Research Report

License-Exempt Wireless Policy: Results of an African Survey

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Abstract

New radio technologies and public policies have, in many countries, allowed transmission on specific frequencies by individuals without a license. These license-exempt, or "unlicensed," bands (including 2.4 GHz and 5 GHz in the United States and much of Europe) are increasingly used for data and voice communications through technologies such as Wi-Fi. We surveyed all African countries on the regulation and use of these bands to assess the implications of unlicensed wireless for telecommunications and Internet development in Africa. Responses from differing country informants, though mostly from regulators, were received from nearly every country on the continent. Responses showed significant policy diversity across countries, with wide variation observed in licensing and equipment certification requirements, enforcement, and restrictions on power output, range, and service offerings. We argue that this regulatory diversity across the continent inhibits economies of scale and may discourage large entrants. Furthermore, lack of clarity and enforcement discourages innovation and small entrepreneurs.

Introduction

Consensus is building on the importance of Internet usage as a catalyst for international development. While debate continues regarding the urgency of ensuring connectivity in low-income countries,[1] even low-income countries have exhibited firm demand and willingness to pay for basic communications services (Blattman et al. 2004), and there are now strong indications that information and communications technologies (ICTs) have helped developing countries strengthen their health, education, and business sectors (Pitroda 1993, Hawkins 2002). Many challenges remain, of course. Chief among them is finding practical ways to extend Internet connectivity to more areas in the developing world.

The rapid success of wireless telephony in developing countries, combined with ongoing advances in wireless data technologies, suggests that wireless solutions can play a major role in addressing the challenge of achieving greater Internet access. In particular, license-exempt or "unlicensed" wireless technologies—designed to use spectrum in a shared fashion, without need for exclusive licensing—may be especially important in the developing country context. Equipment based on unlicensed wireless local area network (WLAN) technologies, such as the Wi-Fi (IEEE 802.11b) standards, are now widely available commercially, inexpensive, and require little technical expertise to install (Carter et al. 2003). Such

**The findings, interpretations and conclusions expressed here are those of the author and do not necessarily reflect the views of the World Bank.*

1. Some argue that there is currently neither a solid theoretical basis nor convincing empirical evidence to support huge optimism. See for example Eggleston et al. 2002.

equipment can be used to create wireless data networks without investing time and money in acquiring a spectrum license up front, or without depending on a telecommunications operator for use of the airwaves. By lowering costs and reducing entry barriers, unlicensed wireless potentially enables a larger and more diverse set of actors who can provide Internet access. In particular, low entry barriers should prove friendly to entrepreneurship. Indeed, a number of small-scale, locally-based projects and entrepreneurial vendor and solutions companies have already targeted developing countries using unlicensed wireless technologies.[2]

Realizing the potential of unlicensed wireless more broadly, however, depends critically on how regulators in developing countries approach this technology. As Qadir (2002) discusses, regulatory capture is a particular problem in developing countries, with regulators sometimes favoring the incumbent operators and their interests, for example by delaying the licensing process or denying licenses altogether for smaller players. To make matters worse, especially in countries where the telecommunications infrastructure is state-run, high spectrum licensing fees are put in place, with an eye to the immediate needs of the state treasury (Beardsley et al. 2002). These structural factors contribute to high license-related barriers to entry. Unlicensed wireless has the potential to greatly reduce license-related barriers and, thus, significantly improve the prospects for wireless network deployment. Regulatory capture may not disappear entirely, however. We therefore found it interesting to ask how far licensing-related barriers have actually been reduced in developing countries—specifically in Africa—for the 2.4 and 5 GHz spectrum bands most commonly used for unlicensed wireless transmission.

We were able to find only very limited information about the regulation of these bands around the world. In 2003 the ITU introduced a new, general question in its annual survey to regulators, regarding the policy for WLAN licensing.[3] Responses are limited and incomplete, however, particularly in the context of Africa.[4] The U.S. State Department has also collected information about the use of WLAN; however, its data are confidential (Lamb, e-mail, December 2003). The Global Internet Policy Initiative (GIPI) has issued a document describing policies in four countries: United States, Nigeria, Bulgaria, and India (GIPI 2002). More generally, there is quite a bit of literature discussing spectrum policy reform and advancing radio technology, but it rarely focuses on the developing country context.[5] Exceptions can be found. The Wireless Opportunity Initiative, with the UN ICT Task Force, held a conference in June 2003 on "The Wireless Opportunity for Developing Countries" (W2i 2003). The ITU has also addressed the role of wireless technologies in development (Best 2003).

To fill this gap, we conducted a survey of African countries to understand their policies toward the 2.4 and 5 GHz bands. The following section describes the survey methodology. Briefly, we surveyed mainly regulators (though not exclusively), and asked whether countries required any form of license for use of these bands, and what conditions of use (such as power and range limitations) applied. Further, we asked whether the bands are in use in each country, and if so, for what types of applications.

The third section details the key findings from the survey responses. They show a significant diversity in the regulation of these bands across Africa. Not only do licensing requirements and conditions vary widely from country to country, so do power, range, and service restrictions, as well as equipment certification requirements. Indeed, we find that as the burden of licensing for transmission on these bands is relaxed, there is often an increase in restrictions on power, range, or type of service. Further, we find that regulation is still not in place in some countries and is changing in others, while enforcement is often minimal in countries where regulations do exist. This diversity in regulations notwithstanding, these bands are indeed being utilized for wire-

2. A list of selected projects, companies, and related resources can be found at Neto 2004: 20.

3. In the 2003 survey the ITU asked regulators: Is there a policy for licensing Wireless LAN (e.g., Wi-Fi 802.11)? If Yes, explain (ITU 2003).

4. ITU World Telecommunication Regulatory database, based on responses to 2003 regulatory survey, obtained from Nancy Sundberg, ITU.

5. For example, the New America Foundation advocates unlicensed wireless, but focuses mainly on the U.S. context (Snider 2003; Snider and Holmes 2004) For a sense of the debate over whether spectrum should be treated as private property or a commons, see Cave 2002; Benkler 2002; and Kwerel and Williams 2002.

less Internet services in most African countries, often providing "hotspot"-style coverage in urban areas, but also in some settings providing infrastructure coverage over larger areas. A significant 37% of the countries that responded to the survey use wireless technologies operating in these bands for backhaul network connectivity in rural areas.

The fourth section discusses the policy implications of these findings. In particular, we argue that the significant diversity in regulations across the continent inhibits economies of scale and may discourage large entrants. Furthermore, the lack of clarity and enforcement discourages innovation and small entrepreneurs. To address these concerns, we propose that the New Partnership for Africa's Development (NEPAD), working with regional economic communities and international players, work to harmonize spectrum regulations across the continent and build personnel and enforcement capacity. These harmonized regulations should accommodate and encourage license-exempt transmission over the standard 2.4 and 5 GHz bands.

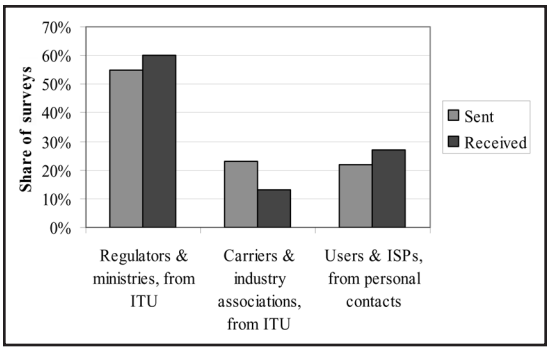

Figure 1. Percentage share of survey targets.

