we have initiated informal discussions. As the economics presented will show, the financial viability is not as much an issue as policy and political decisions.

## 4. Proposed project development objective(s)

This project aims to:

a) Enable wider and cheaper access to information and knowledge for the general public in Africa which would promote, extend and sustain the existing development programs, and enhance the competitiveness of Africa in global arena as well as narrow the chasm between Africa and the rest of the world.
b) Provide better connection to public service providers, for example, schools, hospitals, and libraries, which could address social and humanitarian challenges.
c) Help reduce communication, transaction, and training costs for private sector activities that could facilitate employment generation and thus higher growth and equity.
d) Work towards the Millennium Development Goals (MDGs) – particularly Goal 8: Develop a global partnership for development and Target 18: in cooperation with the private sector, make available the benefits of new technologies, especially ICT:
    a. Indicator 47: Telephone lines and cellular lines per 100 population;
    b. Indicator 48a: Personal computers in use per 100 population and internet users per 100 population;
    c. Indicator 48b: Internet users per 100 population.

    *FiberAfrica indirectly enables achievement of the other MDGs.*

While the direct benefits are easy to measure (e.g., penetration, costs, etc.), the complementary and social development targets remain difficult to quantify, especially as a priori targets.

## 5. Beneficiary Sectors/Groups

*Human Development (Health and Education), Private Sector Development, and Infrastructure:* This proposed network has a potential to provide public users such as schools, hospitals, libraries, etc. with free access to basic connectivity.[23] This can be an enabler for both e-governance as well as social and humanitarian activities such as improving literacy and tackling HIV/AIDS. With widespread deployment of such a network, citizens would find much lower transaction costs, and, potentially, far greater transparency in their interactions with government and business. A slightly longer-term vision is not simply doing things less expensively than today, but doing things differently as well. ICT based employment can have positive impact on growth rates, and can bring many countries into the global knowledge-based economy, e.g., seen in parts of Ghana.

[23] There are an estimated 600,000 schools in Africa, and significantly fewer institutions of higher learning and libraries. Even adding in healthcare facilities, the total number of such public deployment points would likely be on the order of one to two million. While end-user costs are not shown in the analysis, even at an estimate of some $200/user, this is only an additional few hundred million dollars capital cost, distributed amongst and scaling with users.

## 6. Preliminary project description

The accompanying figure and write-up in Appendix II show a schematic for a new optical fiber backbone proposed under this project, FA. Combining new technologies including Dense Wavelength Division Multiplexing optical networking and broadband wireless, this project aims for near universal access at very low if not zero cost to most end-users, with small charges for value-added services.

*Core network:* The core of the network is an optical fiber backbone, connecting virtually all major population centers at multi-gigabit speeds. Even if these cities are not all “lit” in the first phase of the network, it becomes much easier to connect them over time as demand warrants. This design offers almost limitless capacity, scalability and “future-proofness.” A preliminary design indicates that the core network would be of approximately 70,000 route kilometers in size linking 400 cities in Africa with minimum populations of 250,000 persons each. An additional 30,000 km of fiber spurs (not shown) would be laid to reach other areas and to provide for wireless hubs.

*Access solutions:* A backbone network is of limited value without users accessing the network, and this is where new wireless technologies are expected to play a major role. Wireless technologies are exceptionally attractive not only because of their ability to be deployed with limited existing infrastructure, but also because they are based on a shared medium, which lends itself well to low densities of users. While 802.11 (“WiFi”) has led to “hot spots” and entrepreneurial innovation for wireless access, there are emerging technologies better suited for wide-area networking (such as 802.16 –“WiMax” or specialized alternatives). The routes along the fiber backbone are an obvious starting point for long reach wireless hubs, and regional optical fiber spurs would extend the wireless footprint; satellite-based connectivity would be useful for remote locations where extending optical fiber connectivity is not cost effective. The aim is for most users have access available within walking or easy cycling distance, and the revolutionary pricing model (free basic connectivity) eliminates barriers for entry to for users. A number of life cycle analyses have shown that hardware is not the major expense for end-users (and these are continuously becoming cheaper). Connectivity is the major cost for many users, along with applications. With adequate bandwidth, many applications can be run remotely, and could even use voice-based interfaces in local languages.

