

eduroam in Africa

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Abstract: eduroam is the secure, world-wide roaming access service developed for the international research and education community to address the increasing need for fast and secure Internet connection everywhere. With over 6.4 billion international authentications to date stretching across 106 countries, eduroam is expanding in Africa where National Research and Education Networks (NRENs) are going beyond the traditional campus connectivity aiming at bridging the digital divide. Uganda, South Africa and Kenya are leading the way and connecting users off campus at bus stops, libraries, cafes, and hospitals. NRENs are at the helm of Africa's digital transformation and eduroam is a tangible solution to bridging the digital divide. This paper is therefore a guidebook detailing the technology behind eduroam, the benefits and the challenges for its four main target groups in Africa: users, institutions, NRENs and municipalities. The call for action is to further deploy eduroam hotspots and provide connectivity everywhere on the continent, including remote areas and unprivileged communities where students, researchers and teachers are present.

Keywords: AfricaConnect, AfricaConnect2, AfricaConnect3, Internet Connectivity, Research and Education Community, NRENs, eduroam, digital divide, inclusion, ICT4D, eduGAIN, roaming, students, authentication, federation, e-learning, COVID-19, UbuntuNet Alliance, WACREN, ASREN, GÉANT, RENU, TENET, KENET, European Commission.

1. Introduction

Students, researchers and lecturers are becoming more and more mobile. They are never stationed in one place. Lecturers often teach in different universities or campuses; students usually roam between different locations such as libraries, classrooms, hostels, and other assembly points; researchers move from place to place, looking for collaborations and exchanges. The need for fast and secure Internet connection everywhere has seen a drastic increase with the outbreak of the COVID-19 pandemic and the advent of remote working and online learning.

However, despite the urgent need of users to connect in different locations, institutions hardly have the capacity to address wireless network needs. This leaves roaming students and staff to resort to insecure practices such as borrowing login details or accessing open networks.

In this context, eduroam plays a key role in addressing the problem.

1.1 What is eduroam?

As the name suggests – it comes from **education roaming** -, eduroam is the secure, world-wide roaming access service developed for the international research and education community. By simply opening their laptop or picking up their phone and with just one profile, users can connect anywhere and anytime when visiting participating institutions.

Its main target groups consist of students, researchers, and staff who can benefit from the flexibility of obtaining Internet connectivity across campus and abroad, as well as

municipalities who want to respond to the evolving needs of mobile students and break the impression that Africa is lagging behind.

1.2 How it started

Back in 2002, Klaas Wierenga – then working for SURFnet and now Chief Information & Technology Officer at GÉANT – was “*getting annoyed by the fact that whenever I visited a university I had to register my wireless card or borrow one from the local IT department to get online*” [1]. After some initial experiments, Klaas turned to what was then called the TERENA Task Force on Mobility¹, a group of experts from the wider European National Research and Education Networks (NRENs) Community, to get feedback and improve his ideas.

The eduroam initiative launched in 2003 with 6 countries, the Netherlands, Germany, Finland, Portugal, Croatia, and the United Kingdom.

Twenty years on, eduroam has reached over 6 billion national and international authentications [2]. Now eduroam is a project of the pan-European network GÉANT, and it receives funding from the European Union’s Horizon 2020 research and innovation programme [3]. Thanks to the global agreement, the eduroam Wi-Fi roaming service is free-of-charge to users. The fee for member institutions is covered by the basic fee infrastructure that they pay to the respective NREN.

What started as a “half-baked” [4] idea to bring a solution to an annoyance is now available in 106 territories worldwide, of which 17 are in Africa [5], where users can now roam freely and securely from hundreds of hotspots, like cafes, hospitals, campuses, bus stations, and libraries.