Note: The total number of sent and received surveys is different, and therefore the columns in the figure show the relative difference in percentage, and not in actual number of surveys.

Methodology

The survey asked three groups of questions about the unlicensed bands, using both multiple-choice and open-response formats:

- Rules for spectrum licensing and enforcement in the 2.4 (specifically, 2.4–2.4835) and 5 (specifically, 5.15–5.35, 5.47–5.725, and 5.725–5.875) GHz bands;
- Motivation, rationale, and origins of these regulations;
- Implementation and experiences of use.[6]

We sent the survey via e-mail to about 260 contacts in all 54 African countries.[7] As Figure 1 shows, most of the e-mail addresses came from the ITU Global Directory of member states (i.e., ministries and independent regulators) and sector members (i.e., telecommunications operators and industry associations).[8] We focused primarily on regulators, expecting them to have the most up-to-date information on spectrum allocation, assignment, and licensing rules. In countries where we were unable to find a contact for a regulator, or no regulator responded, we focused on sector members. We derived supplemental contacts for many countries from two other sources:

- Participants in the ITU Telecommunication Development Bureau's 4th Annual Global Symposium for Regulators;[9]
- Personal contacts with knowledgeable individuals and associations working in the field of telecommunications and Internet connectivity in Africa (see Acknowledgments). These contacts were particularly helpful in reaching Internet users and service providers (ISPs), whose perspective we especially sought on the implementation and results of government policies.

Using e-mail to distribute the survey exposed the communication challenges of the African continent. In some cases, frequent power or equipment failures

6. Details about the survey methodology, including the questions asked, contacts, and responses can be found in the appendices of Neto 2004. The survey and telephone contacts were conducted in English, French, and Portuguese, according to the official language of each country.

7. This counts Western Sahara as a separate country. However, this territory is under de facto control of Morocco. According to the Moroccan regulator, the Moroccan survey results include this territory.

8. This directory is accessible from the ITU Web site, http://www.itu.int/members/

9. This workshop was held December 8–9, 2003 in Geneva, just before the World Summit on the Information Society. Participants are listed at http://www.itu.int/ITU-D/treg/Events/Seminars/2003/GSR/Documents/Participants-Final.pdf

were cited as a reason for delayed responses, with e-mail or other servers sometimes down for several weeks at a time. In other cases, e-mail simply was not checked regularly. In addition, around 20% of the e-mail addresses used proved outdated or otherwise invalid. Follow-up telephone contacts, fax, and postal mail were therefore essential to the survey's successful response rate. Between January and April 2004, surveys were returned by 20% of those contacted, representing 47 of the 54 African countries. Thus the per-country response rate was nearly 87%, or 97% when weighted by population.[10]

The highest response rate came from regulators, which was also the largest group contacted. As a result, the survey yielded more detailed information about regulatory policies and less about experiences of use. The next section presents the results of data which we analyze with summary statistics, cross-sectional analysis across countries, and correlations with per-country telecommunications and general governance indicators.

Key Findings

This section describes the main survey findings about the regulatory regimes in African countries for the 2.4 and 5 GHz bands and their use. The results show significant heterogeneity in the regulatory regimes among the countries. Some of this heterogeneity is to be expected. In some countries for example, these bands are regulated as unlicensed, whereas other countries require the issuance of a license to operate; there are also differences in the enforcement capability. There are a wide range of other dimensions that can also differ. For example, countries establish different restrictions on power or range, some countries apply different rules for different players, or some apply special restrictions (e.g., to voice services).

Along with significant diversity, this scenario points to the general uncertainty and confusion associated with the regulatory regimes of the 2.4 and 5 GHz bands across Africa.

"Unlicensed" Has Various Meanings

From the survey's responses we find that the licensed/unlicensed categorization means different things in different countries across Africa. The regulatory regimes in place across the continent can be grouped in the categories shown in Table 1.

The six categories defined in Table 1 constitute progressively more restrictive licensing categories, and are used to categorize the licensing regimes in place[11] as shown in figures throughout the paper. Figures 2 and 3 show the licensing regimes in place in the different African countries for the 2.4 and 5 GHz bands, respectively. These figures illustrate the significant diversity that exists across the continent.

It can be seen in the 2.4 GHz band that 19% of the countries allow unlicensed use, but require a registration (15% for the 5 GHz band). Exceptions for the 2.4 GHz band are Rwanda, Lesotho, and Tunisia. It is significant that unlicensed bands, as they are normally thought of in the United States (i.e., no license or registration required), only exist in Africa in these three countries (6% of Africa) for the 2.4 GHz band, and two countries (4%) for the 5 GHz band. These are extremely low values. As for licensed use, license attribution is mostly automatic on payment of a fee[12] (~40% of total countries for both 2.4 and 5 GHz bands).

The different categories and the diversity in regulation appear particularly surprising when considered in conjunction with another finding from the survey, namely, that 59% of the countries say they base their regulations on the same source: the ITU. While some countries also cite other institutions—including other countries (11%), CEPT/ERC, ETSI, or the FCC[13] (all with 7%)—as a basis for the regulation adopted, the ITU is by far the largest source. Even within the group of countries relying on the ITU, however, a wide variety of regulatory policies have

10. The following countries did not respond: Djibouti, Equatorial Guinea, Guinea-Bissau, Libya, Republic of Congo (Brazzaville), Sierra Leone, and Swaziland. Only a partial response is available for Zimbabwe.

11. The distinction between the "Unlicensed regime with registration" and the "Licensed automatic regime" is mostly the issuance, for the latter, of a formal license and authorization, and often a more cumbersome process, implying the payment of a fee. However, in Kenya, which is under the "Unlicensed regime with registration," payment of a fee is still required.

12. For Botswana, some minimum conditions may still apply.

13. CEPT/ERC (European Conference of Postal and Telecommunications/European Radiocommunications Committee) are European regional organizations dealing with telecommunications issues; ETSI is the European Telecommunications Standards Institute; FCC (Federal Communications Commission) is the U.S. regulator for the communications sector.