*Capital costs:* The capital costs for the entire continent are expected to total under a billion dollars (based on the assumptions detailed below, and excluding certain end-user equipment like computers or modems). While this appears a very large sum, this is only roughly one dollar one-time cost per person. Amortizing the initial costs, these are only a few percent (~2%) of the current annual ICT expenditure in Africa.

## 7. Possible Business and Governance Model

For this network, there can be several business and financing models, and a few of these are discussed here in brief (the models are not mutually exclusive). We propose to separate the construction of FA from its operation and from its ownership. This is important given the limited funds available from the nations themselves, and to ensure that this network has a strong African stake and participation.

*Capital Costs:* Given the modest capital costs, which can be amortized under $100 million/year, the initial capital can come from several sources, including:

a) *Donor countries* such as the G-8 and a few others. They would stand to gain in that countries that donated monies could reap free (but secure) connectivity for their embassies, aid agencies, etc.
b) *Private sources of funding* would raise the costs to end-users, but probably not to a detrimental level. Even still, multilateral support would be beneficial for risk mitigation, and providing "soft" support such as through relationships with countries and for capacity building.
c) *Vendors and technology providers* often provide vendor financing for large projects. They stand to gain as this initial network will seed numerous further contracts for regional, metro, and enterprise networks.
d) *Governments* can also contribute through taxpayer revenues, just as they pay for infrastructure such as roads. In fact, the costs per government are relatively modest compared to roads, which can cost up to several million dollars per kilometer depending on the location and quality—making FA 2 orders of magnitude less expensive.

Beneficiary countries are not required to pay any capital costs, but only provide the appropriate regulatory/policy environment to allow FA to be built as their "buy in."

*Ownership:* Ownership could lie with a consortium built of member-states, similar to the original Intelsat model. The system can be fair, for example, with voting rights separated from a GDP-based financial stake. We propose The New Partnership for Africa's Development (NEPAD) as the stakeholder entity to spearhead FA, which brings together all the countries in Africa in a continental partnership. NEPAD's e-Africa Commission has a mandate to bridge the digital divide in the continent and facilitate development. Each country could choose one (or more) entity to act as a nodal entity or even local operator.

*Complementary Participation:* The model for FiberAfrica Network envisions widespread distributed access and complementary development, especially for applications and reselling access. Kiosk and shared community access providers are a key component of helping spread the penetration into rural areas, as shared access is vital for bridging the digital, information and knowledge divide in an affordable and sustainable manner.

*Operations:* FA itself would have operating costs would be on the same order as the annualized capital costs, under $100 million per annum, a conservative estimate that includes multiple points of international connectivity, R&D, maintenance, emergency back-up power, rentals, etc. This excludes the costs (capital or operating) by resellers and entrepreneurs who help increase access to value added services such as video on demand, IP Videophones, e-learning and telemedicine, or the costs by the government for content and e-governance. The network would be operated by a private operator(s) under the control or regulation of the ownership consortium; Intelsat itself might be an appropriate body given their technical expertise as well as relationships with all the countries in Africa.

*Costs and Payments:* The operating costs are estimated to be at least an order of magnitude lower than today's costs for core network connectivity. We propose to structure access charges in a manner where public end-users (like schools, libraries, hospitals, etc.) could receive free basic connectivity, while certain classes of commercial users, or end-users who use value-added applications (like voice-telephony, entertainment, etc.), would pay corresponding charges (perhaps using pre-paid cards), ensuring the business viability of the network. Kiosk operators could also be given very inexpensive connectivity, under the condition that basic access by consumers would be free for limited and for educational use.

Appendix III has more details on the business model.

## 8. Alternative approaches considered

Without a network designed similar to the one proposed, with great economies of scale, each country will need to replicate much of the network, especially when it comes to international connectivity, uplinking, and data centers. Alternate incremental network designs and upgrades will only lead to incremental or marginal benefits. In fact, ICT does not always lend itself well to intermediate efforts but rather favors leapfrogging and widespread deployment, because of the so-called "network effect" – the value of a network can be proportional to the square of the number of users. This network is designed with rural areas in mind, and under alternative models, including trickle-down and private sector efforts, one remains unable to reach the "have-nots."