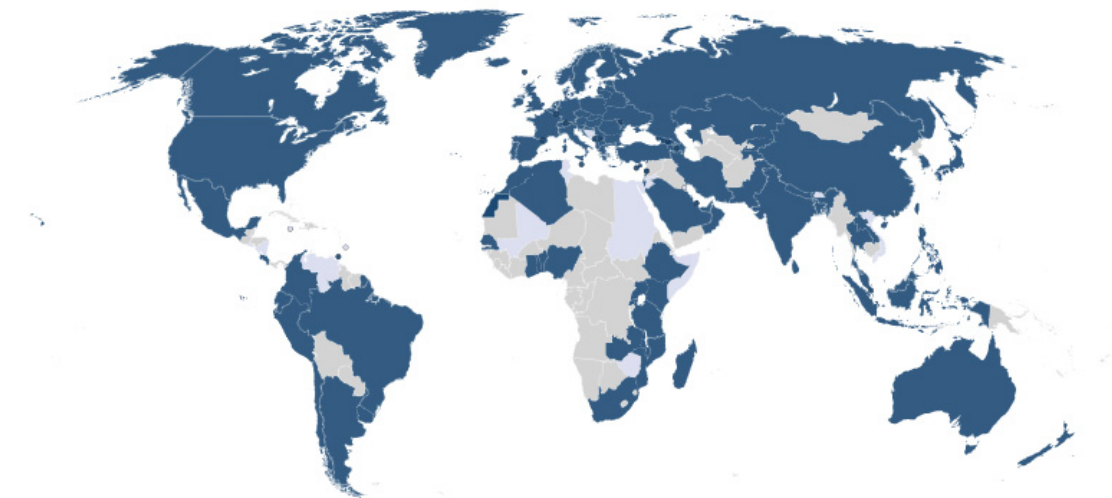


Figure 1: world eduroam map, September 2022. Source: <https://eduroam.org/where/>

1.3 Paper structure

This paper will address some of the key achievements of eduroam in African countries and highlight its crucial role for the continent’s digital transformation.

It begins by briefly explaining the technology and governance of eduroam and continues to demonstrate its added value detailing the vast array of its applications and developments in Africa. It shows the main achievements and impact, with a special focus on the key role that eduroam played during the COVID-19 pandemic. It continues to lay out

¹ TERENA merged with DANTE to become the GÉANT Association in 2014. The Task Force on Mobility moved to become the Task Force on Mobility and Network Middleware. The Task Force ceased to exist when the European eduroam confederation was established as part of the GÉANT project.

the benefits for the main target groups: African researchers and students, institutions, NRENs, and municipalities. Finally, it discusses the existing challenges that will need to be overcome to unlock eduroam's full potential.

2. Objectives

This paper will present the impact of eduroam in African research and education communities and will be a useful basis for developing guidelines for stakeholders interested in considering and assessing the eduroam service. The ultimate goal is to advocate the case for more institutions to adopt the secure, world-wide roaming access service and leave no one behind in an increasingly digitalised world.

3. How does eduroam work?

The technology behind eduroam is based on the IEEE 802.1X standard and a hierarchy of RADIUS proxy servers² [6]. The abovementioned Task Force on Mobility created a test bed to demonstrate the feasibility of combining a RADIUS-based infrastructure with 802.1X standard technology to provide roaming network access across research and education networks. With every successful test, eduroam started gaining momentum in the European Community and with other NRENs joining, the infrastructure was eventually named eduroam. [7]

eduroam allows users from member sites to connect to an authenticated network at any other location where the service is enabled. Depending on the policies of each institution, users might also have access to additional resources.

eduroam is operated as a digital commons, reconfirming the crucial role of collaboration in the research and education community.

Thanks to its secure and privacy-preserving technology, connecting to eduroam does not require entering any credentials. The device will identify a valid eduroam access point and login automatically, using pre-configured credentials. The password for the user's online identity is provided by their home institution.

The user credentials are kept secure and are not shared with the access point. Instead, the credentials are forwarded securely to the user's home institution, where they can be verified and validated. The system uses a network of servers run by the institutions, and the participating institutions to securely route these requests back to your home institute. All this happens seamlessly, virtually, and instantaneously.

Participating organisations can apply their own filtering policies as long as they clearly inform users about the rules.

All these features make the eduroam service far more secure than typical commercial hotspots.

4. Supporting eduroam globally: governance and participation

The Global eduroam Governance Committee (GeGC), which comprises of regional representatives of roaming operators (ROs) including from Africa, monitors that eduroam operators comply with the service's high technical and organisational standards [8].

