Challenges and Benefits of Educational Roaming (eduroam) Service to ZAMREN Member Institutions

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Abstract

Eduroam (education roaming) is a secure, world-wide roaming service which allows researchers, students and staff from participating education and research institutions access Internet when they visit other participating institutions. Zambia Research and Education Network (ZAMREN) is a specialized Internet service provider with its sole purpose of supporting the needs of the research and education communities in Zambia. As such, there is need for ZAMREN to be service oriented by providing services that could enable research and learning among its member institutions which the commercial Internet Service Providers (ISPs) cannot provide. Eduroam if fully utilized could be of great benefit to member academic institutions. Despite the benefits which could be attributed to eduroam, challenges as well exist. Eduroam utilize the combining features of RADIUS-based infrastructure with IEEE802.1X standard technologies which can be timid to some of the technical personnel in most of the member institutions. Individual institutional ICT policy can disadvantage some roaming user in terms of traffic allowed. Users' confidence in performing sensitive transaction on wireless networks is another hindering factor for fear of eavesdropping. There is also the challenge of low bandwidth capacity at some of the member institutions. The outlined challenges could substantially affect the confidence of users towards eduroam and thereafter its implementation in ZAMREN member institutions. This paper investigates the challenges and implementation of eduroam in Zambia and presents results of the survey conducted on the use of eduroam in the ZAMREN member institutions.

Keywords

Eduroam, RADIUS Server, IEEE802.1X, ZAMREN, Education and Research Institutions

1. Introduction

EDUcation ROAMing referred to as eduroam is the secure, world-wide Internet roaming access service developed for research and education purposes (Milinović, 2008). Eduroam allows researchers, students and staff from participating institutions to obtain Local Area Network (LAN) and Internet connectivity when they visit other participating institutions. Zambia Research and Education Network (ZAMREN) is a specialized Internet service provider with its sole purpose of supporting the needs of the research and education communities in Zambia (ZAMREN, 2014). As such, there is need for ZAMREN to be service oriented by providing services that could enable research and learning among its member institutions which the commercial Internet Service Providers (ISPs) cannot provide. One such service is eduroam, with over 15 member institutions affiliated to ZAMREN (Mkandawire, 2013), eduroam if fully utilized could be of great benefit to member institutions.

Despite the benefits which could be attributed to eduroam, there are many challenges however. Eduroam utilizes the combined features of RADIUS-based infrastructure with IEEE802.1X standard technologies which can be timid to some of the technical personnel in most of the member institutions. Different institutions have different ICT policies which could not exclusively allow certain devices to access their resources as well as denying certain traffic in their network (e.g. YouTube traffic), this might disadvantage some users. There is need to extensively educate users on the need and benefits of using eduroam as some users are sceptical of connecting to just any network for fear of losing their sensitive information that is on their laptops or device they use to connect to such networks by eavesdropping. There is also the challenge of low bandwidth capacity at some of the member institutions. This affects the quality of the service that an eduroam user would receive, when connecting to a host network with low bandwidth capacity. Such a user would end up getting frustrated since the low bandwidth would not allow them to perform the needed tasks such as streaming video content or downloading literature and software. Some institutions do not have reliable and continuous Internet connectivity. The outlined challenges could substantial affect the confidence and thereafter use of eduroam in the institutions by intended users. To the best knowledge of the authors, this is the first attempt to outline challenges and opportunities of eduroam use in Zambia. Therefore, the important contributions of this paper are three fold namely: Investigate the opportunities and challenges of eduroam and its implementation in Zambia; Provide a detailed architecture of eduroam implementation in Zambia with ZAMREN at the centre; Present the results obtained from the survey of eduroam usage in ZAMREN member institutions where eduroam is already implemented.