Table 1. Categorization of Regulatory Regimes Across Africa

Regulation	Explanation and examples
No regulation or regulator	De facto unlicensed because of a regulatory vacuum. For example, in Somalia and Liberia there is no regulator. In Mali, the regulator is currently being set up, but no regulation is in place yet.
Unlicensed (no registration required)	Users are granted a general authorization to operate in the bands, provided they follow certain guidelines for power, range, etc.
Unlicensed, but registration required	Same as above, but regulator may require the users to register. This is generally a simple process (requiring only an address). Payment of a fee is generally not required, but there are exceptions (e.g., Kenya requires payment of a small fee).
Licensed, but automatic on payment of a fee	Users are granted a general authorization to operate in the bands, provided they follow certain guidelines for power, range, etc. In general, in licensed regimes the regulator authorizes the use of the bands by issuing a license. This is normally accompanied by the payment of a license fee. In this particular case the authorization is granted automatically (i.e., in practice it is a tax). Even when licenses are granted automatically, there are cases where some minimum conditions apply. In Botswana, for example, to apply for a license the operators have to be registered in the country and present a business plan.
Licensed, not automatic	Same as above, but license allocation is not automatic. Operators have to go through an application process and fulfill certain conditions. The regulator can limit the number of licenses attributed.
Use barred	This is the case of Zimbabwe where, since the beginning of 2004, the regulator has banned the use of these bands. The 2.4 GHz band had been uncontrolled and used extensively for data links to ISPs and within commercial organizations. According to the information gathered, as of the end of January 2004 ISPs can no longer operate in this band.

been implemented (Figure 4). This outcome highlights the nature of the ITU's harmonization role to date for the 2.4 and 5 GHz bands, which has simply been to recommend that radio communications equipment operating in these bands must accept any interference caused by industrial, scientific, and medical (ISM) applications.[14] The ITU leaves the specific licensing regime for this type of equipment up to each nation.[15]

More "Unlicensed" Bands Face More Limiting Technical Restrictions

The survey results further show that the more "unlicensed" the bands, the more technical restrictions are imposed that limit their application. This means that information about licensing will not, on its own, properly characterize the possible uses of these bands; that is, the fact that a band is unlicensed does not necessarily mean that access or use is easier, since regulation can be accompanied by specific restrictions for use, for example in terms of power and range. One of the responses to the survey, for example, describes the situation where use is unlicensed, but "if one intends to use either band beyond the boundaries of one's property, it's illegal."[16] It is therefore important to understand which kind of restrictions accompany the regulations.

Technical restrictions can be applied in many different ways. Use can be restricted, for example, by limiting the power, or circumscribing the allowed range—by limiting it to indoors, to the bounds of a particular property, etc. These two are obviously related, since power will determine the range and vice versa.

14. The most common ISM device in the 2.4 GHz band is the domestic microwave oven.
15. This is true for the 2.4–2.5 and 5.725–5.875 GHZ bands. The additional 5.15–5.35 and 5.47–5.725 GHz bands were allocated at the 2003 World Radio Conference for mobile service use for the implementation of wireless access systems (WAS), including radio local area networks.
16. Contact with ISP in Namibia.

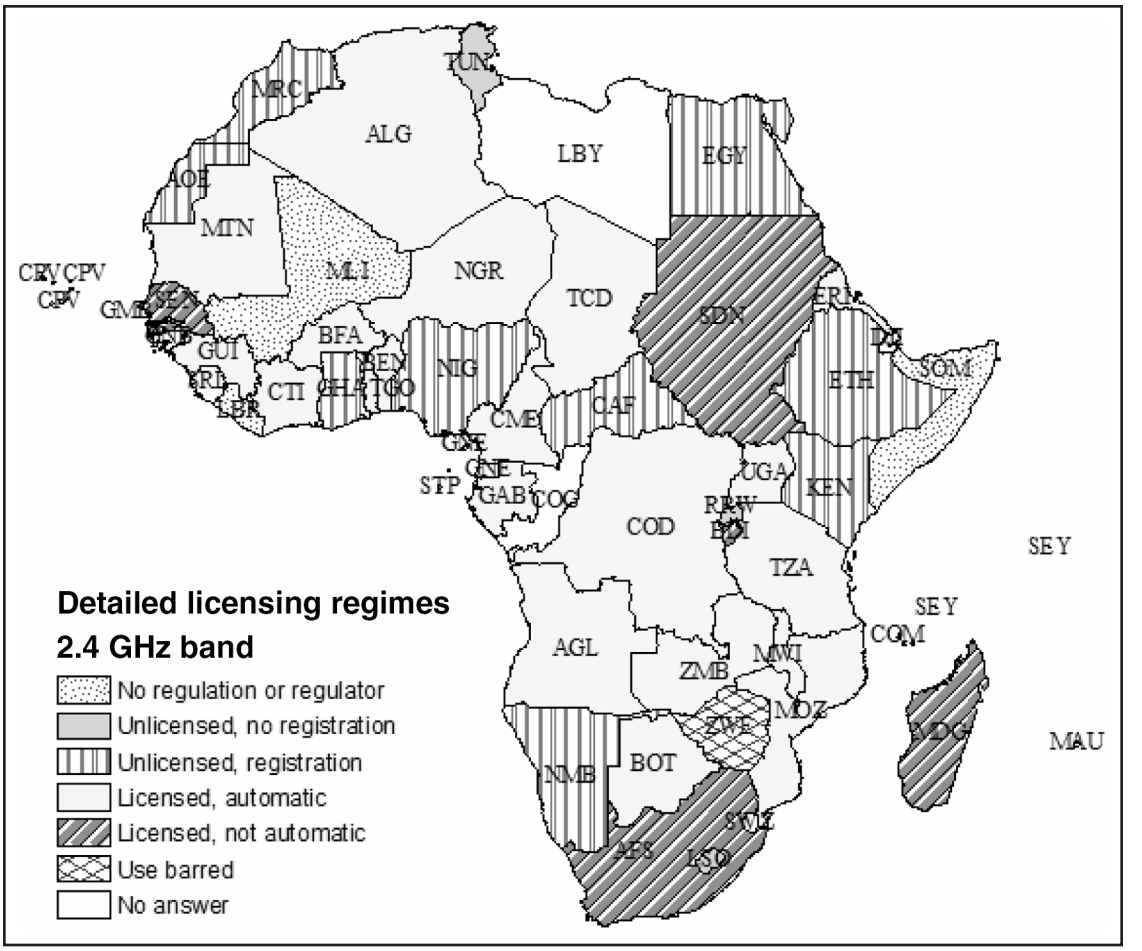

Figure 2. Map of licensing regimes—detailed categories for the 2.4 GHz band.

The manner in which country-level information from the survey is reported makes it difficult to catalogue restrictions precisely. It is, however, possible and useful to study the "restrictiveness" trend between unlicensed and licensed bands. Are power and range more limited, in general, for unlicensed bands? To answer this question, we have defined categories for both power and range restrictions. These are indicated in the vertical axes of Figure 5. The groupings defined are constructed and do not intend to represent a particular distribution. The objective is purely to allow for comparison—within the same category (power or range) of the levels of restrictions in different countries. The power restrictions are defined in terms of the maximum allowable Effective Isotropic Radiated Power (EIRP), measured in Watts.

The data from the survey were used to calculate average values of power and range restrictions associated with the different licensing regimes. Figure 5 shows the trend of "restrictiveness" across licensing types for the 2.4 GHz band. From the graph we can see a trend toward allowing higher power and longer range as more license barriers are imposed upfront.