Given the goal is to have maximum penetration at lowest costs, FA appears more attractive than traditional solutions whereby international connectivity (through submarine cables and/or satellite) is the design focus. Oceanic cables are much more expensive, have higher maintenance costs, and provide little employment to local labor. Because of the relatively small size (user base) of the Net in Africa, a continental scale network (multi-region, in the initial stages) will provide the lowest cost uplinking.[24]

## 9. Potential risks and mitigation

There are a number of issues and concerns with such a large project, not limited to financing. One of the main sources of potential failure would be fewer people connecting than planned, but even then the cost-benefit calculus should remain positive. The optical fiber infrastructure, a large fraction of the capital costs, will be usable well into the future, with a very long usability life, and ducted construction will even allow new fibers to be used in the future with much lower investment. In comparison, other grand schemes like

[24] There is a proposal by NEPAD to build a fiber-optic backbone for multiple countries in the Eastern portion of Africa based on submarine cables – EASSY – Eastern Africa Submarine Cable System. This is a very positive step in bringing countries together, but FA might be a better design for the same stakeholders to consider. In addition to the much higher cost for EASSY—estimated ~10 times higher per km for the submarine fiber than the low-cost terrestrial figure of $3,000/km inclusive of initial equipment—"bringing the Internet to more countries," even at high speeds, does very little for increasing access and penetration, especially in rural areas. Also, this network has not been envisaged with innovations in business plans or true open access, which would be required to make ICT available and affordable to more people.

Teledesic were more capital intensive, had shorter timeframes for amortization, and had lower richness in terms of value-addition.

*Cooperation:* This vision requires cooperation between all the countries in Africa, potentially through NEPAD. While there are some regional cooperative networks, such as COMESA and WAEMU, etc., FA, being Pan-African, reduces local and regional rivalry issues. A country may choose to not join, but it might lose out significantly (and face higher "entry costs" in the future).

*Security:* Physical and data security are paramount in this network, with extensive redundancy and robustness in the design to counter issues such as inter- and intra-nation conflict. To ameliorate vandalism and theft concerns though greater participation of local communities in the network, local participation is important. For example, at every site that requires equipment housing (every 60 to 80 kilometers, say), a local entrepreneur would be given concessional connectivity for Value Added Services. He or she would help secure and physically maintain some of the equipment. By providing local connectivity, it is possible not only to spread access around the routing of the backbone, but also reduce local opposition and mischief. Experience from India also suggests several techniques for reducing theft of optical fiber and cables. While copper is often dug out from access networks due to its resale value, optical fiber has very little resale value, something would-be-thieves quickly learned after superfluous bundles were purposely left behind at construction sites.

*National Policies:* Countries need to commit to investments to help spread penetration, and develop the applications for harnessing the power of the network, such as e-governance initiatives. Member countries must also enact enabling legislation/regulations that allow FA to be built, e.g., allowing appropriate spectrum availability and disruptive technologies such as Voice over IP. At the same time, FA must work within the bounds of sovereign decision-making. Countries must also allow appropriate cost reductions such as duty import waivers or free rights of way – without these the costs to the consumers will increase. The network should be built such that access is non-discriminatory and largely free. Otherwise, there remain concerns that incumbents and alternative players would object. Here, experience from rural development initiatives in other countries have shown that urban utilities and service providers often do not oppose networks that have a rural focus, as they consider such areas unattractive commercially. ISPs and other providers today would also benefit from FA, especially if regulators allow it to be used for complementary services (such as aggregated voice transport). However, such calculations are not part of the focus of FA, nor included in the business model.

## 10. Next Steps

*Issues that need to be resolved:*

- Working with the diverse countries within their sovereign regulations and policies; Inter-country collaboration (through NEPAD?); issues in inter-country conflicts and resolution
- Collaboration with donor and development agencies; optimizing interactions with existing and complementary projects

- Financing and business models that ensure independence and operational sustainability for FA
- Synergizing sectoral linkages to maximize social and economic benefits

To begin, this project needs to build consensus amongst stakeholders. NEPAD and the World Bank can play complementary roles. The Bank (or perhaps UN/ITU?) can act as a facilitator, with relationships amongst all the African countries as well as donors and technology players.

