GLOBAL INTERNET POLICY INITIATIVE

Internet Exchange Points
Their Importance to Development of the Internet and
Strategies for their Deployment – The African Example

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Summary

To speed the spread of the Internet in developing countries, the cost of Internet connectivity and bandwidth must be reduced and the quality of service improved. One of the most effective mechanisms to accomplish both cost and service gains is the Internet Exchange Point (IXP). An IXP interconnects Internet service providers (ISPs) in a region or country, allowing them to exchange domestic Internet traffic locally without having to send those messages across multiple international hops to reach their destination.

This paper focuses on the problems and opportunities for IXP deployment in Africa, but the lessons and strategies are equally relevant throughout the developing world.

Currently there is only one IXP on the African continent between South Africa and Morocco. As a result, nearly every African ISP must rely on satellite connectivity, which is more expensive and entails vastly greater network capacity than the use of fiber optic cable.

Among the central inhibitors to IXP deployment in Africa are legal provisions (prohibitions on non-regulated telecommunications facilities, restrictive licensing regimes, burdensome tax treatments), regulatory agencies (often seeking to extend their statutory authority over telephony to Internet infrastructure), and monopoly telecom operators and large ISPs (seeking to prevent effective competition).

A strategy to support the deployment of IXPs in developing countries should consist of three elements: (1) organizing educational workshops that will bring together government officials, academics, ISP executives, technical experts, and others, to examine the legal, regulatory, political, and technical issues surrounding IXP deployment; (2) assisting neutral, non-profit ISP associations in their efforts to establish IXPs; and (3) advising governments and stakeholders on how to remove legal/regulatory/policy obstacles to the deployment of IXPs.

What Is an IXP?

An Internet Exchange Point is a facility operated by a single entity to facilitate the exchange of Internet traffic between three or more ISPs. (In technical terms, the IXP is a Layer 2 physical network facility.) An IXP is characterized by neutrality among all user/subscriber ISPs; often, it will be administered by a non-profit ISP association.

Typically, the IXP owns and operates the switching platforms used to interconnect the various users/subscribers. That is, the IXP consists of a shared switch fabric, where users arrange peering via bi-lateral agreements and then establish sessions between their routers to exchange routes and traffic.*

Why Do IXPs Matter?

IXPs are among the most critical elements in the infrastructure of the Internet. The Internet is a network of interconnected networks; IXPs are the points at which multiple networks interconnect. Without IXPs, there would be no Internet, as we have come to know it.

In more concrete terms, IXPs generate two primary advantages for member ISPs and their customers: lower costs and improved quality of service.

- **Cost Advantages**

Currently, nearly all developing countries lack IXPs, meaning that all inter-ISP traffic (both domestic- and foreign-bound) must be exchanged through exchanges outside the country. Absent a domestic IXP, then, an ISP must send all outbound traffic through its international links, most commonly satellite and occasionally submarine fiber.

International links entail both upstream and downstream packet traffic, the costs of which must be borne by either the sending or the receiving ISP. Here, we observe a troubling imbalance: Unlike in the telephony world, where ITU-mandated rules require that the costs of international calls be shared 50/50 between telecom operators, international Internet connectivity operates according to the peering/transit dichotomy. ISPs are not subject to the ITU's cost-sharing rules; rather, connectivity costs are allocated according to bilateral contracts, which can generally be classified as either *peering* or *transit* agreements. (It should be noted that this dichotomy is a vast oversimplification: ISPs have developed a vast range of varying interconnection agreements, involving often highly sophisticated settlement regimes; however, for purposes of analyzing developing country connectivity costs and options, the basic models cover most situations.)

The distinction is significant:

A *peering* agreement is a bilateral business and technical arrangement in which two connectivity providers agree to accept traffic from one another (and from one another's customers, and their customers' customers). In a peering agreement, there is no obligation for the peer to carry traffic to third parties. There are no cash payments involved – rather, it is more like barter, with each ISP trading direct connectivity to its customers in exchange for connectivity to the ISP's customers.

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* For more information about the technology of IXPs, see RFC 1771, http://www.ietf.org/rfc/rfc1771.txt, which describes the Border Gateway Protocol 4, a protocol widely-used by networks to route traffic to each other.

A *transit* agreement is also a bilateral business and technical arrangement, but one in which the transit provider agrees to carry traffic from the customer to third parties, and from third parties to the customer. The customer ISP is thus regarded as an end point for the traffic; the transit provider serves as a conduit to the global Internet. Generally, the transit provider will undertake to carry traffic not only to/from its other customers but to/from every destination on the Internet. Transit agreements typically involve a defined price for access to the entire Internet.