2. Eduroam Infrastructure Implementation Architecture

Eduroam is a technological infrastructure that allows academic institution users to access internet services at different institutions with eduroam enabled in a secure manage. It is based on different underlying technology with the prominent one being RADIUS protocol (Rigney, 2000). The main principle is that a user is authenticated at home institution using the authentication methods provided while being authorized to access network resources at the visited institution (Milinović, 2008). Figure 1 depicts the architectural implementation of eduroam. The architecture is built on the hierarchy of RADIUS servers from academic institutions to federal ISP (ZAMREN) up to global RADIUS server entities. When a user (user@realm, where realm is DNS identifier of the user's institution eg user@mu.ac.zm for Mulungushi University (MU), user@unza.zm for University of Zambia (UNZA) etc) want to access eduroam services from another institution, the local RADIUS server at that institution will forward that request to the national RADIUS server at ZAMREN which in turn will forward the authentication request to the authenticating server at home of the requesting user. The RADIUS servers at the national federation identify home servers of users based on realms. Once the user is authenticated, the response will be sent back to the remote server using the same hierarchical transportation where access to the network resources is granted to the roaming user.

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TOP LEVEL RADIUS SERVERS (GLOBAL)

          ZAMREN PROXY RADIUS SERVER

HOME INSTITUTION        Authentication Request      VISITED INSTITUTION

                                                    REMOTE RADIUS
  HOME RADIUS                                        SERVER
  SERVER         Authentication Re

                                                    RI SP
  HI IdP                                              NETWORK
  Auth S                                              ACCESS

HI IdP – Home Institution
Auth S- Authentication Services
RI SP- Remote Institution Service Provider            ROAMING
                                                       USER
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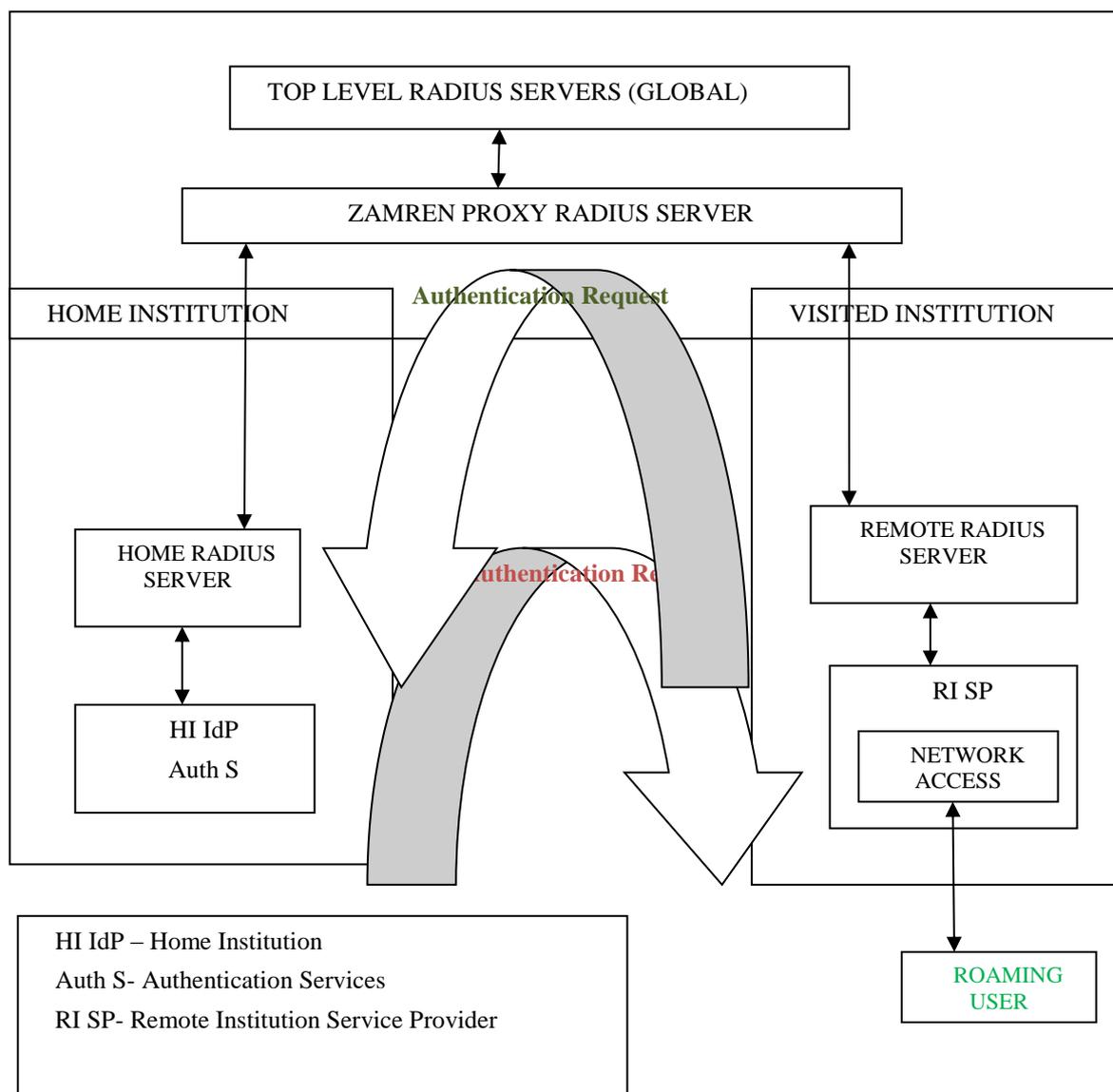
Figure 1: Architecture Implementation of eduroam