The next steps would involve the development of a detailed project report/business plan, over, perhaps, a few months. This would incorporate synergies with other plans with similar objectives, as well as governmental projects.

FiberAfrica will likely begin in one or more countries or region in Africa. In addition to the required planning, design, and financing, there must be strong synergies to existing networks and infrastructure, e.g., unutilized or underutilized fiber.[25] One important step must be local partners and stakeholders (ideally, owners), and the identification of "champions" who can shepherd the concept through the political system(s) in place. After agreements on such issues, the first portion of the network can begin by the target date, 2007. Appendix IV gives more details on how to bring FA to fruition.

[25] Often, optical fiber is laid along energy or other infrastructure. Such companies or entities might want to use telecommunications for internal SCADA (Supervisory Control and Data Acquisition), but this needs only need modest bandwidth. One win-win solution is for such fibers to be used for Open Access networks for the public (such as through FiberAfrica), and in-return the company can get free connectivity for internal and Internet needs, without the expense and headache of operating a telecommunications facilities. They would also be paid for the costs of the fiber.

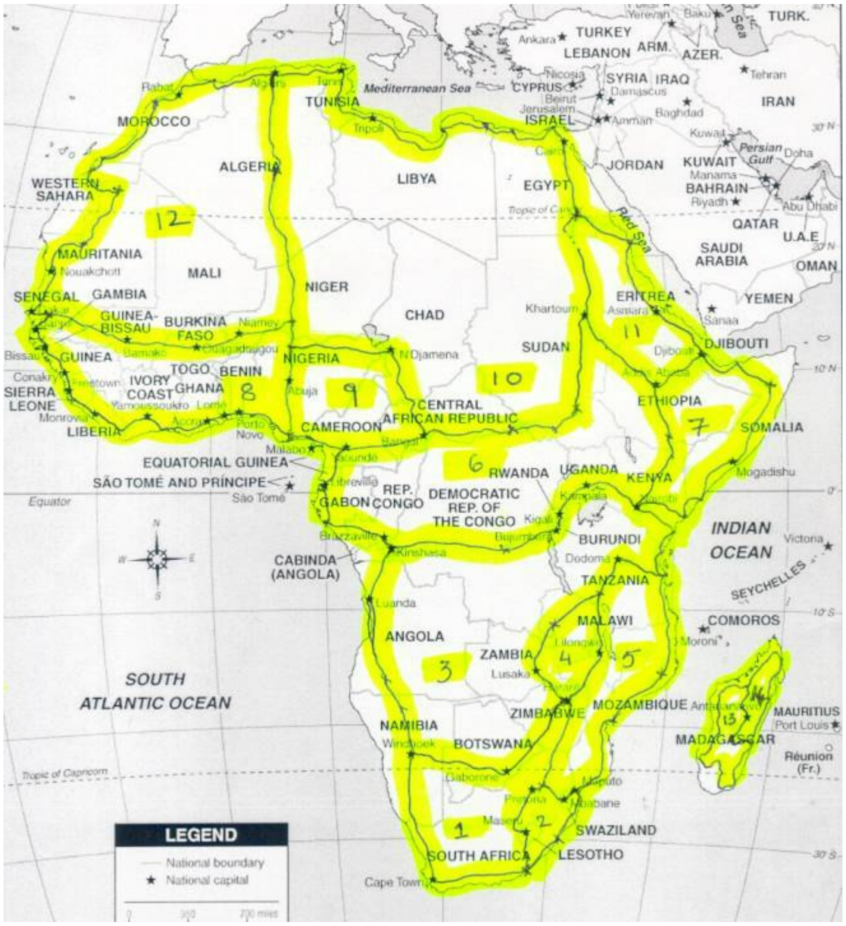
## **Appendix I**: WSIS Summary of Targets

