AfricaConnect3: Connecting Africa to Unlimited possibilities

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Abstract:

Despite availability of infrastructures having significantly progressed over the recent years, tertiary education and research institutions in Africa are still among the least connected in the academic world, a situation that is particularly critical for landlocked countries. In this context, the AfricaConnect3 project strives to establish secure, adequate, and affordable network infrastructures and offers dedicated services to African National Research and Education Networks (NRENs), as well as it builds adequate human resource capacities and expertise within the community and raises the awareness of the role of digital transformation for research and education (R&E). This paper aims at presenting the achievements and impact of AfricaConnect3 on African R&E communities, as well as advocating for NRENs, by detailing the activities implemented and services offered to R&E institutions in Africa. Finally, this paper addresses the need for NRENs to be better represented in the African digital landscape and understood as part of the solution.

Keywords: AfricaConnect, AfricaConnect2, AfricaConnect3, Internet Connectivity, Research and Education Community, NRENs, global, connectivity, eduroam, digital divide, inclusion, eduGAIN, roaming, students, authentication, federation, UbuntuNet Alliance, WACREN, ASREN, GÉANT, European Commission.

1. Introduction

With an exponential population growth in Africa that should reach 2.5 billion people by 2050[1], investing in human capital is essential. Youth unemployment is a critical issue affecting many countries across the continent, and tertiary education and research are sectors which should play a key role in addressing this problem by fostering the development of human capital and skills and contributing to economic growth and to the creation of societal opportunities. Those sectors however do not fully maximise their potential and fail to deliver the expected social and economic returns.

Although the African continent is surrounded by submarine cables, it also faces some of the lowest internet penetration rates worldwide. This results in Africa contributing to less than 2% of the world's research output with only 91 researchers per million people compared to 4,272 for North America and Western Europe[2].
This is partly due to the high costs of connectivity and e-infrastructure, a situation primarily created by Telecom monopolies, landing station monopolies, and last mile monopolies.

Other issues of concerns are the absence of harmonised ICT legal and regulatory frameworks and, in certain countries, excessive taxation of telecommunication providers[3]. Therefore, some countries are lagging behind in terms of national fibre infrastructure and NRENs in some countries not yet having national backbones.
If properly harnessed, the Internet can provide both students and lecturers with a wealth of invaluable educational resources. Lecturers can use the Internet to prepare lessons, disseminate information to students and assess them, and students can access online content to extend their range of learning.

Yet, despite availability of infrastructures having significantly progressed over the recent years, especially through the deployment of international undersea cables circling Africa, tertiary education and research institutions in Africa are still among the least connected in the academic world, a situation that is particularly critical for landlocked countries.
As a result, those factors translate into a general disconnectedness of the continent from the global digital economy and all its opportunities.

In this context, strengthening the African Research and Education Networks (RENs) is key to address the problem. As of March 2021, Africa hosts 38 National Research and Education Networks (NRENs) accounting for around a third of the world's total. Each NREN serves the ICT needs of its national research and education communities. At an upper level, NRENs are interconnected through three Regional Research and Education Networks (RRENs):

- Northern African NRENs are grouped under the Arab States Research and Education Network (ASREN).
- West and Central Africa NRENs form the Western and Central African Research and Education Network (WACREN).
- Eastern and Southern Africa NRENs form the UbuntuNet Alliance (UA).

This paper will address some of the key achievements of the AfricaConnect3 project and point out to the main challenges that are obstructing further development in the R&E continent. It begins by briefly explaining the objectives and the methodology of the project, and continues to demonstrate NRENs' added value detailing the vast array of implemented services in the field of network management, cloud, sustainability, capacity building, and advocacy and donor engagement. It shows the main achievements and impact, with a special focus on the key role of NRENs on higher education during the COVID-19 pandemic. Finally, it lays out the project's business benefits for African researchers and students, the NRENs, and the R&E community worldwide.

