equipments such as routers, switches and printers connected to a network using the Internet protocol. Indeed, it is thanks to the footprints which are left by their IP addresses on servers that network professionals and other interested parties such as government and law enforcement agencies can locate malwares and other cyber-security threats. Currently, there are two types of Internet Protocol (IP) addresses in active use: IP version 4 (IPv4) and IP version 6 (IPv6). Basically an IP address uses numbers comprised between 0 and 255 and separated by full stops such as 234.252.2.148. The Internet Assigned Numbers Authority (IANA) is responsible for global coordination of the Internet Protocol addressing systems, as well as the Autonomous System Numbers used for routing Internet traffic.

Ipv4 vs. IPv6

IPv4 was initially deployed on 1 January 1983 and is still the most commonly used version. IPv4 addresses are 32-bit numbers often expressed as 4 octets in "dotted decimal" notation (for example,192.0.2.53). Deployment of the IPv6 protocol began in 1999. IPv6 addresses are 128-bit numbers and are conventionally expressed using hexadecimal strings (for example 2001:0db8:582:ae33:29). Both IPv4 and IPv6 addresses are generally assigned in a hierarchical manner. Users are assigned IP addresses by Internet service providers (ISPs) who obtain allocations of IP addresses from a local Internet registry (LIR) or National Internet Registry (NIR), or from their appropriate Regional Internet Registry (RIR). The Autonomous System (AS) numbers are used by various routing protocols.

The number of web-based devices is expanding at an exponential rate, virtualization is making a very static environment dynamic, and now with the exhaustion of IPv4 resources and the oncoming complexities of IPv6, network operators must reevaluate what IP Address Management (IPAM) really is.

TCP/IP, (Transmission Control Protocol/Internet Protocol) is the technology that devices use to interact. IP addresses are the unique identifier that devices use to communicate to each other over the Global Internet. To continue the operation of the Internet, Internet Protocol version 6 (IPv6) was created. This address space is vast —**more than 170 undecillion addresses** — and unlikely to be depleted in the next 50 years. Networks wishing to grow, or new networks wishing to enter the market must undertake a transition to include both IPv6 and IPv4, eventually transitioning entirely to the new protocol. This evolution will require an entirely new paradigm of IP resource management. IP addresses are distributed in blocks called "subnets". A subnet is assigned and routed to an organization, and then that organization can use that subset of IP addresses to access the Internet through the physical circuit connecting them to their Internet Service Provider (ISP). It is up to the network engineer to "architect" a subnet, making sure he/she is subdividing those IP address across their network based on growth needs, growth projections, capacity planning, etc. This is a very crucial first step in the IP management process.

Current status of IP resources in African higher education institutions (HEIs)

As per the indications of AfriNIC, the Africa Internet registry which allocates IP Addresses to African network operators, African higher education institutions have not yet fully grasp the importance of getting their own Internet resources. Thus, very few of them are direct members of AfriNIC, as they are getting IP addresses from local ISPs, while, as campus networks and/or national research and education networks, they do qualify for obtaining upstream IP allocation. Also, despite the special academia waiver provided by AfriNIC over IPv6, only one out of two hundreds universities and research centres have requested and obtained IPv6 resources allocation and are now migrating from IPv4 to IPv6.

Why should African HEIs have their own IP resources?

Knowledge has become a key driver of growth and development. Countries with higher skill levels are better equipped to face new challenges and master technological discoveries. In Sub-Saharan Africa (SSA), qualified human capital remains scarce compared to the continent's development needs. This situation hinders growth and undermines the foundation for sustainable development. Thus, developing cost effective ICT mechanisms to enable the free flow of information and knowledge within and among universities is key to them playing their role in African societies. For this, they should:

- Invest in deploying robust and up to date networks;
- Professionally manage IP platforms that are conducive to innovation;
- Develop locally relevant multi-disciplinary content for rural populations using multimedia dissemination channels;
- Develop a range of ICT applications that strengthen the participating universities' outreach and extension programs to marginalized populations such as women, older people, and the poor;
- Engage in research and development initiatives related to the role of universities as incubators of telecenters and other outreach implementations.

Universities are key for generating innovations and applications which are important for the African growth and therefore, the e-readiness of such universities is of paramount importance. The e-readiness of African universities is clearly relevant to the global creation and distribution of knowledge. The e-readiness in the university context should include :

- ICT facilities and network access;
- Personnel available to support the design and production of digital materials such as CDs, web sites and distance learning (training) packages;
- Academic programs including field experience opportunities that prepare students for applying ICT to communication and development;
- University policies that encourage faculty participation in community outreach programs;
- A faculty ICT posture – for example, a positive disposition toward the use and efficacy of ICT in teaching, learning and research.

Another important reason for African Institutions of higher education to embrace ICT and networking facilities is the fact that as connection speeds increase and the ubiquity of the Internet pervades, digital content reigns. And in this era, free education has never been so accessible. The Web gives lifelong learners the tools to become autodidacts, and more and more services that are fit to the communities tend to be innovated outside the academia.

Universities can be valuable actors in providing some of the resources needed; as an example, telecenters thrive in most places in Africa and colleges and universities as enduring entities in most countries, could use these artifacts to pursue their social role of creating, storing and disseminating knowledge. Yet, few major programs link universities to telecenters as an institutionalized source of information, knowledge and training - the basic commodities of a telecenter.