In order to be authorised to use the eduroam service, institutions need to be part of the respective national RO, which, in most cases, is the NREN but it can be any lead institution

² To read about the details of the eduroam architecture of network roaming, visit <https://www.rfc-editor.org/rfc/rfc7593> (2015, September)

willing to take on the role. It is important to point this out as not all African countries have a functioning NREN and yet could join eduroam³.

eduroam access can also be made available through public, commercial or city Wi-Fi initiatives to broaden access for students. This is possible because eduroam separates the functions of access infrastructure and user authentication in a scalable and secure manner. This means that commercial entities cannot become identity providers and offer services to their customers that will work via eduroam. Instead, they set up the access infrastructure to provide hotspots, which then reintegrate into eduroam through the national ROs. If they partner with eduroam, commercial entities cannot charge users of a hotspot for accessing the Wi-Fi network.

5. Target groups

The four main target groups of eduroam are individual users, institutions, NRENs, as well as municipalities in Africa.

5.1 eduroam for users

For students, researchers and academic staff, the possibility to turn on their device and immediately get high performance, secure Wi-Fi access is a game-changer as it completely transforms their learning and work experience. Learners have better chances to excel thanks to easy and fast access to good quality Internet and the learning material they need.

5.2 eduroam for institutions

As eduroam provides a single solution for all the mobile connectivity requirements of an institution, the administrative burden imposed on local IT departments for supporting visitors is reduced drastically. Implementing and maintaining eduroam does not cost more than deploying any other secure Wi-Fi solution and brings significant cost savings thanks to the reduced IT department workload. Not only does it support local users to connect to the local network, but it also provides streamlined connectivity to visiting users and allows local users to connect to other participating networks.

5.3 eduroam for African NRENs

eduroam offers a unique value-added service that NRENs can offer to their member institutions for the benefit of the ever-growing mobile audience. With research and education becoming increasingly international, eduroam becomes a key tool to enable collaboration and mobility by giving students and researchers the ability to roam for free across 106 countries around the world.

5.4 eduroam on city wireless networks

Many cities across Africa are increasingly focusing on responding to students' mobility needs and are taking active steps to ensure that those students, often from under-privileged backgrounds, have equal opportunities. By deploying eduroam on city wireless networks – leveraging existing infrastructure and fibre optics - and making it available on multiple public hotspots allow students to access study materials closer to their homes and decrease the number of journeys to university campuses while, at the same time, reduces the burden of high cellular data costs [9].

With eduroam available at public access points, African cities break the impression that Africa is lagging behind and instead are world-class destinations for international students and academics. The deployment of eduroam in both Cape Town and Kampala (see 8.1 and

³ New institutions can use the eduroam Configuration Assistant Tool (CAT) to help them offer eduroam to their users. The tool is customised to support the individual configuration of every campus:
<https://eduroam.org/how/>

8.2) has attracted international attention, and visitors who connect to eduroam in unexpected locations praise their experience on various social media. This means there are significant direct and indirect public relations opportunities for cities to showcase that they care for their research and education community [10].

6. Eduroam in Africa

To date, eduroam is available in 106 territories worldwide, 17 of which are in Africa.

6.1 AfricaConnect3 support to eduroam in Africa

The AfricaConnect3 regional Partners -the UbuntuNet Alliance (UA), the West and Central African Research and Education Network (WACREN) and the Arab States Research and Education Network (ASREN)⁴, played a crucial role in implementing eduroam across the African continent. They established an African eduroam confederation that resulted in the deployment of regional proxy servers in Johannesburg, South Africa and Lagos, Nigeria which not only improved the quality of service but also provided community support for NREN roaming operators.

The Partners also work with NRENs in the region and support them where necessary in deploying the service. The activity will also include enhancements of the service in those NRENs where the service already exists and where further work needs to be done on the NROs.

In particular, during the first year of implementation, AfricaConnect3 supported 7 NRENs. In Eastern and Southern African, UA supported EthERNET and MAREN by enhancing their eduroam service, both NRENs already had some eduroam infrastructure that was not operating optimally.

In Western and Central Africa, 3 WACREN NRENs in Benin, Côte d'Ivoire and Togo received support.

In North Africa, all 4 ASREN member NRENs received support to deploy eduroam. During the reporting period, the NRENs continued to maintain and to enhance their eduroam services. Algeria and Morocco, for instance, continued to roll out eduroam and identity federation services. Egypt deployed eduroam services at EUN premises and efforts are underway to deploy at universities. Tunisia is in the eduroam pilot phase.