Even when accounting for standard errors (see Figure 5) and computing significance (Neto 2004), this trend still holds for both power and range; that is, higher power and longer range are allowed as more license barriers are imposed upfront. The same analysis was done for the 5 GHz band. The 5 GHz band is less restrictive than the 2.4 GHz band in terms of power, which matches the differing propagation characteristics for these frequencies. The

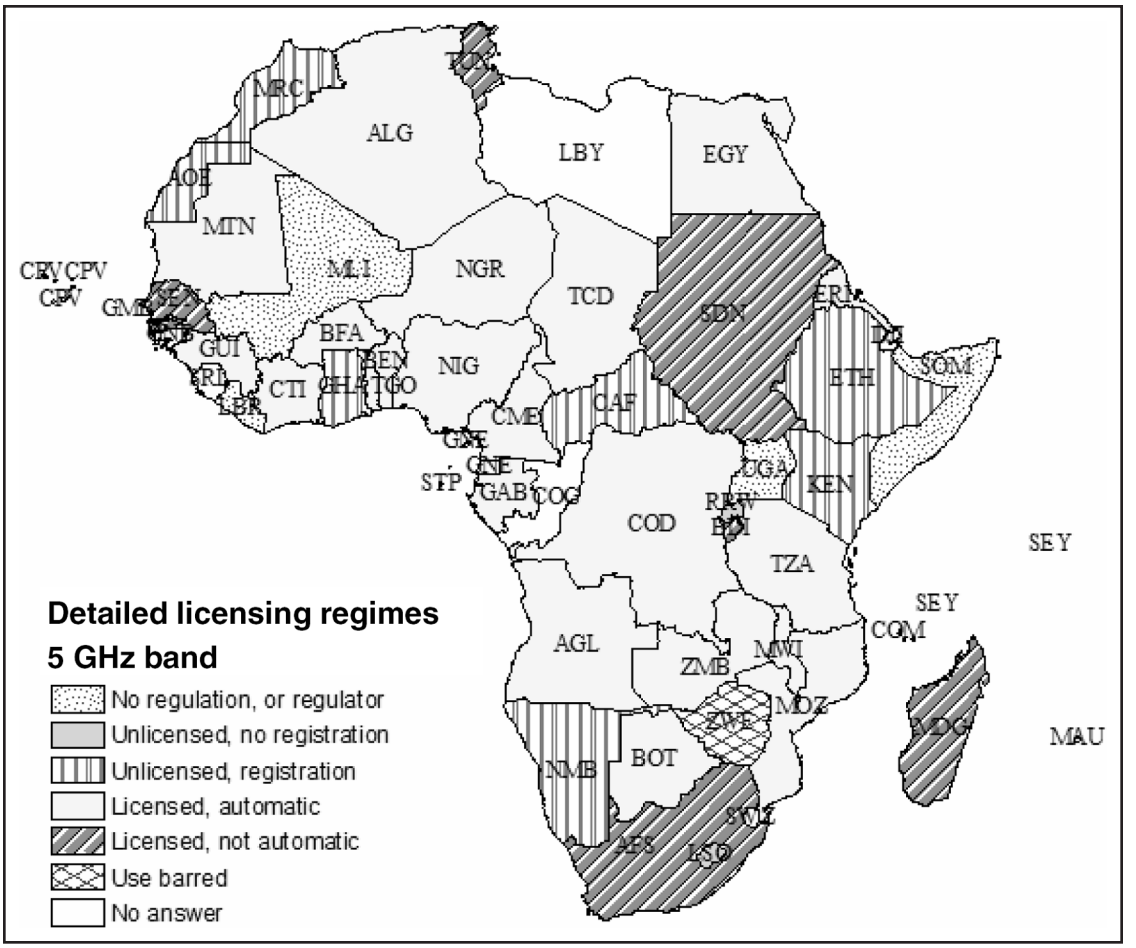

Figure 3. Map of licensing regimes—detailed categories for the 5 GHz band.

same trend holds in the 5 GHz band, although results are only significant for the power values.

This is an important result, since it suggests that the African countries that use unlicensed regulation tend to place a burden on the conditions for band use. One could argue that this is justifiable, for instance, when relaxing the licensing regime and permitting more users to coexist in the same band, the regulator needs to tighten technical restrictions to ensure quality of service. It should be noted, however, that the licensed regimes do not imply exclusivity. Indeed, and irrespective of the licensing regime in place, 89% of the countries do not require exclusive use, even when requiring a license. This, coupled with the fact that technology operating in these bands is generally resilient to interference, shows that the stronger technical restrictions placed in more lax licensing regimes may be unwarranted. This further indicates that, should unlicensed bands be perceived as less successful, the reason could be the fact that the associated restrictions are higher.

We also studied the correlation between regulation in these bands and general indicators for the nation and ICT sector.[17] We find that generally countries with lower competition in their local and long distance markets impose more restrictions on use, in particular on power and range. This seems to suggest that the use of unlicensed spectrum is less restricted in African countries that enjoy a higher degree of competition in the telecommunications

17. More details can be found in Neto 2004.

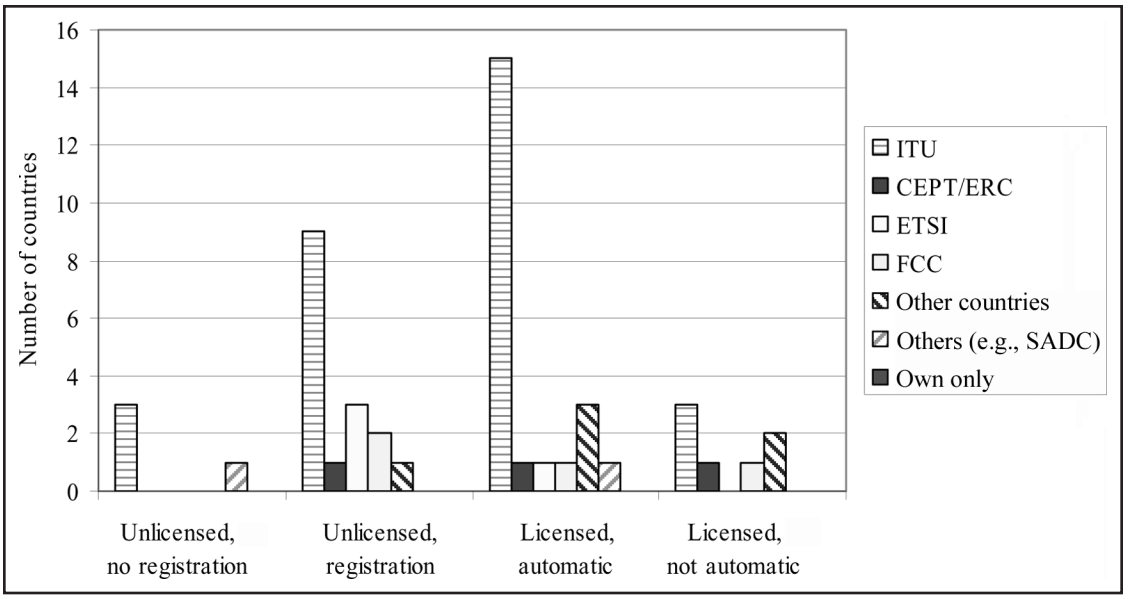

Figure 4. Basis for regulations, by type of licensing.