Current advances in Information and Communication Technologies (ICTs) have improved computer power leading to faster data transfer rates and its attendant lowering of costs. It is an established fact that the effective integration of these technologies into educational curricula has been demonstrated to have positive effects on student learning. Technology-enabled instruction, especially online learning, has emerged as the most feasible and economically sound means of expanding access to quality higher education. Online learning is thus being rapidly adopted by educational institutions worldwide as an alternate or complementary mode of education delivery, and indeed has been heralded as the next democratizing force in education, particularly in higher education . Thus, in the United States, for example, over 3.5 million college students took at least one online course in the fall term of 2006.

In Sub-Saharan Africa, however, where it is estimated that only 1 in 250 people have access to the Internet as against the global average of 1 in 15 (UNESCO Institute for Statistics, 2007), online learning in higher education poses a great challenge as this mode of instruction delivery relies primarily on information and communication technology infrastructure. In addition, most institutions within the sub-region are currently in a state of crises – having to cope with collapsing infrastructure, brain drain, and dwindling financial resources, whilst under increasing pressure to cater for larger student populations.

Despite these constraints, online learning is still being touted as the best possible solution to the problem of access to quality higher education in Sub-Saharan Africa, especially as it has been demonstrated within other settings (notably the developed world) that learners who have participated in online learning, mostly report that they perceive this mode of learning as being convenient and flexible, offering a greater access to learning resources, increasing student motivation and self-esteem, enhancing learner participation and interactivity, and more significantly, improving the quality of learning.

What should HEIs do to obtain their own IP resources?

A rationale for higher education institutions as key players should be to embark on a plan of action for establishing communication linkages among ICT policy makers in government, faculty members in universities, scientists in research institutes, agricultural and business enterprises, farmer groups and rural communities. One should reckon that most institutions within Sub-Saharan Africa are beginning to explore the possibility of adopting e-learning as a mode of learning to help address the ever-growing demand for tertiary education within the sub region (UNESCO, 2007). Unfortunately, this is mostly being done with little recourse to trying to understand the students' characteristics and their perceptions about the helpfulness, accessibility, and usability of these technologies within their context.

For African universities and research centres to become fully involved in national and regional development issues, they should seek to reinforce national research and education networks on the one hand, and be at the pole position for innovation, knowledge creation and internetworking with non academia partners on the other hand. Having a robust connectivity as well as fully fledged academic resources is a minimum, and acquisition of IP Addresses cannot be neglected.

This requests a change in the overall paradigm of managing university or research networks: traditional lecture mode delivery should be revisited; e-learning possibilities should be investigated and deployed; curriculum frameworks should be adjusted to espouse current digital content production schemes.

There is a need for adopting strategies which encompass:

- Effective adoption of ICT related technologies for drastically transforming education delivery;

- Stimulate student engagement through online course delivery;
- Capacity development at all levels for lecturers, network professionals and students.

Nevertheless, Castro's (2000) puts it "... introducing technology into educational institutions is not a technical issue but a sociological experiment. The hurdles are not technical but have to do with the internal logic of the institution, with built-in incentive systems, with values, with expectations, and with prejudices. It is not a chapter in the science of technology but in the art of institutional change" (p. 15).

Because skills for the knowledge economy are built at the tertiary education level, improving tertiary education systems should be high on SSA's development agenda. And African tertiary education institutions and policy makers must ensure that the workforce acquires the skills to compete, innovate, and respond to complex social, environmental, and economical situations.

In this context, the acquisition of large platforms of Internet protocol resources allows higher education institutions to boost connectivity and content production, and open up to the industry and business through innovation and research. Links with AfriNIC, the African Internet registry, should be further enhanced so that African higher education institutions could fully benefit from the gamut of services. This includes IP allocation, discount through the AAU-AfriNIC agreement for African higher education institutions and research institutions, special waiver on IPv6 adoption and capacity development through participation to the series of technical workshops.

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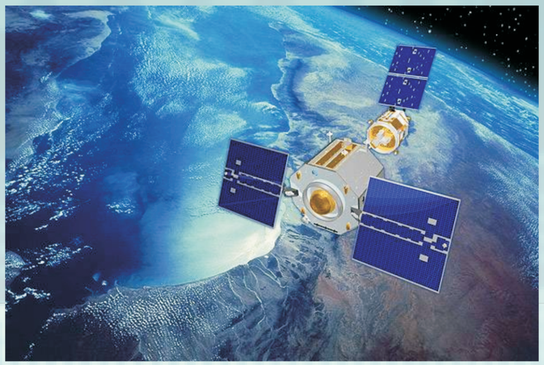

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Policy Brief

Internet Protocol Resources:

A Tool For Positioning African Higher Education Institutions As Knowledge, Innovation And Development Centres

by Pierre Dandjinou

Executive summary

This policy brief introduces Internet protocol resources and advocates for the importance for African higher Education Institutions to acquire their own IP platforms in a view to expand and consolidate current networking activities. The policy brief further argues that for African Academic Institutions to become effective centres for knowledge production, innovation and development inducers, there is a need for a paradigm shift in their service delivery. They should embark on new service delivery schemes which include capacity development, online education, linkages with the industry and business, and opening up to society at large. Networking activities based on the Internet protocols and more so on IPv6 are transforming the digital economy and impacting stakeholders' relationships; thus, governments and leaders of academic and research institutions have a unique opportunity for harnessing ICT for overall socio-economic development.

Introduction: What are Internet Protocol resources?

An IP (Internet Protocol) address is a number which identifies any computer connected to the Internet. It also serves as an interface with a network of computers and other communication