| | **Target** | **FA Addresses?** |
|---|---|---|
| 1 | To connect villages with ICTs and establish community access points. | Yes (community access points themselves will be set up by entrepreneurs and others; FA enables these) |
| 2 | To connect universities, colleges, secondary schools and primary schools with ICTs. | Yes |
| 3 | To connect scientific and research centers with ICTs. | Yes |
| 4 | To connect public libraries, cultural centers, museums, post offices and archives with ICTs. | Yes |
| 5 | To connect health centers and hospitals with ICTs. | Yes |
| 6 | To connect all local and central government departments and establish websites and e-mail addresses. | Yes (FA enables the implementation of e-governance) |
| 7 | To adapt all primary and secondary school curricula to meet the challenges of the Information Society, taking into account national circumstances. | Indirectly (FA enables knowledge-centric curricula) |
| 8 | To ensure that all of the world's population has access to television and radio services. | Indirectly (countries can leapfrog to digital information services, carried over FA). |
| 9 | To encourage the development of content and to put in place technical conditions in order to facilitate the presence and use of all world languages on the Internet. | Yes (FA encourages local content) |
| 10 | To ensure that more than half the world's inhabitants have access to ICTs within their reach. | **YES** |

## Millennium Development Goals

| | **Goal** | **FA Role** |
|---|---|---|
| 1 | Eradicate extreme poverty and hunger | Indirect |
| 2 | Achieve universal primary education | Direct |
| 3 | Promote gender equality and empower women | Indirect |
| 4 | Reduce child mortality | Indirect |
| 5 | Improve maternal health | Indirect |
| 6 | Combat HIV/AIDS, malaria, and other diseases | Indirect |
| 7 | Ensure environmental sustainability | Indirect |
| 8 | Develop a global partnership for development | Direct |

**Appendix II: FiberAfrica Preliminary Design and Features**




*Salient Features*

Core network estimate (shown): 70,000 km

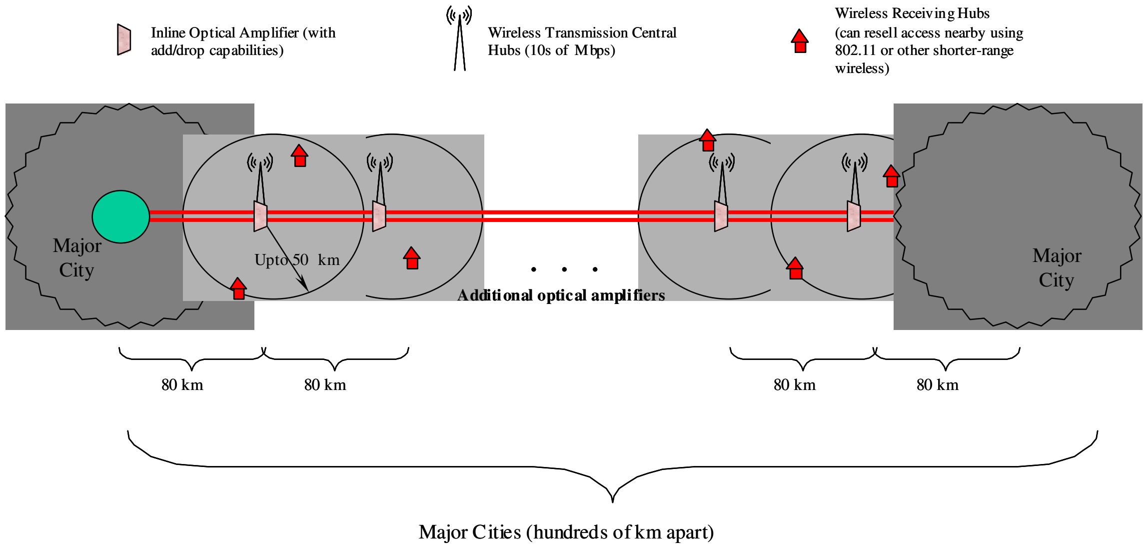
Regional Fiber Spurs (to reach other major areas not in yellow and to connect Wireless Hubs): 30,000 km

~ 400 population centers are connected, including all capitals and larger cities.

The links shown are largely along major roads, which thus cover many population centers. Preliminary GIS modeling indicates good penetration of this fiber/wireless hybrid design.

Fiber (including laying) is roughly half the capital costs – implies most expenditure can have a long amortization horizon.