1. Objectives

The AfricaConnect3 project aims to support the creation and consolidation of national and regional RENs across Africa that provide access to dedicated, high-capacity internet connectivity and offer a gateway to global R&E collaborations through their interconnection with the pan-European GÉANT network.

AfricaConnect3 strives to enhance access to tertiary education and research institutions by establishing secure, adequate, and affordable network infrastructures. It fosters the development of research and education through services, applications, and dedicated user support. Finally, it builds adequate human resource capacities and expertise within NRENs

and education and research communities and raises the awareness of the role of digital transformation for education and research.

This paper will present the main achievements of the AfricaConnect3 project in African R&E communities and will advocate for the case for African NRENs defending the right for Africa research and education not to be left behind in an increasingly digitalised world.

2. Methodology

The AfricaConnect3 project is implemented through the following Work Packages:

- **Network Management and E-infrastructures.** RRENs ensures secure, adequate, and affordable network infrastructures by providing daily management of the networks, to include procurement for expansions and upgrades.
- **Dedicated Services for R&E Institutions**. RRENs deploy Trust and Identity services, such eduroam and eduGAIN, and ensure cybersecurity by establishing security team services and a cooperation framework for NREN Computer Security Incident Response Teams (CSIRTs).
- **Sustainability and Capacity Building.** On a regional level, RRENs focus on building human resource capacity and expertise through strengthening their own governance and implementing their financial sustainability plans. On a national level, the project's partners support their member NRENs by hosting trainings and workshops, promoting exchange of best practices and strengthening coordination.
- **Advocacy and Donor Engagement.** RRENs have set up an advocacy and donor engagement strategy and plan targeted at decision makers as well as at international donors and other stakeholders to influence policy change and mobilise funding.

The implementation of these activities follows a regional approach. The local NRENs are grouped under geographical areas (also known as "clusters") and are involved in the delivery of the project in their respective regions. The three clusters are:

- Cluster 1: Eastern and Southern Africa, led by UbuntuNet Alliance.
- Cluster 2: Western and Central Africa, led by the Western and Central African Research and Education Network (WACREN).
- Cluster 3: North African region, led by the Arab States Research and Education Network (ASREN).

In the execution of their activities, the African RRENs liaise with their own constituencies (member NRENs) and also seek to maximise synergies across regions in the different areas, such as deployment of connectivity, capacity building, and open science cloud. As a result, this fosters collaboration between R&E communities in Africa as well as in Europe, which may lead to other opportunities under EU programmes such as Erasmus+ and Horizon Europe.

3. Services Offer

3.1 Network Management and E-infrastructure

To ensure that users continue to benefit from secure, adequate, and affordable network infrastructures, RRENs have set up a Network Operating Centre (NOC), staffed by engineers who monitor performance, resolve any issues that arise and take preventative steps to optimise up-time. RRENs also extend or upgrade the infrastructures as and when required to cater for any additional needs.

Cloud e-infrastructures are especially relevant to support the development of a trusted and open environment for the scientific community to store, share and re-use scientific data and results. RRENs deploy cloud e-infrastructure individually, with the ultimate aim of achieving inter-operability in order to consolidate a common African Open Science platform for flexible and seamless access to a wealth of online computing services and data repositories.

3.2 Dedicated Services for R&E Institutions

As they become more digitally driven, academic and research institutions need specific services to support their collaboration activities and to access resources worldwide. In collaboration with the NRENs, the partners raise awareness among end users of the available relevant services gather the requirements of the end users and identify technical recommendations for the deployment of additional e-services and applications such as Trust and Identity services, including eduroam and eduGAIN.

With the motto "*Open your laptop and be online!*", eduroam enables students and researchers to enjoy the most secure encryption and authentication standards in existence today as well as roaming access in more than 100 territories. The eduroam community is a worldwide success with over 2 billion international authentications to date[4].

eduGAIN, instead, simplifies access to content, resources and the trustworthy exchange of information related to identity, authentication and authorisation (AAI). With about 2,390 identity providers accessing services from about 1,520 service providers, eduGAIN has fast become the primary inter-federation mechanism for research and education collaborations around the world[5].