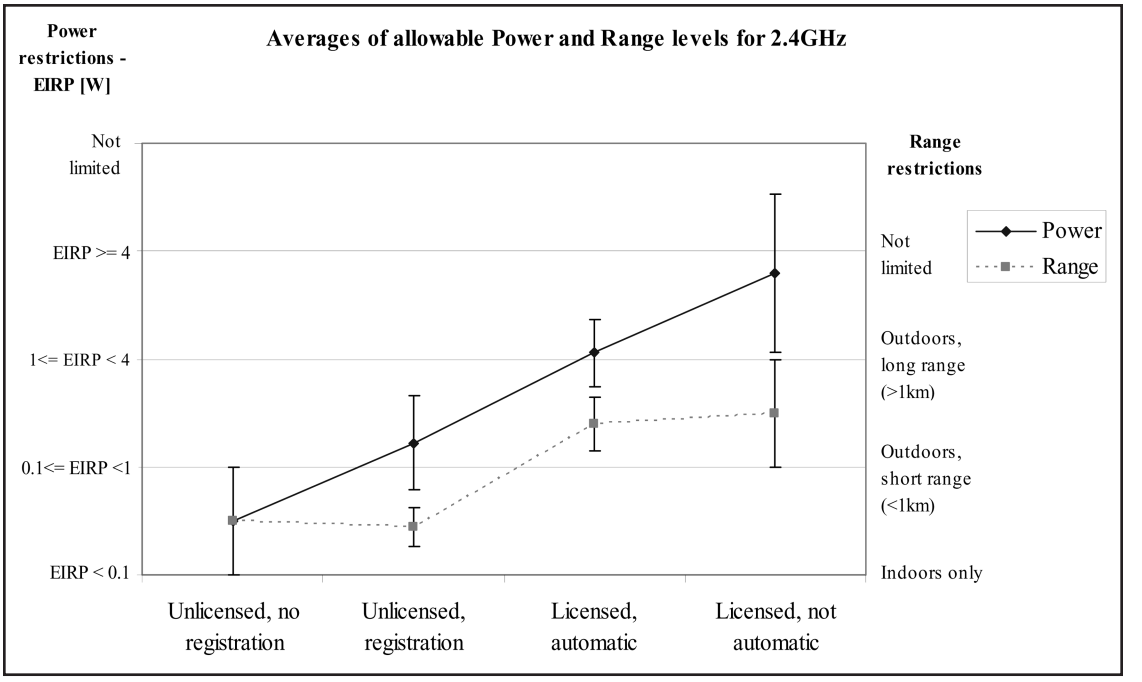

Figure 5. Averages of allowable power and range levels for 2.4 GHz band, by licensing type, including standard error bars.

market, and potentially a lower degree of regulatory capture. Other countries may be using restrictions to control market power and keep barriers to entry high. The effectiveness of entrepreneurship-type solutions may therefore be limited in countries where the degree of competition is low.

Business-Related Restrictions Create a Hodgepodge of Approaches

In addition to the licensing regimes and the technical restrictions imposed on the use of the 2.4 and 5 GHz bands, a variety of other regulatory and business-related restrictions create further heterogeneity and contribute to significant uncertainty in the regulatory frameworks. In this section we will look at some of these restrictions.

Enforcement

An indirect form of restriction is the type of enforcement in place; rules can be very restrictive, but if no enforcement is in place, it is the equivalent of saying that conditions of use are relaxed. The survey results show that enforcement of these rules is limited. The survey asked the regulators if the regulations in the 2.4 and 5 GHz bands were strictly enforced. It also asked whether regulators had the capacity (technical or otherwise) to enforce regulations. Some responses affirmed that regulations were strictly enforced. Nevertheless, some of these regulators lacked the capacity to do it. Figure 6 shows the corresponding results. Even though 50% of the countries contacted say the regulations are strictly enforced, it is significant that only 20% say they have the capacity to do so. Another 30% of the countries state explicitly they do not enforce the regulations.

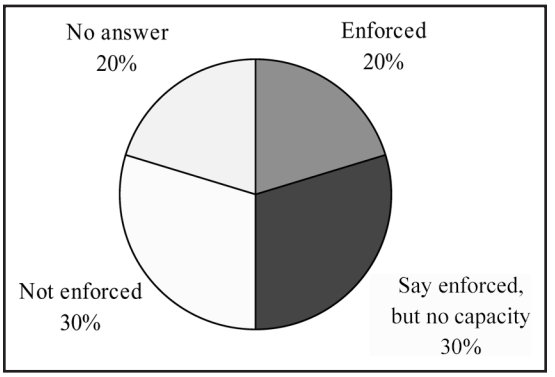

Figure 6. Enforcement, by percentage of countries.

In crossing enforcement data with licensing information for the 2.4 GHz band, results show that enforcement is least intensive for the unlicensed, unregistered regulation. This may indicate that, in practice, regulators choose unlicensed regulation to "wash their hands" of responsibility to monitor or resolve conflicts. For the remaining categories, the more regulated the use, the less enforcement is exercised—the regulator may consider that, by restricting the licensing a priori, it can relax enforcement ex ante.

From the information collected, it seems that in many countries there are significant levels of "illegal transmitters," or transmitters going above the maximum allowable power levels. There are such reports from Gabon, Senegal, Namibia, Cameroon, Angola, and Uganda. This may happen because operators know regulation is not or cannot be enforced. Botswana has advanced an alternative explanation: the significant heterogeneity and uncertainty in regulation may lead to misinformation. Since these bands are unlicensed in some countries, people may believe they are also unlicensed in countries where, in fact, they are not. In other words, heterogeneity may lead to confusion as to what is or is not allowed.

The lack of enforcement has in practice been a problem in some countries, where bands are said to be saturated because users exceed the allowable power levels. According to the survey, this is the case in Cameroon, Angola, and Uganda. Regulators in Angola, Botswana, Cameroon, Gabon, Malawi, and Senegal have stated they are in the process of acquiring appropriate monitoring equipment to reduce the abuses.

Certification

Equipment certification, required in some countries, is another source of difference in regulatory regimes. Certification generally consists of a series of tests to ensure the equipment complies with certain specifications, for example, in terms of out-of-band emission. Both the FCC in the United States (FCC 2004) and the European Union (EU 2004) certify devices in this manner. In some African countries, certification may consist of accepting another country or region's certification approval (e.g., the U.S. FCC or the EU), while other countries may establish their own procedures and requirements. The survey data do not give sufficient information about the

specific de facto certification requirements in the different countries. The fact that some countries do require certification and some do not, however, creates confusion and uncertainty: different certification requirements make it harder for manufacturers and operators that want to operate in different countries to take advantage of economies of scale.

The survey inquired about whether the regulators certify equipment to operate in the 2.4 and 5 GHz bands. At least half of the countries certify equipment for both bands, and certification is higher for the 2.4 GHz band. This result was expected, since equipment in this band is more "mature."

In the United States, certification is used with unlicensed bands[18] and can be seen as a counterbalance to licensing. Figure 7 shows information on certification by licensing categories for the 2.4 GHz band. The trends in the data suggest two combined effects. On one hand, more lax licensing regimes can sometimes be the consequence of regulators that want to "wash their hands" of the problem of ensuring well-functioning bands. This may explain why certification requirements are not strong for the less restrictive licensing regimes. In the opposite direction, since these bands are normally regulated on a "best-effort" or "no Quality of Service (QoS) guarantee" basis, regulators may choose to certify the equipment to operate in these bands to have some control over interference. This may explain the strong certification requirements for the countries with an "Unlicensed/Registration" regime.[19] Results are similar for the 5 GHz band.