At the physical topology of the home institutions' network, the Access Points (APs) and switches use IEEE802.1X protocol (Congdon, 2003) based on Extensible Authentication Protocol (EAP). EAP implementation include secure tunnel through which users can forward authentication information to the home institution. To create a secure channel, three protocols based on EAP is used which are EAP-TTLS, PEAP and EAP-TLS with the later based on public X.509 certificates (Dantu, 2007). Eduroam confederation infrastructure is based on the RADIUS server hierarchy which is implemented using RADIUS AAA protocol architecture (Nakhjiri, 2005). The hierarchy consists of institutional RADIUS servers which are connected to national RADIUS server proxy (ZAMREN RADIUS proxy server), in turn the proxy at ZAMREN interconnects the institution and the other RADIUS entities globally. Much of the burden in the RADIUS server hierarchy is placed on the home server (HI). The HI server is responsible for authenticating its own local users (ie users connected to the LAN of the institution) as well as users who have visited other institutions (RI). The authentication is done by checking credentials supplied by users against those stored in the local database through a local identity management system. Once the authentication is done, the HI server is responsible for forwarding requests made by roaming users to national proxy server at

ZAMREN which also forwards to the RI. At the user end devices, the supplicant software that use 802.1X protocol to send authentication request using EAP must be installed if not in-cooperated in the operating system. The request is sent through an AP which also forwards to the RADIUS server. Depending on the ICT policy of the institution, the authenticated roaming user can be assigned to specific VLAN (Congdon, 2003) by the AP based on the information received from the RADIUS server.