Furthermore, AfricaConnect3 support the provision of dedicated services to African communities and support specific or cross-border end-user communities (e.g., librarians and Earth observations groups). An example is the LIBSENSE (Library Support for Embedded NREN Services and E-infrastructure) initiative. The WACREN-led activity brings together RENs and academic library communities in order to strengthen open access and open science in Africa. It aims at providing shared open access infrastructures (regional repository and journal hosting platforms) and federated identity management for library communities. Since its start, the initiative has hosted several workshop and can already count multiple achievements, including three regional surveys and reports, terms of Reference for NREN-Library collaboration in African countries, metadata guidelines for repositories, plans for a regional repository hosting service, national and institutional policy templates.

3.3 Sustainability and Capacity building

AfricaConnect3 focuses on strengthening human resources capacities and expertise at different levels. At regional level, the partners strengthen their own governance and systems and implement their sustainability plans. They also provide support to their member NRENs in order to encourage exchange of ideas and best practices as well as to reinforce technical skills through trainings in specific areas.

An example of this is the RRENs' support for the development of a community of women in African NRENs and promote the role of women in science, technology, engineering and

mathematics (STEM). Leading the Women-in-WACREN initiative, WACREN hosts hackathons and cyber events, equipping women with a robust skillset in IT, computers, and software. Another example of how African RENs and NRENs have been actively engaging women and girls in STEM is the ICT4Girls program led by the Nigerian NREN, Eko-Konnect. The program offers online courses for women to gain hands-on skills in physical computing and data analysis, virtual hackathons to exploit what they learn and conferences to build community and promote innovation in tech.

3.4 Advocacy and donor engagement

In order to emphasise the role of digital tools in the transformation of education and research and their multiplier effect for skills development, employability and economic growth, AfricaConnect3 has a greater focus on Advocacy and Donor Engagement and sets up campaigns targeted at decision makers as well as at international donors and other stakeholders to influence policy change and mobilise funding.

The project's partners are committed to join regional conferences where they are able to engage with end users or with peers with a specific outreach focus on earth observations and agricultural capacities.

4. Achievements to date

Since the start of the project in 2011, 20 countries have been connected to the regional networks: Burundi, Democratic Republic of Congo, Kenya, Malawi, Mozambique, Rwanda, Somalia, South Africa, Tanzania, Uganda, Zambia and Zimbabwe (under the UbuntuNet Alliance), Côte d'Ivoire, Ghana, Nigeria and Togo (under WACREN), Algeria, Egypt, Morocco and Tunisia (under ASREN).

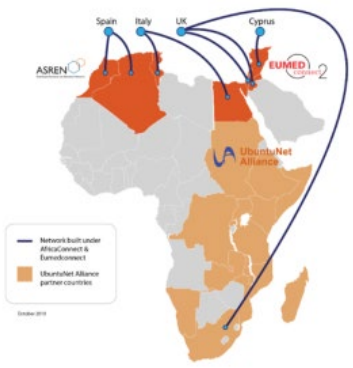
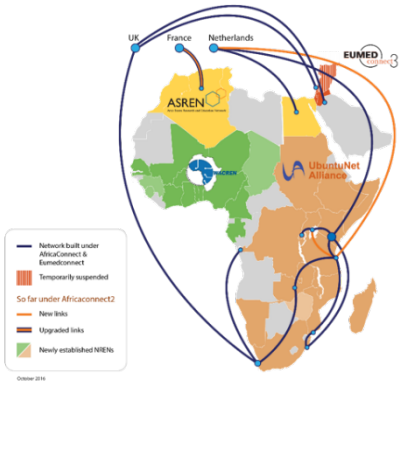
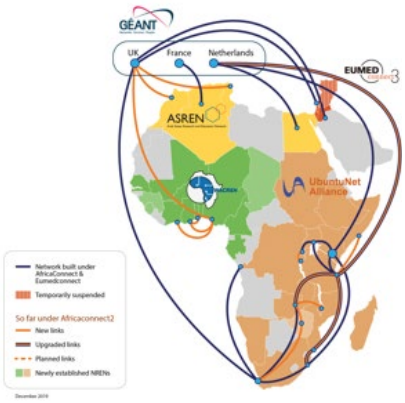
October 2010	October 2016	December 2020
		