By 2020, NRENs in Africa had supported the deployment of eduroam in 151 institutions (116 in UA, 30 in WACREN and 5 in ASREN) and 303 locations. As of February 2023, the numbers of connected institutions have increased to 205 and locations to 345. By the end of the project in 2023, they aim at deploying eduroam in a total of 267 institutions⁵.

National Roaming Operators	Country	No. of eduroam Service Locations ⁶	No. of eduroam Identity Providers	No. of eduroam Service Providers
UA				
1 EthERNET	Etiophia	1	2	2
2 KENET	Kenya	43	43	43
3 iRENALA	Madagascar	1	3	1
4 MAREN	Malawi	3	4	4
5 MoRENet	Mozambique	-	1	1

⁴ More information about the AfricaConnect project and its third and current phase, AfricaConnect3, can be found at <https://africaconnect3.net/>

⁵ These data have been sourced from the AfricaConnect3 project's interim reports.

⁶ While a service provider is a federation partner that provides services to the end user, an identity provider manages and authenticates the user identity. Service locations, also known as hotspots, are the sites where the user can connect to the eduroam network, i.e. a school, a library, a café, a bus station, etc.

6	TENET	South Africa	169	44	46
7	TERNET	Tanzania	5	8	4
8	RENU	Uganda	42 ⁷	89	16
9	ZAMREN	Zambia	-	73	72
WACREN					
10	BeninRER	Benin	N/A	N/A	N/A
11	GARNET	Ghana	75	4	4
12	NgREN	Nigeria	-	7	6
13	SnRER	Senegal	N/A	N/A	N/A
14	TogoRER	Togo	N/A	N/A	N/A
ASREN					
15	MARWAN	Morocco	6	6	6
16	ARN	Algeria	N/A	N/A	N/A
Total			345	284	205

Table 1: eduroam rollout in Africa as of February 2023. Source: www.monitor.eduroam.org. KENET figures were sources from <https://eduroam.ac.ke/>

7. Case Studies

While traditionally eduroam is mainly present on university campuses, African NRENs are more and more innovative and committed to bridge the digital divide and offer connectivity wherever students are.

The following case studies are examples of good practice in the countries of Uganda, South Africa and Kenya that can potentially be adopted elsewhere.

7.1 Connecting off campus with metro eduroam in Uganda

Since the COVID-19 pandemic broke out in 2020, institutions have been experiencing learning disruptions and have had to quickly adapt to the needs of their students being away from campus. To support their member institutions switching to online learning and their students and staff studying and working off-campus, on 1st September 2020 the Research and Education Network of Uganda (RENU), launched metro eduroam, an unprecedented initiative in the continent that allows students, university staff, and researchers to access free and secure wireless Internet connectivity off-campus [11].

Users with an eduroam profile can connect in over 400 locations countrywide at no cost. The number of available hotspots and participating institutions is rapidly increasing [12].

Since the launch of Metro eduroam, as of August 2022, 37 institutions joined the initiative and 609,916 successful logins have been registered, out of which 1,556 are unique, with the average daily peak traffic being 33.37 Mbps⁸.

Metro eduroam has also seen challenges. A fundamental requirement to adopt the eduroam service is for the institution to have a user database under their institutional domain, but this is not always available. The institutional user database is used for managing eduroam authentications at any hotspot. As an alternative solution, the RENU team is exploring a managed Identity Provider (Managed IdP) solution, which would free institutions from the burden of having to set up costly user database to benefit from the eduroam service.

Building on the success of metro eduroam and in an effort to address the limitation of coverage, in September 2022 RENU launched eduroam on the Go, a pocket-size routing device that enables researchers and university staff to connect to eduroam fulltime and not only from a few fixed locations. eduroam on the Go works with the same authentication

⁷ This does not include the number of service locations for metro eduroam and eduroam on the go.

⁸ Locations can be checked at <https://eduroam.renu.ac.ug/>

infrastructure as eduroam and metro eduroam, so the features of security and gratuity for the users remain unchanged. Researchers, students and academic staff from RENU member institutions can enjoy unlimited data connection while on the move. [13]

7.2 Connecting public libraries and hospitals with eduroam in South Africa

In June 2019 the City of Cape Town and the Tertiary Education and Research Network of South Africa (TENET), installed eduroam in 57 of Cape Town's public libraries [14]. This has given access to students and staff from any university which uses eduroam, including all four of the public universities in the Western Cape (Cape Peninsula University of Technology, Stellenbosch University, University of Cape Town and the University of the Western Cape), to their institution's high-speed Internet network from local libraries. This way students not only reduce their travel time to campuses but also drastically reduce their mobile data bills.