3. Opportunities and Challenges of Eduroam in Zambia

This section discusses benefits and challenges of implementing eduroam in ZAMREN member institutions. There are more than 15 institutions affiliated to ZAMREN currently (Mkandawire, 2013). However, only few of the affiliated members are using ZAMREN as its primary ISP to access the internet, among which include: University of Zambia (UNZA), Copperbelt University (CBU), Mulungushi University (MU), Zambia Centre for Accountancy Studies (ZCAS), Rusangu University (RU) to mention just a few. Among the fully connected institutions, only four have implemented eduroam access networks which are CBU in Kitwe, MU in Kabwe which has connected its two campuses, UNZA and ZCAS in Lusaka. Figure 2 below shows the institutions with eduroam enabled as obtained at http://www.eduroam.zm/ [accessed on 25th October, 2014]. The subsequent sub-sectionsdiscusses the benefit and challenges of eduroam usage in Zambia.
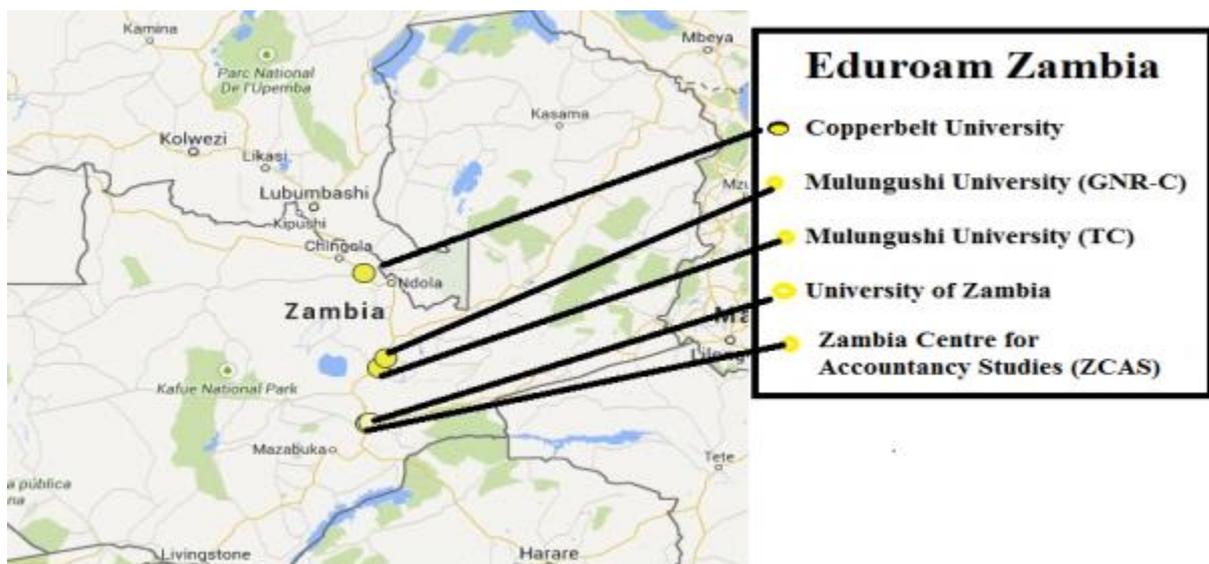

Figure 2: Institutions with eduroam enabled in Zambia

3.1 Opportunities of Implementing Eduroam

Once eduroam is deployed in many institutions of learning in Zambia, there are many advantages which come with the implementation which can be grouped as technical and accessibility.

1.1.1 Technical Benefit of Eduroam
1. In most institutions in Zambia, internet access at campus is stand-alone, meaning each institution has implemented its wireless access with different technology and different authentication methods. If a new guest wants to access the network resources, the ICT department has to be informed in

advance and that guest needs to be provided with new account or guest account in order to access the network. With eduroam however, there is no need to involve the technical department of the visiting institution for creating a user account. The visitor will use the credentials (username and password) from his/her home university in order to access the network services in the visited institution. This reduces the overhead of the technical staff as they can concentrate on other tasks instead of creating user account for each new user who visits the institution.

2. Eduroam is based on a reliable and secure technology for authentication, authorization and accounting, the architecture build on top of RADIUS protocol. Eduroam allows all authentication mechanism to be done in a secure manner with reliable encryption mechanisms and not vulnerable to eavesdropping or man-in-middle attack who would want to steal the passwords.

3. The use of certification at the device level (or server side) allows only students, academic and non academic staff have access to the eduroam service as only there devices will be installed with the certificates to connect to the service.

4. Any device with wireless adapter can connect to eduroam access network without involving the technical team, all one need is a username and password thereafter connection is granted on a fly.

1.1.2 Accessibility Benefit of Eduroam

1. With eduroam, there is freedom to access the internet everywhere the service is enabled. Students from MU or CBU who come from Lusaka can easily go to UNZA or any other eduroam enabled institution in Lusaka and access the internet freely during vacation.

2. Apart from freedom of accessing the internet, the internet come at no cost for as long as one is a member of participating institution, be it a student or staff. This allows students who come from low income families to access the internet free of charge instead of going to the internet cafes with exorbitant browsing prices.

3. Not only freedom of access and free internet access, eduroam service at any institution will allow a user to access the internet as if he/she is part of that institution without any restriction as to what one access. With this, all the services (e.g. instant messaging) that users in a particular institution receive so will the eduroam roaming user receive without blocking any port.

4. Eduroam allow users to have access to network based resources that a member of the visited institution access. For example, if research material is only available on a campus network (e.g. accessing the library catalogue), the roaming user will also access this material. Furthermore, depending on the policy of the institution, an eduroam roaming user can as well use network printers and other network based devices for educational purposes.