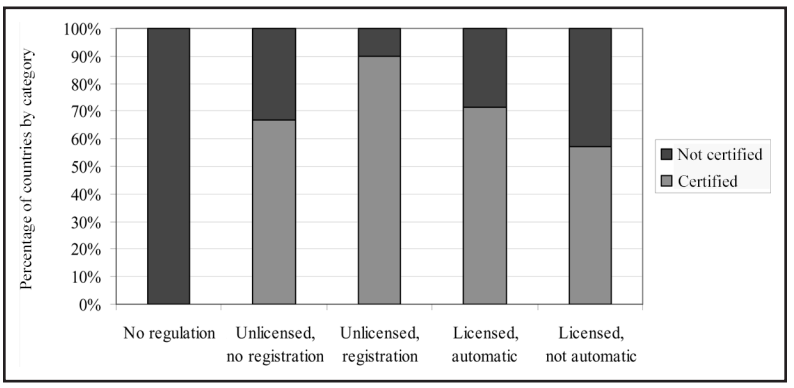

Figure 7. Certification vs. licensing regime for 2.4 GHz band.

Non-Standard Configurations, Heterogeneity, and Additional Uncertainty

In addition to the differences described above, some countries impose special regimes, such as setting different conditions for incumbents or requiring companies to register in the country. For example:

- In Eritrea, the monopoly operator can use the 2.4 and 5 GHz bands freely, while companies such as ISPs must pay a fee.
- In Botswana, despite the fact that license attribution is said to be automatic, some minimum conditions apply: to receive a license, ISP operators must be a registered company in Botswana and must also prove their financial sustainability by providing their business plan.
- In Namibia the bands are unlicensed but any use beyond the boundaries of one's property is illegal.
- South Africa and Mauritius have a tiered regime, with different licensing requirements or fees for different transmitter ranges. In South Africa, use is unlicensed in more restrictive range conditions (within single premises or indoors), while it is licensed beyond those limits (between premises or outdoors).
- In Mozambique the use of the 2.4 GHz band is prohibited for commercial purposes.

The regulatory scenario described speaks to the general uncertainty and confusion associated with the regulatory regimes of the 2.4 and 5 GHz bands across Africa. These regimes are uncertain within each country with low enforcement and are relatively complicated (i.e., with diverse associated restrictions). There are, in addition, other sources of uncertainty. For example:

18. According to Part 15 regulation.

19. For significance analysis see Neto (2004) Appendix VIII. Not all the differences in proportions are significant. For unlicensed bands in particular, results are weak because of small sample size.

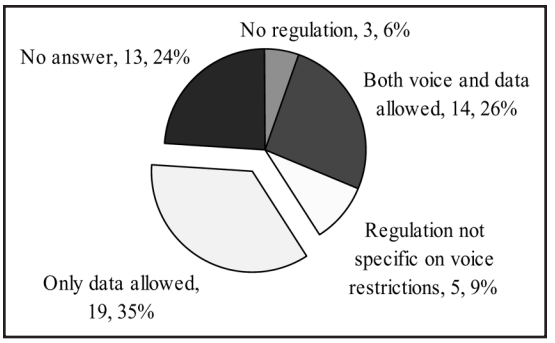

Figure 8. Services restrictions imposed on 2.4 GHz band (number of countries, % of countries in each category).

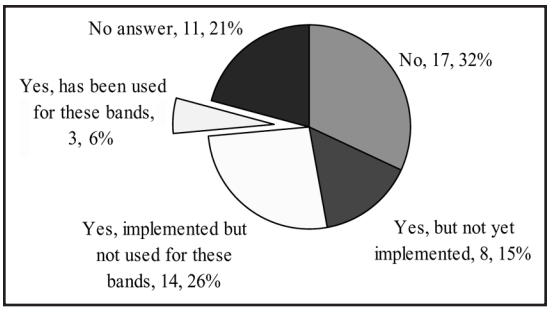

Figure 9. Universal service policies in place and use for 2.4 or 5 GHz bands (number of countries, % of countries in each category).

- The Democratic Republic of Congo (Kinshasa) responded that, although licensing is said to be automatic on payment of a fee, it is difficult to obtain a license, since "there are many taxes to pay" and there is no specific policy in terms of telecom.[20] Congo further mentions that "there have been conflicts between the Telecom and the Media Ministry about regulation and licenses."
- Benin indicated that service restrictions are defined on a case-by-case basis.
- There are reports that in Mozambique the regulator tried to block use of the 2.4 GHz band saying it was illegal, but later it was found that there were in fact no regulations for this area of the communications services (W2i 2003).

Regulation in the 2.4 and, especially, in the 5 GHz bands is relatively recent. In some countries (e.g., Mali, Somalia, Liberia) regulation is not clearly defined, and several countries are implementing regulation or changing the existing regulation. Such are the cases of Guinea, Egypt, Nigeria, and Uganda. The results point to significant heterogeneity of licensing regimes across African countries.

Service Type

Further restrictions can be applied on the type of services to be used by, for example, barring voice services. As can be seen in Figure 8, regulators do bar voice services in 35% of the countries. Not allowing voice services, for example, by barring VoIP, can be a way to protect the incumbent and existing operators by shielding them from competition.

Universal Service Programs Are an Untapped Opportunity

The 2.4 and 5 GHz bands can potentially provide rural connectivity and Universal Service. Given the identified potential for this technology and its low cost, allowing the use of Universal Service funds for wireless projects in these bands may represent a cost-effective utilization of the subsidies. According to the survey, however, Universal Service programs are so far largely an untapped opportunity vis-à-vis unlicensed wireless technologies.

From the countries that replied to the survey, at least 47% have Universal Service policies in place. However, only three responses—or 6% of the countries—mentioned that Universal Service funds have been used to deploy equipment in the 2.4 and 5 GHz bands: Kenya, Madagascar, and Rwanda (see Figure 9).

Possible reasons for this low figure are explained and discussed in the following section.

The 2.4 and 5 GHz Bands Are Used in Most African Countries

Despite the heterogeneity and potential restrictions imposed on these bands, they are used in most African countries. The main users are ISPs, followed by telecommunications operators. There are reports of the advantages of using these bands, such as the low cost and reduced fees and barriers to entry. We find that the most common use of these bands is for "hotspots" or other localized coverage in urban

20. In Congo (Kinshasa) there is full competition in most telecommunications sectors, according to the ITU.

areas. Nonetheless, a significant 37% of the countries that responded use wireless technologies operating in these bands to provide backhaul network connectivity in rural areas. This may point to a particular need that can be met using these technologies.

User Base and Experiences of Use

Some of the technology used in the 2.4 and 5 GHz bands is relatively new. Given the generally low penetration and use of technology in Africa, and the fact that some technology takes time to reach the continent, it could be expected that these bands would have a moderate-to-low use. Responses to the survey show, however, that these bands are actually being used in most African countries. From the countries that replied to the survey, only two (Central African Republic and Ethiopia) do not use either band. Some countries indicated explicitly that only the 2.4 GHz band is currently used.