Only in the first week of eduroam use in the Cape Town, eduroam saw over 15,000 authentications from 121 institutions including users from Europe, Asia, America, and Oceania. This is indicative of the reach of the eduroam service.

More recently in 2021, TENET worked with the Western Cape Government, an initiative by Stellenbosch University, to pilot the roll out of eduroam to four hospitals in the Western Cape [15]. The pilot was successful, and plans are underway to expand it to other hospitals in the area and also in the Gauteng provincial government.

The 2019 Statistics South Africa General Household survey revealed that less than one-tenth (9,1%) of South African households had access to the Internet at home [16]. The COVID-19 crisis has really amplified the impact of the gaping digital divide in the country with many students battling high data costs and poor Internet connection. TENET's eduroam initiatives do not only address the universal right to affordable connectivity but are serve the South African research and education community by giving institutions and users the means to be active contributors. Rolling out eduroam to public libraries shows that they play a crucial role in democratising access to information and, therefore, creating opportunities to participate as active digital citizens [17].

7.3 Connecting students' halls of residences with eduroam in Kenya

The Kenyan Education Network (KENET) implemented its first eduroam deployment in 2010 and has since then activated eduroam in 44 universities and colleges [18]. Traditionally, eduroam Wi-Fi locations were situated in libraries and areas where students, staff and researchers would normally converge at while on-campus.

Over the years and with the adoption of blended learning due to the COVID-19 pandemic, there has been an increased need for students to access to connectivity off-campus to, for example, attend classes virtually while at their hostels or halls of residence. Oftentimes, the halls of residence that are located inside the university lack both cables and wireless connectivity and those that are off-campus face similar challenges.

In order to find a solution to this problem, in 2022 KENET, in collaboration with selected universities, deployed the first ever cloud based OpenWifi architecture in Africa by extending Wi-Fi coverage of student learning spaces, lecturer halls, and hostels at main campus of Kenyatta University, in Nairobi, Kenya [19].

The expansion extended the reach of eduroam to at least 1,700 additional students residing at the halls of residence at Kenyatta University with a capacity of supporting approximately 14,000 concurrent connections, mostly within and around the hostels. This expansion also increased the eduroam coverage at Kenyatta University to 90% of the students within the university⁹.

⁹ This information is not public but based on factual knowledge on KENET's knowledge of the project and its outcomes.

KENET has also extended eduroam to students' hostels at Jomo Kenyatta University of Agriculture and Technology as well as Laikipia University with an aim of providing ubiquitous connectivity to students while on campus and also at their halls of residence in order to promote seamless learning and access to educational resources.

8. Challenges

If properly harnessed, eduroam can provide both students and lecturers access to 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.

With the recent focus on e-learning methods and connectivity, especially since the outbreak of the COVID-19 pandemic, eduroam has proved its crucial role within the research and education community. However, many challenges still exist and need to be overcome.

8.1 Limited locations in Africa

With only 17 African countries with access to eduroam in 345 locations, the potential of eduroam is not yet fully unlocked on the continent. NRENs in Africa need support, need to go beyond standard practice, use existing case studies, and continue to be innovative to bring connectivity where needed to all students, researchers, and lecturers.

Remote and rural areas often do not yet have access to eduroam due to several of the challenges highlighted below.

8.2 Insufficient and unaffordable connectivity

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.

Overall, African education and research communities suffer from very low Internet penetration levels as well as from very high connectivity prices, a situation compounded by the presence of telecom monopolies or market dominance by a single player and a weak regulatory environment [20]. As a result, those factors translate into a general disconnectedness of the continent from the global digital economy and all its opportunities.

In order for eduroam to operate optimally, sufficient connectivity need to be provided by the institutions to the students, but, in practice, institutions often consume the connectivity they can afford rather than the connectivity that they need.

Furthermore, small coverage areas can be improved by increasing the number of access points, but this could lead to overwhelming the already insufficient bandwidth in some institutions.