Figure 1: AfricaConnect3 Connectivity Map evolution

The AfricaConnect project enabled over 540 institutions to have access to more affordable, reliable and high-speed internet to exchange high volumes of research data. This represents over 5 million students and researchers in Africa that can freely collaborate with their peers across the globe.

Beyond connecting institutions, African Research and Educations networks have a multiplier effect and a greater impact on society: from helping researchers solve some of society's greatest challenges, in fields like disaster management, agriculture, healthcare, environment, climatology and more, to bridging the digital divide and unlocking opportunities for online education and training.

In particular during the COVID-19 pandemic, RENs have confirmed their place at the heart of R&E networking by supporting the survival of higher education institutions.
In North Africa, the Ministry of Education in Morocco launched an e-learning portal, Morocco eLPortal, hosted by the MARWAN network. EUN, the Egyptian Universities Network, has coordinated with IT vendors to support university services in the country. The Tunisian NREN, CCK, has set up a Jitsi-based videoconferencing tool for online classes in Tunisian universities as well as a VPN-SSL service for easy access to scientific resources for the academic community.

In East and Southern African, the Zambian NREN, ZAMREN, installed Moodle offering free hosting for 22 member institutions across the country. In Kenya, KENET is offering a 40% discount on data bundle to university students. In Uganda, RENU unveiled the metro eduroam initiative aimed at expanding the reach of the NREN's network to users beyond university campuses. The Ugandan Research and Education Network also introduced zero-rated mobile access for students and staff of its member institutions.

In Western and Central Africa, WACREN is organising online training activities, including LIBSENSE online workshops, and has been supporting the COVID-19 Smart Development Hack by gathering implementation proposals on an Open Science platform in response to the pandemic. The regional REN also offered its members a licensed use on its Zoom service until the end of 2020 to support their need for online collaboration tools. In Ghana, GARNET is conducting tests to support e-learning via a pilot eduID Ghana federation now involving providers from 12 institutions. In Sierra Leone, SLREN is helping higher education institutions to leverage existing commercial internet access to online e-resources websites and provide zero rating of universities URLs.

5. Business Benefits

Despite the evident progress, NRENs and RRENs are still facing some specific challenges in Africa. The slow progress of some of them is not a reflection of a lack of interest on the part of potential end users. It is rather due to lack of awareness of their benefits and offering.
While the need for NRENs may be well understood among academic and higher education communities, there is insufficient recognition of these organisations nationally and regionally. In some African countries, NRENs are wrongly seen by Telecom providers as competitors. They are also insufficiently represented in the African digital landscape and cannot adequately carry the voices and needs of their end users. Outreach and advocacy work is required to promote greater awareness of the role among national and regional policy makers, donors, decision makers in R&E institutions and telecom providers.

The economic case for NRENs is very tangible: by regrouping the demand for internet connectivity and services nationally, universities and research centres can create economies of scale and obtain preferential rates.

To provide connectivity to their institutional clients, NRENs lease capacity on fibre infrastructure. In this sense, they are like Internet Service Providers (ISPs), but, contrary to commodity networks, NRENs' bandwidth offering is not shared.
NRENs' added-value lies in the fact that they provide dedicated bandwidth to each of their member institutions, such as universities, research centres, vocational education and training institutions. They also offer higher levels of security and unique services that differentiate them from commercial ISPs, such as AAI, software licenses, library subscriptions, grid computing middleware, cloud computing services, computing hardware, e-learning and e-science applications as well as technical support.