The ubiquitous use of the 2.4 and 5 GHz bands indicates that they may hold an opportunity for the countries in Africa. Unfortunately, the data gathered do not give enough information about the intensity of use of the bands; we only know whether the bands are being used in a particular country, but do not know whether use is widespread, in-depth, or sporadic.

Low-cost equipment, accessibility, and an opportunity to build an alternative to the incumbent operator may explain the ubiquitous use of the bands. In addition, deregulation of the bands and reduced fees may further lower barriers to entry. In Kenya, for example, the survey reports that:

> Even though, these users must apply for a permit from the commission for the sake of our database and inventories, the fee . . . is minimal US$132. This factor has attracted a great deal of operators into these bands unlike before when they used to be charged approximately US$800.

The main users of the bands are ISPs. More than half the countries (56%) have indicated ISPs as one of the users. Telecom operators are the second-most important users (28%), followed by private companies/networks (24%). Several companies use the 2.4 GHz band to provide connectivity between their buildings or sites.

There are reports that these bands can serve as a viable alternative to leased lines: in Cape Verde the government itself uses the 2.4 GHz band to connect ministries and government sites because leased lines are too expensive. In the Seychelles the 2.4 GHz band is said to compete effectively with leased lines. Senegal mentioned that the lack of reliable infrastructure has led operators to develop wireless solutions to offer quality service to their customers.

Localized Coverage vs. Backhaul Connectivity in Rural Areas

In the United States, the most visible public use of 2.4 and 5 GHz unlicensed wireless technologies has been for "hotspots," set up in urban centers in coffee shops, hotel lobbies, airports, etc. This is consistent with the fact that the most widespread unlicensed radio equipment conforms to the IEEE 802.11 family of wireless local area network (Wi-Fi) standards, designed primarily for short-range coverage (Gast 2002).

Similarly, in Africa the most common use of the 2.4 and 5 GHz bands is for hotspot-style or other localized coverage in urban areas. Nonetheless, a significant 37% of the countries that responded use wireless technologies operating in these bands to provide backhaul network connectivity in rural areas.[21] While some Wi-Fi equipment can be modified to support longer-range connectivity (for example, through the use of directional antennas), it is more likely that such links employ proprietary wireless technologies designed for longer-range (and sometimes point-to-point) connectivity.[22] This result suggests that Africa's need for backhaul connectivity may be even better addressed by wireless technologies in these bands in the future, as longer-range technologies become more standardized and widely available.[23]

21. Unfortunately, the granularity of the survey data is not sufficient to determine who uses the bands for which purpose; we do not know whether it is an ISP or other operator who uses the bands for localized versus wider-area coverage.

22. Examples of proprietary technologies of this sort include CorDECT and products from Motorola (Canopy) and Alvarion. For a summary and more detailed discussion of the different technologies and standards, see Neto 2004.

23. For example, the IEEE 802.16 WiMax standards, being developed as of this writing, are designed to operate in several possible frequency bands, including the 5 GHz.

Regulation serves different purposes. Because enhancing rural connectivity represents an important opportunity for Africa, where a large percentage of the rural population remains isolated from most telecommunications infrastructure, it is important to look at the licensing regimes that favor this type of coverage and ensure that there are no unnecessary or excessive barriers to entry and use in the longer-range market.

Figure 10 breaks down the information concerning the type of use by licensed and unlicensed regulation. It shows that wider-area networks are relatively more common in licensed environments than in unlicensed ones. The results discussed earlier—that the restrictions placed on power and range are, on average, higher for more lax licensing regimes—suggest one possible explanation for this finding, namely, that the use of unlicensed bands may be so restrictive in terms of power and range that the bands are not viable for wider area coverage. Other explanations are also possible. There may be a bias in the data, since regulators are less likely to be aware of the type of use for unlicensed bands, which they do not control. Alternatively, at least until WiMax equipment becomes available, the least expensive and most widely available unlicensed equipment tends to be short-range, so the smaller players who adopt it may simply provide localized coverage by default. Or it may be that wider-area coverage implies higher implementation and coordination costs, and operators in this domain prefer a more protected and certain environment. This possibility suggests caution, in particular in ensuring some certainty and stability in the business environment. Understanding the reasons behind this trend is beyond the scope of this paper. Additional research and data are needed to fully characterize the use of these bands.

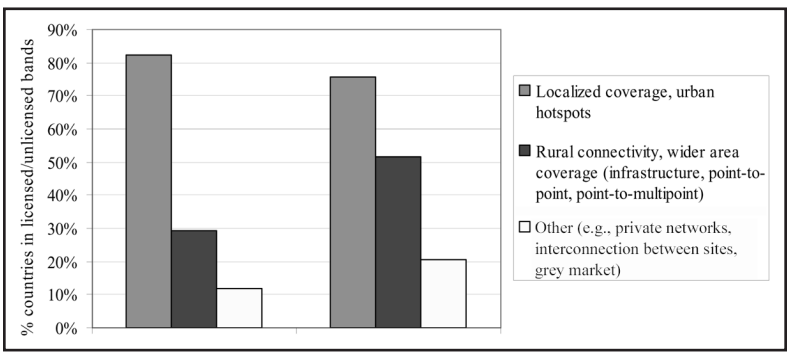

Figure 10. Main types of use crossed with 2.4 GHz band regulation.

Notes: 1. This graph is constructed crossing usage information (which is for both the 2.4 and 5GHz band) and licensing information—for the 2.4GHz band only. Since the 2.4GHz band is the one with most widespread use, this should not introduce a big distortion.
2. These are percentages of different numbers, so the fact that the percentage goes down does NOT necessarily mean that there are fewer countries providing that service.

Policy Recommendations

In this section we consider the major challenges brought to light by the survey results, and offer policy recommendations for the regulation of the 2.4 and 5 GHz bands.

Harmonize Regulations Continent-Wide; Build Enforcement Capacity

We argue that the significant heterogeneity in regulation of 2.4 and 5 GHz bands across the African continent inhibits growth of telecommunications and the Internet by diminishing potential economies of scale. This heterogeneity promotes confusion, uncertainty, and lack of enforcement capacity, which can harm, in particular, new entrants and small players.

Some regional economic communities in Africa have already begun initiatives designed to increase cooperation on ICT regulatory activities. For instance, the Economic Commission of West African States (ECOWAS) has created the West African Telecommunications Regulatory Association designed to pool best practices in ICT regulation within the region and to harmonize policies. Similarly, the South African Development Community (SADC) has made good early progress in policy harmonization through its Telecommunications Regulators Association of Southern Africa. These and similar groups have had some early discussions on harmonization of spectrum policies, at least within regional communities; however, we are unaware of significant progress or continent-wide initiatives.

The New Partnership for Africa's Development (NEPAD), the principal development program of the African Union, is well suited to anchor a continent-wide project to harmonize regulations and build capacity. NEPAD has identified a number of critical infrastructure activities, such as roads, power, and water to which it gives special attention. We believe that NEPAD should adopt its "ICT Policy and Regulatory Frameworks at the Regional Level" infrastructure action plan as a designated "flagship project" deserving of continent-wide attention. Working through this action plan, and with relevant regional economic communities such as ECOWAS and SADC, continent-wide harmonization of spectrum policy and regulation can be advanced. In addition, NEPAD should engage technical resources and financial support, both from development partners, such as the ITU, and from major non-African regulatory agencies, such as the U.S. FCC, which has an international desk already active on the continent, and the European CEPT. Working with these regional and development partners, NEPAD could engage the range of stakeholders, including African ISPs, telecommunications operators, and multinational equipment manufacturers.