3.2 Challenges of Eduroam deployment in Zambia

Despite the benefits and opportunities that come with eduroam service as mentioned above, there are challenges which come with eduroam implementation and deployment in Zambia. We discuss the challenges below and some of the measures which can be undertaken to overcome them.

1. Currently, there are only four institutions with eduroam enabled out of over 15 institutions affiliated to ZAMREN. This is a challenge as it restricts the freedom of internet access as earlier mentioned to only four institutions. Hence, there is need to bring on board as many institutions as possible for full benefits of eduroam to be realised. ZAMREN through workshops have been advocating for eduroam implementation in its member institution, hence, many institutions are envisioned to be connected in a near future.

2. Different institutions have different ICT policies on how network resources are accessed. For example some institutions may allow certain traffic (e.g. YouTube, torrents) to go through yet others may ban the same traffic due to various reasons which might include the low bandwidth of that institution, for this reason, there is need to standardise ICT policy documents in order to effectively govern how eduroam users are to access the services among institutions, end users and NRENs. (Wierenga, 2005)

3. The technical confidence of IT personnel in handling security of WLAN in most of the member institution for ZAMREN is worrisome. ZAMREN conducted two hand-on trainingworkshops for IT technical personnel from its member institutions on basic switching and routing in February and March, 2014 with support from INASP, it was discovered that some of the trainees had little or limited knowledge in most of the basics of networking. The outcome of the workshop was that most members cited security of the wireless network as one area which was crucial to them and needed much attention. This prompted ZAMREN to organise a security training workshop in April 2014 with the latest workshop for advanced switching and routing held in September 2014 (ZAMREN, 2014). For eduroam to be fully implemented there is need to have competent IT personnel who understand the RADIUS architecture and its deployment which may not be the case at the moment. Effort has been made by ZAMREN to train the IT personnel from member institutions to bridge that gap through the hands-on workshops.

4. Increasing number of users in any network comes at a cost in terms of bandwidth. Currently, some institutions within ZAMREN members have as low as 1Mbps bandwidth for accessing the Internet. This can be a burden as the number of users increases due to roaming users. There is need to lower the cost of accessing the Internet especially in Zambia for the benefit of eduroam service to be enjoyed by all participating institutions.

5. Some users are not just willing to connect to any network especially from other institutions using their devices for fear of losing their information on the devices. Hence there is need to enlighten users of the great benefit that comes with eduroam and its secure mode of operation.

6. Some devices using the legacy wireless adapter cards that may not work with eduroam authentication processes, hence there would be need to buy new wireless adapter for such devices which can be a cost burden to some users of the institution which might discourage them from appreciating eduroam services. Therefore, IT personnel need to educate users on the technical aspects of how to connect to eduroam and the adapters compatible with the protocols used and outline the benefit of connecting to eduroam.

7. Before authentication, a pre-configured secret is shared between RADIUS entities and has to go through hierarchy of other servers to reach the intended authoring server if the user is roaming. This approach brings one point of failure in the authentication process. For example if a user from CBU accessing eduroam service at UNZA or MU and there is a link failure in the RADIUS server hierarchy, that user will not be authenticated and hence can not access the service, which could result in frustration. As such there is need

to have redundant links within the ZAMREN network to avoid one point of failure when authenticating users of eduroam.

8. One security concern is malicious user who could come with rogue access points broadcasting the eduroam SSID in the campus and people would want to connect to such an AP. The malicious user might then steal the username and password for such users and use them for their malicious activities. This vulnerability can be mitigated by not connecting to any AP which asks for one to change the certificate which was once installed by their home institution. For this reason, users have to make sure that they install a certificate on their device from their home institutions before attempting to access eduroam services from other institutions.

4. Analysis and Discussion of Survey Results

This section discusses the outcome of the survey which was conducted on the use of eduroam service in ZAMREN member institutions. Of the three institutions where the survey was conducted, there were 118 respondents in total of which 94 were from MU representing 80%, 12 from CBU and 9 from UNZA. Out of the 118, 85 were students, 18 academic staff and 15 non academic staff. The survey was conducted to establish if end users are aware of implementation of eduroam in their institutions and if they use it as well as establish what they use eduroam for and some of the challenges they face in using eduroam.