For virtually all developing country ISPs, the only option for connectivity to the global Internet is a transit agreement. That is, a given developing country ISP has such a small customer base that the international Tier-1 and Tier-2 providers have no business incentive to enter a shared-cost peering agreement with it. Instead, the developing country ISP must sign a transit agreement with its upstream provider.

The result (to oversimplify slightly) is that developing country ISPs must pay 100% of both outbound and inbound traffic; under the terms of the transit agreement, the ISP on the other end of the international link does not share the cost of exchanged traffic. This means that the developing country ISP must pay 100% of the international transit costs for all packet traffic (email, web pages, file transfers, etc.) that originates with its customers and that terminates with its customers. In other words, if the customer of a Mozambican ISP sends an email to a friend in the United States, the Mozambican ISP bears the full cost of the packets' outbound transmission over its international link. Neither the recipient's ISP nor intermediate upstream carriers bear any of the transit cost. If the friend in the United States sends an email reply back to Mozambique, the Mozambican ISP must again bear the full cost of inbound transmission over its international link.

- **Quality of Service Advantages**

Due to the lack of fiber optic links, most developing country ISPs use VSAT satellite circuits for international connectivity to upstream ISPs. Satellite connections introduce significant latency (delay) in the network. More problematic is the reality that, without an IXP, even domestic traffic must be exchanged internationally, entailing at least two satellite hops. (Indeed, even were hard fiber connections available, the length of transatlantic cables introduces needless (though much smaller) latency in the connection.)

Significant network latency translates into extremely slow connections for users, putting a tremendous range of Internet services out of practical reach. Local Internet enterprises find themselves at an inherent disadvantage if they attempt to serve international customers. Ironically, they find themselves at a double disadvantage in serving domestic customers, whose queries must traverse at least two satellite hops to reach them, and another two satellite hops to receive the response. Forcing local ISPs to interconnect in another country thus places a major obstacle to the development of domestic Internet-based business. Indeed, many and perhaps most developing country Internet services are hosted on servers in the United States or Europe, to eliminate at least one satellite hop out of each transaction (including domestic).

Making the problem worse, nearly every developing country is experiencing rapidly growing demand for Internet connectivity, with ISPs offering faster local connections and users requiring greater volumes and more bandwidth-intensive types of Internet services. The growth in demand places ever-increasing burdens on the transmission capabilities of ISPs, whose provisioning of bandwidth must keep pace. In many cases, ISPs use their transmission lines at 100% of capacity, resulting in dropped transmission of packets of data, re-transmissions of dropped packets, and a resulting compounded latency for completing Internet transactions.

An IXP slashes network latency by eliminating the need for any satellite hops in the routing of domestic-bound traffic. The result is that more customers use domestic Internet services, increasing local demand for bandwidth and prompting a cycle in which ever more bandwidth is dedicated to local interconnection. Since domestic bandwidth is always cheaper than international bandwidth, the business cases for domestic Internet enterprises improve dramatically – not just for ISPs, but for online banking, e-commerce sites, online government, enterprise VPNs, content hosting, web services, etc.

Regardless of the medium, then, a closer connection will be cheaper, faster, and more efficient. Put another way, the localization of packet traffic – keeping the physical path traversed by packets as short as possible – produces measurable improvements in service cost, performance, and efficiency.

-- The Case of Kenya

The experience of the Kenyan ISPs in attempting to organize and launch an IXP provides a object lesson in the practical barriers that confront the deployment of IXPs in Africa.

Prior to Kenya's, there was no IXP on the African continent between Morocco and South Africa. In early 2000, the association of Kenya's competitive ISPs (i.e., those other than Telkom Kenya, the state-owned monopoly telecom), called TESPOK, undertook to organize an neutral, non-profit IXP for its members. After nearly a year of preparatory work, including the design and implementation of a capable technical operation, funding model, and legal framework, the KIXP was launched in late November 2000, located in Nairobi. Almost immediately, Telkom Kenya filed a complaint with the Communications Commission of Kenya (CCK) arguing that the KIXP violated Telkom Kenya's exclusive monopoly on the carriage of international traffic. Within two weeks, the CCK concluded that the KIXP required a license, and ordered that it be shut down as an illegal telecommunications facility.

Telkom Kenya's legal monopoly does, in fact, extend to all fixed network infrastructure, including local, national, international, and leased lines. In Kenya, ISP services are open to competition, but ISPs rely on Telkom Kenya for underlying infrastructure. In addition, Telkom Kenya has the exclusive right to operate a national backbone for purposes of carrying international traffic.