The goal of this process should be the rapid harmonization of spectrum policies along lines that are good for the continent and integrate well enough into the international context. NEPAD should also drive the publication of spectrum policies with an eye toward reducing confusion and uncertainty. It should facilitate, along with regional players and development partners, the development of human and enforcement capacity of regulators at the state level.

Allow License-Exempt Transmission; Closely Track Technology Advances

We have witnessed a clear increase in services, access, and innovation in Europe, the United States, and some parts of Africa, encouraged by regulations that allow license-exempt transmission on specific radio bands (Carter et al. 2003). We propose that de-licensing of the 2.4 GHz and 5 GHz bands should be an integral part of the African regulatory harmonization process described above and that more spectrum be considered for license-exempt use. However, as we previously describe, there are a larger number of regulatory choices beyond licensing categories, for instance, restrictions on power and range, level of enforcement, equipment certification requirements, and restrictions on services. The purpose of these restrictions is to strike a balance around a number of issues, namely, increased access, the rights and privileges of incumbents and existing providers, QoS guarantees consumer protection, management of interference between multiple uncoordinated transmitters, rent-seeking activities, and, perhaps, issues of national security.

Some of these concerns were raised by survey respondents. Tanzania mentioned that its licensing regime allows it to enforce good quality of service on the network; Uganda defended licensing in order to ensure "more discipline in the use of the bands." In some contrast, Kenya pointed out that its unlicensed regime has lowered the cost of entry for service providers, which should increase access opportunities.

New technologies and business models are beginning to address many of the concerns raised by license-exempt transmissions. New radio technologies are increasingly able to reduce incidences of interference or mitigate such interference when it does occur. Particular innovations, such as interlays where transmission occurs only during times of radio silence among competing transmitters, could be significant in Africa where the spectrum is relatively unencumbered. Furthermore, problems in QoS are responding to technological advances. New entrepreneurial business models, relying on these radio technologies, have shown that permissive spectrum regulations encourage innovation and increase access, thus helping a government meet its Universal Service objectives. Moreover, it has been shown that many of these business models can be "win-win," where even incumbent operators enjoy increased revenues as they interconnect and transmit data off a local entrepreneur's wireless network.

Thus, we propose that Africa should lead the way in liberal unlicensing of spectrum, should be relatively permissive in restrictions on use, and should closely track (and influence) technological advancement to its advantage.

Revise Universal Service Policies for Use in These Bands

Although the practical management of Universal Service funds presents some challenges (including ownership, accountability, and bureaucracy), the use of such funds has proved effective in some circumstances, for example in Chile or in Peru (World Bank

2002a, 2002b). We believe that countries should review Universal Service funding policies in light of their applicability to new market entrants and alternative technologies such as those operating in license-exempt bands. Targeted, flexible, and accessible Universal Service funds should be implemented.

Unlicensed bands can potentially be used to provide rural connectivity and Universal Service. Given the identified potential for this technology and its low cost, allowing wireless projects in these bands to compete for Universal Service funds may represent a cost-effective utilization of the subsidies.

Although there is an ongoing debate about which services should be included in the "essential services package" (Crandall and Waverman 2000; Gillett 2000; Garnham 1997; Compaine and Weinraub 2001), increasingly the trend will be to make data, as well as voice services, eligible for Universal Service funds. In addition, while WLAN-type technology is generally associated with Internet and data applications, this need not always be the case. Some technologies (e.g., CorDECT) specifically support voice, as well as data communications.[24] While there remain some issues with QoS, capacity and reliability of the backbone, as VoIP technology is improved, WLANs will increasingly support voice and integrate phone-like features with Internet access (Rappaport 2002).

Earlier, we indicate that the use of Universal Service funds to finance telecommunications projects in these bands is limited. Although 47% of the countries have policies in place, only Kenya, Madagascar, and Rwanda have used them in this context. The infrequent use of these funds for these types of wireless projects may be due to targeting the fund primarily (or exclusively) to incumbent or large operators who are uninterested in these approaches. Or, in some cases, particular technologies may be mandated when using these funds, which may exclude those that transmit on these bands.

If appropriate Universal Service policies are in place, the corresponding funding mechanisms can be used to deploy these types of technologies. This is especially true if the specific Universal Service policies allow for competitive, targeted, and efficient subsidies; for example, allocation of funds/subsidies through competitive targeted bidding (i.e., firms bid for the subsidy on a project-by-project basis and the most competitive wins). This would allow smaller players to apply for the funds, should they be competitive enough.[25]

Conclusions and Further Research

We have surveyed all the African countries on their regulation and use of the 2.4 and 5 GHz microwave bands. A questionnaire was sent via e-mail to contacts in every country and, in many cases, follow-up phone calls were placed. We enjoyed a response from 47 of the 54 countries of Africa, accounting for 95% of the continent's population. Most responses came from the country's regulator, though in some cases we received responses from other informants.

We find that a considerable percentage of African countries have users transmitting on 2.4 or 5 GHz for the provision of Internet hotspots or backhaul infrastructure. This common pattern of usage is true even in the presence of considerable variation in regulation, licensing, and transmission requirements. We do find that countries with more relaxed licensing requirements tend to have more restrictive requirements on transmitter power output and range. We worry that the heterogeneity in regulations across the continent diminish scale economies and, thus, discourage businesses from entering the market. Furthermore, the tendency to overregulate, either by requiring licenses to transmit in these bands or through severe use restrictions, may increase barriers to entry and discourage entrepreneurs and innovation (Anthony et al. 2002).

Further research is necessary if we are to fully understand the opportunities in using wireless technology and license-exempt bands in Africa, as well as to identify and characterize in more detail the appropriate policies and regulatory environments.

Some specific areas for future research include:

- Gather more information on the use of these bands, specifically the extent of use (e.g., is it widespread or only occasional) and the interrelationship of users and type of use (e.g., who

24. Bhutan Telecom, for example, has implemented a pilot project using 802.11b technologies to provide rural voice services. For a more detailed description of the project see Best, 2003.
25. For more, see World Bank 2002a, 2002b; Kerf et al. 2003; Best and Maclay 2002.

provides rural coverage for what). This can be accomplished through field studies and surveys of stakeholders.

- Develop case studies. Different case study categories can be established in terms of income, teledensity, regulation, and use. Case studies can then be developed in representative countries and clusters of categories.
- Carry out further research, using information from the case studies and additional survey work, to establish the appropriate balance between lowering barriers to entry and ensuring well functioning radio transmission on these bands. This work can lead to specific recommendations to improve the regulatory environment.
- Focus research on the business environment in which firms operate, studying sustainable business models, and exploring innovative and creative solutions to ease access to capital, promote structures for trust, etc.

Ensuring accessibility to ICT infrastructure is of significant importance to the developing world, and specifically for Africa, which has some of the lowest levels of telecommunications penetration. Wireless technologies transmitting on unlicensed bands, along with supportive public policies and strong institutional and business environments, can be powerful agents for increasing African connectivity. ■

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