4.1 Awareness of eduroam

One of the questions asked was to assess if end users were aware of eduroam in their institutions. Of 118 respondents, only 4 respondents indicated not to have heard of eduroam before representing 3%. This could be that the respondents do not own a laptop or smart phone to connect to eduroam in their institutions. It was interesting to note that some users have known eduroam for more than three years as indicated in the pie chart below.

Figure 3: Number of yearshas knowledge of eduroam

4.2 Accessibility and Usage

The second category of assessment was to establish whether respondents who are aware of eduroam access the service. Only 5 respondents indicated that they have never accessed eduroam before representing 4% of the total respondents. It was further discovered that only four out of the 118 respondents have never used eduroam before which concludes the 4 users unaware of eduroam in 4.1 above. The figure below presents the result of how often the users access the eduroam in their institution.
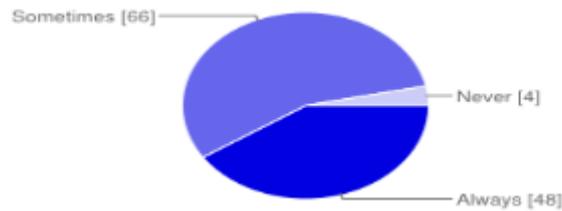
Figure 4: How often one uses eduroam

Not only is accessibility important, but what users use the service for. In regard to that, a question was asked what users use eduroam for and below is the results of this survey.

Google search	**59**	50%
Wikipedia	**37**	31%
Facebook or twitter or other social sites	**39**	33%
Research and learning (eg, Google scholar)	**68**	58%
News and blogs	**40**	34%
Torrents or FTP	**8**	7%
All of the above	**34**	29%
None of the above	**6**	5%

Table 1: Services user use eduroam for

It can be noted that there are more than 118 responses this is because the question was open ended, one could give several responses. The idea was to capture what services users are interested in, and one of the areas of interest was research and learning. It is interesting to note that 68 of the respondents cited research and learning as their primary use for eduroam and only 8 use it for file download. Of the 118 respondents, only 20 indicated that they have accessed eduroam from other institutions apart from theirs. Below is the distribution of which other institution respondents accessed eduroam apart from their institutions.

Institution	No. of responses	Percentage
UNZA	**16**	14%
CBU	**7**	6%
MU	**6**	5%
ZCAS	**3**	3%

Table 2: eduroam access at other institutions

The assumption is that respondents did not indicate their home institution as the visited institution which was clearly elaborated in the questionnaire. Furthermore, it was interesting to note that at least 6 respondents have accessed eduroam outside Zambia.

4.3 Benefit and Challenges faced in eduroam usage

One of the benefit of eduroam is free access at any participating institution as discussed above in section 3.1.2. This can be confirmed by respondents as depicted in the figure below.
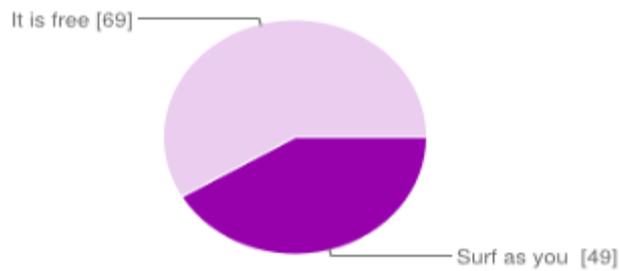
Figure 5: Benefit of eduroam

The surf as you go attribute refers to the easeof accessibility as discussed in section 3.1.2, once you have installed the certificate and accessed eduroam from your institution, the next institution you visit you only need to login using your username and password without going through any other difficulties. Furthermore, users find it easy to use eduroam in these institution as presented in the table 3 below:

Very difficult	10	8%
Fairly difficult	31	26%
Fairly easy	61	52%
Very easy	14	12%

Table 3: How easy to access eduroam in the institution

In addition, many respondents indicated that eduroam service is better than using other wireless network as reported in the figure 6 below. The 44% who indicated worse service could be attributed to the fact that they would be used with wired networks which performs well in most circumstance. However, eduroam could also suffer from huge traffic from many users and low bandwidth provided by individual institutions to access the internet.
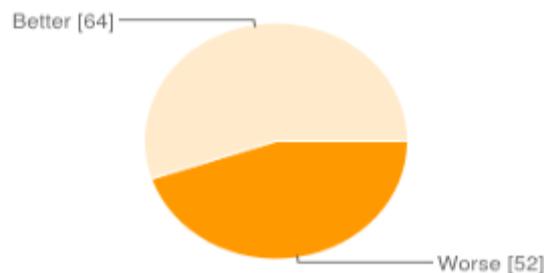

Figure 6: eduroam performance compared to other network

Despite the benefit of eduroam however, there are still challenges which people face. The table below outline some of the challenges faced in eduroam usage, more challenges can be obtained in section 3.2.

Challenges	No. of responses	Percentage

Security concerns	**25**	21%
Eduroam not working in our institution	**27**	23%
Eduroam not working in institutions visited	**12**	10%
Low bandwidth in institutions offering Eduroam	**46**	39%
Authentication problems	**53**	45%
Small coverage area	**43**	36%
Laptop failing to connect to Eduroam, despite being able to connect to other network	**56**	47%

Table 4: Challenges that eduroam users faces

From the responses, authentication is one of the challenges that the end users face, without authentication, an end user will not have access to the eduroam service and that could affect their trust in eduroam. This is demonstrated by number of respondents who indicated laptop failing to connect to eduroam (47%) and authentication problem (45%). Another important challenge which could be noted is that there is low bandwidth in institutions as well as small coverage area of eduroam. Hence, there is need to increase bandwidth to access the internet as the number of users increase and rollout many eduroam access point in institutions to cover large areas, furthermore, authentication problems need to be dealt with by technical staff to avoid the reported authentication problems.

5. Recommendation on some of the challenges outlined in survey

Until users understand the benefit that has come with the implementation of eduroam, they will always be sceptical of using the service. To overcome security concerns of users on the use of eduroam, there is need to seriously sensitise users about the security features that guarantee confidentiality and privacy of their work when using eduroam. It is noted from the survey that availability is an issue in the institutions where eduroam has been implemented. For example 56 out of 118 respondents indicated that they could not connect to eduroam yet they were able to connect to other networks with the same laptop, 53 cited authentication as their problem. Sometimes a user would get connected to eduroam but not access the internet which could still be reported as eduroam not working. All these could lead to respondents reporting that eduroam was not working in their institution. The problem of authentication can be dealt by competent IT staff. Experience does not come at once but is a learning process, hence, there is need to train the IT personnel in the member institutions on how to tackle the authentication problems. It is important to note that ZAMREN in its capacity as a spearhead of education and research in Zambia is already doing that through hands-on training workshops organised from time to time. Internet access in Zambia is still a challenge as it is expensive (ZAMREN, 2014) this has forced many institutions to acquire few Mbps to accommodate large number of its staff and students. It is envisaged that in few years time the cost of bandwidth will come down with the installation of fibre optic network in many parts of Africa (UbuntuNet, 2014), hence many institutions will have to pay less for highbandwidth. Until then bandwidth still remains a challenge to eduroam users. Despite the low bandwidth, traffic going to the internet can be greatly reduced, if some of the contents which users frequently access on the internet could be cached at ZAMREN server.

6. Conclusion

Eduroam is a service that gives end users freedom to access the internet everywhere the service is enabled in a secure manner. However, there are still many challenges that need to be overcome in its implementation in the ZAMREN member institutions. We have discussed the challenges and some benefits of using eduroam in Zambia learning institutions. The survey conducted shows that many people are aware of eduroam and using the service in their institutions. In addition, some users have used eduroam not only in there institution but other institutions as well as outside Zambia. For future work, we will consider other services that ZAMREN could offer the learning institutions to enhance research and teaching, for example, with fibre connecting institutions, some of the traffic could be cached at ZAMREN servers and used within these institutions not only that member institutions could allow users to access teaching material and research output from other institutions without going through the internet.

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