Until KIXP, all Internet traffic in Kenya was exchanged internationally. According to TESPOK, roughly 30% of upstream traffic was to a domestic destination. During the two weeks of KIXP's operation, measurements indicated that latency was reduced from an average fo 1200-

2000 milliseconds (via satellite) to 60-80 milliseconds (via KIXP). Likewise, monthly bandwidth costs for a 64 kbit/s circuit dropped from US$ 3375 to US$200, and for a 512 kbit/s circuit from US$9546 to US$650. [Source: TESPOK]

In response to the CCK's closure order, the Kenyan ISPs argued that the KIXP was a closed user group, and therefore would be legal under the Kenyan Telecommunications Act. Also, they noted that the local exchange of domestic Internet traffic does not contravene Telkom Kenya's international monopoly, as all international traffic would continue to flow over its international links. Telkom Kenya's opposition to KIXP was fierce, fed by the fear of losing a significant portion of its international leased line revenues.

After nearly a year of intensive efforts, including public pressure, threats of litigation, and private diplomacy, TESPOK finally received the approval of CCK in the form of a license, granted in November 2001. The commission's licensing order represented a fairly dramatic turn-around in the CCK's thinking, stating: "An IXP is not an international gateway but a peering facility that enables ISPs to exchange local traffic. The Internet is expanding very fast and since Telkom Kenya has demonstrated that it has some apparently insurmountable difficulty in rolling out Internet facilities, it would be in the best interest of the market to allow other companies to offer IXP services in the country." (See <http://www.cck.go.ke/headline/releasenews/head2001.htm#kixp>). Nevertheless, the CCK requested TESPOK to partner with Telkom Kenya, and the ISPs accordingly approached the company with a proposal to cooperate. By February 2002, however, TESPOK had received no response and elected to re-launch KIXP on their own. Since its facilities went live in mid-February, KIXP has actively interconnected 5 Kenyan ISPs, with 8 others in the process.

-- The Case of Bangladesh

Bangladesh presents a somewhat different angle on the same problem. Bangladesh has no IXP. A central reason, according to BTTB (Bangladesh Telegraph and Telephone Board), the state-owned monopoly telecom operator, is that the company has been unable to secure funding from the government. As a government-ordained monopoly over telecommunications infrastructure, BTTB needs regulatory approval (and budgeting) for any new services. Thus far, the case for an IXP has not been convincing, even though it would save BTTB money, lower costs for users, and improve quality of service.

The absurdity of Bangladesh's situation (and that of similarly IXP-less developing countries) can be seen in the results of a recent traceroute from one Bangladeshi ISP to another: the packets traveled from Bangladesh via satellite to Hong Kong, via satellite to the U.S., then to Canada, back to Hong Kong, and finally to their destination back in Bangladesh. Not surprisingly, the majority of Bangladeshi web sites are hosts in the United States. [Source: OECD, "Internet Traffic Exchange And The Development Of End-To-End International Telecommunication Competition," (March 2002)].

-- The Successful Example of Mongolia

In contrast to the experiences of Kenya and Bangladesh, the case of Mongolia demonstrates that a combination of ISP cooperation and at least tacit support from governmental authorities can lead to the rapid and successful establishment of an IXP in a developing country.

In January 2001, a group of leading Mongolian ISPs met in Ulaanbaatar to explore the creation of a national IXP. At the time, all Mongolian ISPs were interconnected via Tier-1 and Tier-2 providers in the United States or Hong Kong. As a consequence, satellite latencies amounted to a minimum of 650 milliseconds (or over half a second) for each packet of data in each direction. Costs were needlessly high and, not surprisingly, few Mongolian Internet business services were hosted within Mongolia.

Without interference from the Mongolian government, Mongolia's three leading ISPs were able to complete planning for an independent exchange within 3 months. The Mongolian Internet Exchange (MIX) was launched in April 2001 with three ISP members. By March 2002, the MIX had six ISP members, with steadily increasing traffic between them. Today, local latency is less than 10 milliseconds per transaction (compared with a minimum of 1300 milliseconds in the pre-MIX days), and an average of 377 gigabytes of data are transferred domestically each day among MIX's members. Moreover, each domestically-exchanged transaction effectively frees up an equal amount of international bandwidth, improving connection speeds and reducing latency over Mongolia's international links. [Source: MIX].

Obstacles to IXP Deployment

The goal, then, is to enable the domestic exchange of domestic Internet traffic in developing countries. The means is the organization and deployment of neutral, local Internet exchange points.

The obstacles to achieving this objective will vary from country to country, but some common themes emerge.

First, we see strong resistance by the current providers of international leased-line, submarine cable, or regulated VSAT connectivity. In most cases, this means a state-owned monopoly telecom operator. A monopoly telecom can be expected to seek monopoly rents, and leverage its legal exclusivity over international links. In addition to the fear of effective competition, the telecom will generally fail to appreciate that reducing the cost of Internet connectivity for domestic consumers will generate vastly greater investment, more users, and actually greater international leased line revenues. Indeed, a strong case can be made that greater domestic use of the Internet generates a better-connected populace in the broad sense, leading to even greater use of international direct-dial telephony to foster commercial and personal international relationships.