**FiberAfrica Access Model – Wireless with Optical Fiber Interconnection**




**Generic Model for FiberAfrica Core**

This figure shows a generic model for the fiber and wireless system. Major cities are typically hundreds of kilometers apart, and connected using Dense Wavelength Division Multiplexing (DWDM) technology, which can carry terabits of data per second if required. Cities include extensive fiber and wireless networking, equipment for which is not shown in the diagram. Along the route, optimized to cover the greatest population at lowest cost using GIS modeling, networking equipment (optical amplifiers) are required every ~60-80 km to amplify the signal. These locations become ideal sites for wireless transmission central hubs (*potentially* through 802.16 technology – "WiMax"), which can spread a very high speed signal over a 30-50 km radius (with line of sight). These can be picked up by receivers either for direct use (schools, libraries, government, select users, etc.) or can be resold by entrepreneurs, perhaps through complementary wireless technologies such as 802.11 ("WiFi") or simply community access centers. This design can reach a significant share of the population, since a sizeable fraction of the population lives in or relatively near bigger cities. This also bypasses many issues of uplinking that traditional designs (PTT-centric) face, which rely on a third party to interconnect sites, and it allows much higher speeds than typical links, which are often at most a few megabits per second.

While WiFi is very inexpensive, it is not necessarily the best technology for a next-generation network. WiMax has been designed specifically for wide area networking (with features such as interference robustness, no requirement for line-of-sight, multiple frequency possibilities, etc.), and is approaching commercialization. With volume, we expect prices to fall dramatically (similar to 802.11's price trends, shown below), even though our business model assumes 2004 prices, conservatively.[26]

[26] The design does not assume breakthroughs in wireless technologies, even though some might be realized within a few years, including smart antennae (MIMO), mesh networks, and software defined or cognitive radios. We assume medium-range coverage for a central wireless hub, not the "best case" scenarios touted by proponents. We similarly assume 2004 technologies and costs for other network components.

Wireless Cost Trends – The example of 802.11

| | Cost Per Node ($)* |
|---|---|
| 1997 | 800 |
| 1999 | 400 |
| 2000 | 200 |
| 2001 | 100 |
| 2002 | 50 |
| 2003 | 20 |

*Compiled from various sources*

** These costs are for the electronics including packaging and power supply, but exclude any external antennae or towers.*

While WiMax based Central Hubs will cost significantly more, the receiver costs should fall significantly from the hundreds of dollars today. Declines in such costs are important since these are borne by the receiving entities. However, we are unlikely to see similar volumes (or low prices) like WiFi.

**Appendix III: Business Models for FiberAfrica**

The most importance business design feature of FA is the dramatically lower price of connectivity for consumers—there is no lower barrier to usage than free connectivity. Given the ample bandwidth (tens of gigabits in the core, operational from day one) and deep penetration, the population can enjoy free basic (limited) access through kiosks, while paying categories of users also enjoy lower costs from the economies of scale and scope.

*Capital costs:* The capital costs of less than 1 billion dollars[27] can be amortized over 20 years, with capital costs coming to about 80 million dollars annually. Even this amount need not be spent all at once, but over 2-5 years as the network expands with regional and spur networks.[28]

*Operating Costs:* If we assume that donor agencies and countries themselves provide the capital expenses, or a large fraction of these, then only the operating costs must be recovered from users. Failing operating costs recovery, taxpayer and/or aid money would be required for the operating expenses, of about 90 million per year, which is not envisaged. This figure is conservative and includes all costs such as international connectivity, maintenance, upgrades, salaries, extensive R&D, insurance, rent, electricity, etc.

Some fraction (perhaps 1/3) can be recovered through "power" users (such as niche software companies, multinationals, etc.), who would receive bulk connectivity to the high-speed FA network. In reality, such users could actually pay *significantly* more, given the usage and price statistics of today. (Using FA for aggregating and transporting traditional voice traffic alone could justify a significant portion of the investment, but we exclude such calculations for the time being given regulatory and policy uncertainty). The remaining 2/3, or 60 million dollars, could be recovered from the users. 2,000 wireless transmission hubs could cover about 1,000 sq. km. each, and each hub would reach, say, 10 public use users (schools, libraries, govt., etc.) and 10 community access centers/resellers/kiosks (conservatively). The public users could receive free access, as the government pays a nominal charge for the connectivity, equal to the marginal costs, which would still be significantly lower than today's costs paid by the government. Assuming 1,000 students/users per year (only!) per large school or library, that implies only $1 per user per year as costs towards FA (paid by the governments), raising 20 million dollars per year.