8.3 Devices and technical challenges

In addition to sufficient connectivity at the hotspot level, eduroam requires students, educators and researchers to have access to IT devices. Nevertheless, according to the International Telecommunication Union (ITU), the proportion of households in Africa with access to a computer is 9%, compared to over 75% of households in Europe [21]. This digital gap was particularly noticeable during the start of the Covid-19 pandemic, while the rest of the world moved their classes online, millions of students and researchers on the continent were disconnected and could not access e-learning solutions due to lack of affordable equipment.

In addition to the lack of equipment eduroam needs to be compatible with the equipment most commonly purchased on the continent. In fact, according to the State of the

ICT Sector Report in South Africa, smartphone penetration reached over 91% in 2019 [22]. However, some devices using the legacy wireless adapter cards may not work with eduroam authentication processes. Hence, it is crucial for the GeGC and the local IT personnel to be always very attentive that new eduroam updates are compatible with IT equipment purchased in the continent. The eduroam community could develop guidelines to standardise the testing of devices for compatibility, including setting up an interest group with a mandate of testing and providing reports on device compatibility.

8.4 Implementation challenges

ICT policies vary depending on the institution. This means that while some institutions may allow traffic from certain sources (i.e. YouTube or torrents), others may not, creating confusion among the users about the services and sources they can access through eduroam. Therefore, there is a need to create a standardised ICT policy to effectively regulate how eduroam users can access the services. [23]

Another implementation issue is that, before the authentication takes place, a pre-configured key is shared between RADIUS entities but it needs to go through several other servers to reach the intended authorising one if the user is roaming. With this approach, if there is just one point of failure in the authentication process, the user cannot access the service. This issue creates the need to have redundant links within the network to avoid one point of failure when authenticating users of eduroam. [24]

8.5 Human resources and capacity building

Engineers and experts with the right IT skills to deploy, operate and maintain eduroam is essential. Nevertheless, these skills are not always available at a campus or institution level, this is even stronger in remote and rural areas. In addition, higher education institutions have a high staff turnover, which plays a significant role in the amount of regular training that they will need to invest in.

Therefore, the support provided by NRENs is essential, as in several African countries the NREN organises trainings and provide direct engineering assistance to institutions. Institutions can also partner with external trainers and other institutions more experienced in eduroam deployment in order to enhance the human capacity with the aim of reducing the skills gap relating to design, implementation and operation of eduroam infrastructure.

8.6 eduroam awareness raising

Some users are not willing to connect to unknown networks from other institutions, anticipating security issues. Therefore, there is a need to raise awareness among students about eduroam and its secure mode of operation as well as the nearest access point, especially if it is not necessarily in their own institution. Conversely, many students are willing to share access codes with others. Because eduroam credentials are often the student's primary access credential for many services, this activity needs to be discouraged through the awareness programme.

9. Conclusions

This paper provides background information and points to additional material to assist NRENs and their member institutions that are considering rolling out eduroam in their countries, find information on how the eduroam technology works as well as case studies to showcase its value and examples of good practice.

With the global research and education community being ever so mobile and the drastic switch to online learning since the outbreak of the COVID-19 pandemic, there is no better moment in time to roll out eduroam. Although eduroam was originally meant to be deployed on campus only, in recent years there has been a realisation that, students and

researchers need connectivity off-campus as much as on-campus– whether they are studying in their accommodations or visiting a library to do some research.

As a consequence, there have been efforts to deploy eduroam in public spaces and locations other than university campuses. This paper calls for support and action to further deploy hotspots and provide connectivity everywhere on the continent including remote areas and unprivileged communities.

Thanks to its secure encryption and authentication standards, the eduroam roaming service is safer than that of commercial providers. This, together with its low implementation and maintenance costs, worldwide presence and easy login experience, makes it a tangible solution for institutions and NRENs to contribute to bridging the digital divide and offer connectivity to their students and staff.

NRENs are transforming the deployment of and access to digital technologies in Africa. Their work and impact on the community could leapfrog and be fully integrated to the fourth industrial revolution if they bridge the gap with affordable, dedicated, secure and sufficient connectivity for researchers and students.

Students, researchers and academic staff of eduroam member institutions can check the closest access points and all the available local hotspots in their respective regions on the eduroam website. NRENs and institutions that are interested in deploying eduroam can contact their respective regional networks (UA, WACREN or ASREN).

Acknowledgments

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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 (DG INTPA). The remaining funds (€7.5m) are being provided by the African partners. In each cluster, partners 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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