Second, government regulators often side with the telecom, and their alarm is understandable. The governments of developing countries are often heavily dependent on

revenues from the monopoly telecom operator; facing massive budget pressures already, they are reluctant to sanction activities which might squeeze those revenues. For a variety of reasons (ranging from close personal relationships to outright corruption), the telecom's views often carry great weight with regulatory authorities. Often, statutory or other licensing requirements exist which can arguably applied to IXPs. In most cases, the regulatory authority is, at least initially, quite unfamiliar with the technical and economic aspects of Internet facilities and ISP traffic exchange.

Third, we regularly see resistance from the competitive ISPs themselves. Those that feel secure in their market position fear the effects of making connectivity cheaper for their competitors. Moreover, an IXP essentially allows any interested domestic ISP in a developing country to peer with its domestic competitors. This requires a degree of trust among competing ISPs that is quite common in the developed world, but fairly unusual in Africa. Anecdotal experience indicates that even small competitors are reluctant to band together, reflecting an exaggerated sense of competitiveness.

How to Assist IXP Deployment

The case for IXPs is compelling, and the obstacles relatively clear and well-understood. In order to achieve wider IXP deployment in Africa (and elsewhere in the developing world), what is (1) regulatory reform and liberalization, (2) the overcoming of monopoly telecom resistance, and (3) the organization of competitive ISPs into associations capable of neutrally administering shared facilities on behalf of their members. Regulators and competitors alike need to be convinced of the overwhelming benefits of domestic Internet traffic exchange, and of the broader proposition that communication in a developing economy is not a zero-sum game – lower costs for competitors can lead to greater revenues for all, stronger investment from abroad, and lower-cost, higher-quality services for all users.

Current IXP Efforts in Africa

Currently, IXP-organizing efforts are taking place in some African countries. The Ugandan IXP <http://uixp.co.ug> is at an advanced stage of development, with technical operations under construction and the active support of the Ugandan Communications Commission, which has already granted a license.

Less advanced efforts exist in Tanzania, Mozambique, and Ghana.

A number of African ISPs, led by the South Africans and Kenyans, have launched an ISP association (AfrISPA) with the primary goals of organizing non-profit, neutral ISP associations in each African country, and supporting the deployment of IXPs wherever possible. In the longer term, AfrISPA intends to pursue the goal of direct fiber optic connectivity to every African country. The increasingly widespread use of VSAT links is troubling – through they may be cheaper in the near term than fiber optic cabling, making permanent the latency of satellite connections would permanently condemn Africa to second-class international Internet connectivity.

One interesting project under consideration by AfrISPA is the creation of a Pan African Virtual Internet Exchange (PAVIX), which would be a latticed network of interconnected IXPs, for the purpose of reducing the cost of regionally-bound traffic. The PAVIX would consist of bilateral satellite links between individual national IXPs. In a sense, it would be the first step toward a continental backbone for Africa. Compared to a national IXP, PAVIX presents an even larger and more daunting basket of legal/policy policy obstacles, because it would entail international, rather than purely domestic, exchange of traffic. For obvious reasons, the opposition of monopoly telecom operators would be intense. However, the cost and quality of service benefits for African connectivity would be significant.

Other Significant Legal/Policy Issues

In addition, it is worth noting a few of the other key legal and policy issues that affect the deployment of the Internet in the developing world:

- Tax treatment of Internet infrastructure equipment and services
- Telephone tariffs
  - Problem: High per-minute charges, and need for long-distance call to reach POP
  - One solution: Local call charges for Internet, regardless of distance to POP
    - Special area code
    - 18 countries have so far adopted
  - Even better: In Seychelles, 50% lower tariff for Internet calls.
- Liberalization of international links
  - Two-way satellite-based Internet services using very small aperture terminals (VSAT) to connect directly the US or Europe have been quickly adopted where ever regulations allow (DR Congo, Ghana, Mozambique, Nigeria, Tanzania, Uganda and Zambia)
  - Result: ISPs that are not dependent on the monopoly telecom operator for their international bandwidth.
  - Pricing: $700-$900 for two-way KU-band VSAT equipment providing 'better than dialup' speeds (i.e 56Kbps outgoing and 200-400Kbps incoming).

The Role of the Berkman Center in Promoting Developments of IXPs

The Berkman Center for Internet & Society at Harvard Law School will be working in collaboration with GIPI and others to promote the development of IXPs in Africa through (1) organizing educational workshops that will bring together government officials, academics, ISP executives, technical experts, and others, to directly address the legal, regulatory, political, and technical issues surrounding IXP deployment; (2) assisting neutral, non-profit ISP associations in their efforts to establish IXPs; and (3) advising African governments and authorities on how to remove legal/regulatory/policy obstacles to the deployment of IXPs.

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