If we have, say, 20,000 community access centers throughout Africa, each of these could provide services to hundreds of users per year. One innovation for FA would be that users could use basic services (limited email or Internet access) for free. They would register to become users of FA,[29] paying a nominal amount (say, $5) for a pre-paid card.[30] Then,

[27] The capital costs as calculated are conservative. Equipment is costed using 2004 prices, and much lower labor costs for installing optical fibers have been seen in countries like India.

[28] On an annualized basis, the investment would be only on the order of 1-2% of the telecom investment in Africa today (as per ITU data). Even when factoring in end-user equipment, etc., this would still be only on the order of a few percent.

[29] This would also allow greater authentication and security for the network, a major issue for countries with limited cyber security infrastructure or policies. Of course, traditional access similar to Internet Cafes

beyond limited usage or if they used value-added services (such as downloading a movie or making a phone call that ends at a traditional phone line), they would pay nominal charges for these. A fraction of the pre-paid charges would be given to the kiosk/community access center to cover their costs. Even when people use value-added services, the aim is for their total expenditure to be about 2% of their salary, which is affordable. (In contrast, we note that in the US, the average spending on ICT and media has remained constant for many decades at about 6% of earnings, while the global fraction on ICT alone has grown to nearly 3%[31]). Using the African average of about $675/capita (with great variance amongst regions), just 2% implies about $14/year expenditure for such services.

Given that the entire population will not access FA, if we assume just the subscribers are counted, then to cover the remaining 40 million dollars of operating costs (assuming no end-user charges for public users and casual users) implies the value-addition charges of only $2/year must be paid by about 1,000 users per access center (on average), which seems realistic ($2/user, 1,000 users/access center, 10 kiosks/wireless transmission hub, 2,000 hubs across Africa). In practice a higher number would be recovered from end-users (target $14/capita), the bulk of which would go to content providers and to kiosk operators. Even this is modest, given we are not targeting the average person in Africa, but a select group of about 20,000,000 regular *users* (2.5% of the population); the potential users are much higher, and usage can grow over time into the tens of percentage. This target expenditure by a few percent of the population is very reasonable, when we consider that the ~7% of the population in Africa using *telecom* today pays on the order of $300 per user annually (excluding expenditure on *information*).

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of today would also be available, but would cost more than the proposed system (but still less than Internet Cafés of today).

[30] The use of prepaid cards has widespread acceptance in Africa, e.g., for mobile phones. Such a system might be linked to a universal cash card, usable for other economic transactions such as utility bills. The kiosk operator could sell such cards, retaining a percentage for his operating costs.

[31] http://www.itu.int/ITU-D/ict/publications/wtdr_03/index.html

Potential breakdown of annual cash flows (FA), at a continental scale:

| | Annualized requirement (US$ Millions) | Notes/Assumptions |
|---|---|---|
| Capital Costs | 80 | Paid by donors with long-term amortization |
| Operating Costs (recovery) | 90 | All-inclusive |
| *breakdown* | | |
| Donors | 0 | Virtually free connectivity in return for their grants; Future donations are for capacity building, content, and end-user equipment (e.g., computers for schools) |
| Governments | 0 | Virtually free connectivity in exchange for “buy-in” through appropriate policies/regulations and other in-kind contributions such as rights of way, spectrum availability, etc. |
| Public Users (schools, libraries, hospitals, etc.) | 20 | Paid by governments; tens or hundreds of times lower costs than today; higher recoveries from “power” users can reduce government contribution requirements, and donors could assist with such payments for select countries |
| Shared end-users | 40 | If there are 20 million total users, they would pay only $2/year as allocated access charges *for value-added services*; Actual individual expenditure would be higher to cover cost of kiosk operator, content, etc. |
| Commercial Users | 30 | If there is modest growth of such users, including retail (urban) ISPs, this sector’s revenues can grow enormously; Excludes any potential revenues from voice transport (subject to regulations) |

This FA model differs from the typical Internet models of today, whereby users pay much higher costs for bandwidth, but with applications driven at the edge (the network is a “dumb connection”). By enabling (virtually) free basic access, this will allow much greater content creation and utilization. Of course, people could buy bandwidth like traditional models, but the upfront costs would be much higher (not to mention they would face greater hardware costs).