NRENs across the globe have a multiplier effect and a greater impact on society: from helping researchers solve some of society's greatest challenges, in fields like disaster management, agriculture, healthcare, environment, climatology and more, to bridging the digital divide and unlocking opportunities for online education and training.

5.1 Benefits to African students and researchers

AfricaConnect3 greatly improves access for researchers, students and institutions to digital infrastructures and technologies, connecting Africa to unlimited possibilities
More specifically, NRENs narrow the digital divide by improving access to and reducing cost of advanced, reliable internet connectivity for R&E. During the first two phases of the AfricaConnect project, focus was primarily on connecting NRENs to the global R&E community. But now NRENs are also deploying value-added services, such as eduroam, with 16 African countries now being eduroam operators[6] and 7 additional ones in a pilot deployment phase. Not only they provide African students and researchers with high-speed, reliable broadband connectivity and services, but also with access to innovative e-learning tools and advanced research resources. This, in turn, enables students and researchers to more collaborative learning and research with peers around the world.

5.2 Benefits to African NRENs

NRENs not only bring value to their partners by lowering down the cost of connectivity in complex market conditions, but they also strengthen capacity building among their partners to upscale human resources output and enhance human capital development, participate in global R&E events for increased exposure, and transfer knowledge and exchanging best practice.

5.3 Benefits to Global Research and Education

Looking at the global R&E community, NRENs' added value lies in the fact that they connect Africa's scientists, students and educators to the world to, bridging the digital divide and fighting brain drain in Africa and, in turn, unlocking its enormous potential.

6. Conclusions

R&E connectivity and collaboration tools and services provided by NRENs can only be successful and beneficial to societies when built and managed by people supported to do the task. In countries where little national support and recognition is given to the ICT experts who specialise in running networks for specific R&E needs, it is challenging to realise the full potential. Building adequate human capacity and technical skills is essential for interconnecting the world, and the regional network projects play an important role in building the required skill sets among NREN staff.

This paper demonstrated that AfricaConnect3 and its partner NRENs greatly improve access for researchers, students and institutions to digital infrastructures and technologies, connecting Africa to unlimited possibilities.
The current and third phase of the project aims at further extending the reach of the regional R&E networks in order to connect more countries and upgrade the capacity of the core networks as well as set up a cloud infrastructure for open science. The project also focused specifically on service applications, which include an open science cloud, network security, and trust and identity, as well as on capacity building and advocacy for research and education networking.

This paper also made the case for African RENs and NRENs explaining that their real value goes beyond reduced bandwidth prices, in that they are able to provide an advanced and diversified portfolio of ICT services specific to the needs of their members that conventional ISPs, such as eduroam, cloud services, eduGAIN or library databases, do not provide. NRENs have proved to be a vital component in e-learning, e-science and e-research strategies as they bring a common approach to the coordination and deployment of national and international communication networks and services.

The AfricaConnect3 project seeks to establish that connectivity and NRENs are key to improving education and research, and that NRENs are part of the solution.

Acknowledgements

The AfricaConnect3 project is run in collaboration between the European Union, the pan-European networking organisation GÉANT and the three regional partners supporting local research and education networking across Africa: UbuntuNet Alliance (Eastern and Southern Africa), WACREN (Western and Central Africa) and ASREN (Northern Africa and Middle East Arab countries).

AfricaConnect3 builds on the work carried out by AfricaConnect and AfricaConnect2 and aims to foster the creation and consolidation of national and regional research and education (R&E) networks across Africa that provide access to dedicated, high-capacity internet connectivity and offer a gateway to global R&E collaborations through their interconnection with the pan-European GÉANT network.

The total budget for AfricaConnect3 is 37.5 million euros for a period of 4 years from November 2019, with 30 million euros contributed by the European Commission's Directorate-General International Cooperation and Development (DG DEVCO). The remaining funds (€7.5m) are being provided by the African partners.
In each cluster, RRENs are responsible for their own grant agreement with the European Commission whilst GÉANT together with the partners is tasked with the overall project coordination role, including the procurement of connectivity and equipment for all clusters.

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