Another benefit of charging based on usage (and not dumb pipes) is we can incentivize local content. If people wish to download digital libraries (books) from the US instead of local content, they would simply pay a little more for that service, either under the application value-add model, or the traditional bandwidth usage model, which in FA differentiates between users and types of usage. This approach makes it easier to provide

Quality of Service based applications, moving beyond the best-effort Internet of today. Based on this, we can make downloading educational programs free, while downloading the newest hit song or movie something users pay for. This also helps reduce the need for greater international connectivity, which is an expensive link (along with optimized design, local data centers, etc.)

We can see there are multiple models for revenues, and some of these may realize greater earnings than others. All of these are plausible, and some combination of these can provide not only operating costs, but even capital costs (over time).

## Appendix IV: Next Steps and Action Items

<u>Key Stakeholders:</u>

1) Nepad (Proposed) – e-Commission has a mandate for such initiatives
2) World Bank/Donors – World Bank might play a lead in funding organization
3) UN ICT Task Force – help interface with other development entities and other initiatives
4) ITU – technical, regulatory, and standards issues; network design and operation can be independent, however
5) Academia, Industry, Civil Institutions, and NGOs – selective
    a. Several academics interested in supporting the design and deployment; we have already done extensive design and planning thus far
    b. Intelsat or other operator(s) in the commercial sector
    c. Funding for content, schools, etc. and capacity building
6) Beneficiaries / Development groups
    a. FAO – Agriculture, nutrition, and food security are priorities
    b. WHO – HIV, malaria, nutrition, etc. are priority areas
    c. UNESCO – education, training, and capacity building
    d. UNDP – Overall development

While this is a broad list, a handful of these are more critical than others. The subsequent agreement(s) must bring in all the relevant countries within Africa.

<u>Action Steps</u>

*(Not necessarily sequential)*

1. Creation of Detailed Business Model and Network Design
    1.1. Validate the order of magnitude indicated and prepare initial project document.
    1.2. Examine synergies with alternative projects and possibilities to reduce costs through existing infrastructure or Rights of Way.
    1.3. Design the network for scalability, modularity, and cost-effectiveness
2. Decision on FiberAfrica Ownership and Operating Structure
    2.1. Consortium of Countries
        2.1.1. Ownership based on membership, with charges based on a function of some measure of income.
        2.1.2. Countries unable or unwilling to pay their full share can still be a user of the network, but will not receive payments or royalties
    2.2. Technical Operating Body –
        2.2.1. Construction and multi-country coordination processes

2.2.2. Payment for their operating the network, and a mandate (with incentives) to help expand the network aggressively

2.2.3. Recruitment of specialists and training local people

3. Buy-in from Member Countries
    3.1. Agreements on free Rights of Way (RoW)
    3.2. Agreements on Import Duty waivers
    3.3. Agreements on License Fee waivers
    3.4. Agreements on Spectrum Allocation (both licensed and unlicensed)
    3.5. Mechanisms for rapid certification of proposed equipment; can include use of global standards or certifications done elsewhere.
    3.6. Acceptance of disruptive pricing models (e.g., will not extract monopoly rent from users of FA)
    3.7. Commitments for e-governance, e-learning and creating of content
    3.8. Legislation and Institution-building for Digital Information
        3.8.1. Convergence (e.g., allowing IP-based voice)
        3.8.2. Cyber-security
            3.8.2.1. Legislation and Enforcement
            3.8.2.2. Digital signatures
            3.8.2.3. Encryption
            3.8.2.4. Computer Emergency Response Teams
        3.8.3. Content and Intellectual Property
4. Discussions with Funding Entities
    4.1. Donor Countries
        4.1.1. Payment of annualized capital costs as part of development aid
    4.2. Foundations
        4.2.1. Focus on applications, end-users, and niche requirements
    4.3. Vendors
        4.3.1. Standardize equipment for rapid (if not centralized) certification for use in African countries
        4.3.2. Provide equipment and fiber under a Pay-As-You-Grow (PAYG) model, if not direct vendor financing
5. Pilot project(s) spanning one or more countries
    5.1. Selecting countries based on multi-attribute criteria
    5.2. Determining local partners and "champions"