

The Impact of Zeroconf on the Education System of the Countries in Conflict: The Case of the Central African Republic

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Abstract— This article proposes a solution to extend the functionalities of zeroconf outside of a local network to enable young people in conflict areas to benefit from quality distance learning. This proposal, based on a judicious choice of a VPN mode, allows distant teachers and learners in conflict areas to work as if they were face to face.

To support the e-learning service, in this article a broadband network built on the technology of free spaces of television (TVWS) transmission channels is set up. This e-learning solution, using zeroconf protocol, gives the various actors the opportunity to collaborate on practical work in real time; it also helps to encourage the resumption of educational activities of refugees young students in conflict areas to fight against their attempts to integrate armed groups for lack of future prospects.

Keywords—zeroconf, Conflict Zone, e-learning, VPN, TVWS.

I. INTRODUCTION

Repeated crises in the Central African Republic have led to the dropping of higher education for young people living in refugees camps. This situation also affects new graduates from armed groups occupied areas who cannot access the country's only university located in Bangui the capital city. The impacts of these crises are very negative on the education system [1]. The only opportunity they have is to join rebel groups, making difficult the crisis getting out process. In this context, it is essential to work quickly on building the skills of young Central Africans in order to make them actors in the reconstruction of their country.

The Access to the education in general and to higher education in particular is an effective instrument in the sustainability of peace, on the path towards development and emergence.

Several African countries have begun to set up virtual universities to face the massive increasing of student. This is the case of the virtual university of Senegal (UVS), virtual university of Ivory Coast (UVCI) and the virtual university of Chad (UVT) [2, 3, 4].

Each virtual university has implemented a strategy to allow its students to access the content of online training courses.

Senegal has relied on its national fibre optic network, which interconnects 12 of the country's 14 regional capitals, to set up buildings called open digital spaces (ONEs) where students come to follow some courses physically, doing practical work or exams [5].

Other countries such as Ivory Coast relies on the good coverage of operators' networks to give students access to the content of their training.

In the case of CAR, where telecommunication operators' infrastructures have been destroyed in conflict areas that represents 80% of the national territory, virtual university models as used in Senegal or Ivory Coast are not appropriate.

This article proposes a distance higher education solution using the zeroconf protocol to allow the different actors of the university to collaborate in real time as if they were not geographically dispersed.

This solution uses a broadband network based on Television white spaces called TVWS that can be easily deployed.

The rest of this work is organized as follows. Section II describes the state of the art. Section III describes the proposed architecture. Section IV presents the results. Section V concludes the article.

II. STATE OF THE ART

A. The conflict in the Central African Republic

Since December 2012, CAR has been going through a military, political and social crisis without previous, enriched by two rival groups, the seleka and the anti-balaka. The main causes are multiple, and the factors of conflict are political, economic and translate into ethnic, religious and inter-community tensions and their instrumentalization for political purposes [6].

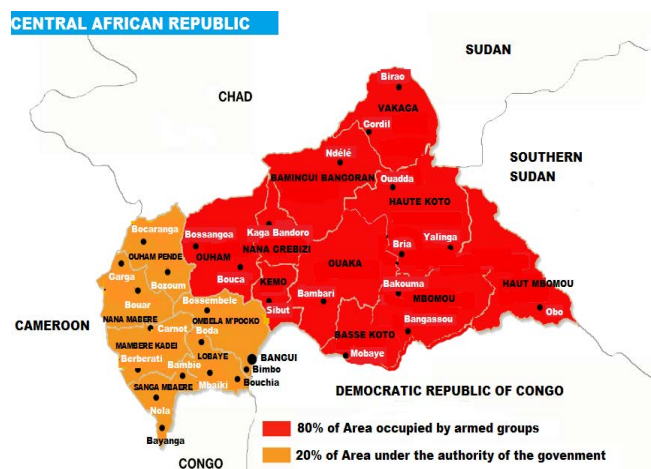


Figure 1. Security situation in the Central African Republic

The map in Figure 1 shows that all the northern, central and eastern parts are occupied by armed groups, while only Bangui the capital city and the western part of the country are controlled by the Government[7].

B. The impact of the crisis on education

Literacy is the foundational skill for any other education[8]. Since 2012, the year in which the war began, the literacy rate in the Central African Republic has dropped considerably due to the destruction of education infrastructures, displaced populations, and the recruitment of young people into the rebellion.

Figure 2 shows the evolution of the literacy rate from 1995 to 2015[9].

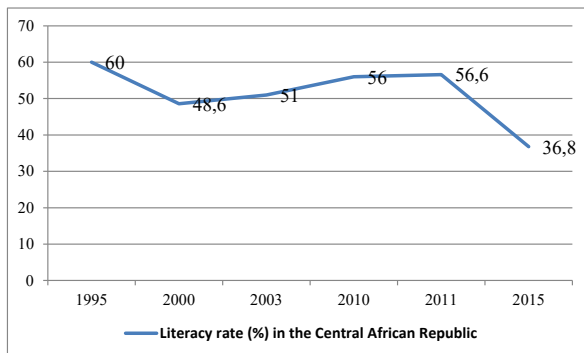


Figure 2. Literacy rate

C. E-Learning

E-learning refers to all the solutions and means allowing learning by electronic means.

The European Union definition is: «e-learning is the use of new multimedia technologies on the Internet to improve the quality of learning by facilitating access to resources and services on the one hand, and distance exchange and collaboration on the other».

Information and communication technologies theoretically make it possible to free oneself from the physical presence of a teacher nearby to develop skills.

Several researchers have proposed solutions to improve distance learning.

The authors in [10] have shown that e-learning systems are increasingly attracting the attention of academics and students because of their flexibility.

In[11], the authors conducted case studies in Ethiopian universities and colleges that identified success factors and proposed an appropriate learning model.

D. TVWS network

Television White Space (TVWS) is a technology that allows the use of free television frequencies to provide a high-speed network in a given region. The UHF free frequency bands used are 470 to 790 MHz in Europe and 54 to 698 MHz in the United States. The use of white spaces is based on dynamic access to secondary unlicensed spectrum (DSA - Dynamic Spectrum Alliance) on the basis of the principle of non-detrimental interference to television operators operating in the area.

The results of these various tests show the advantage of TVWS in creating an environment for offering e-learning services.

In the field of e-learning, wireless technologies such as Wi-Fi have a short range (10 - 250m) and allow exchanges in excess of 100 Mb/s near an access point. On the other hand, the White Space TV network is more efficient in terms of coverage (10 to 30km) and has the advantage of having a better penetration. xDSL wireline technologies have a range of 1.5 to 5.4 km and are used in distribution and transport network. Compared to copper cables, optical fibre covers a greater distance with a lower attenuation and a higher bandwidth.

E. Zeroconf

The Zeroconf project is an IETF project that has created a set of protocols for automatically configuring a local network. Zeroconf is now one of the most widely used technologies for discovering services in local networks without prior configuration. This is why it is pre-installed on operating systems and implemented by manufacturers in electronic devices such as network equipment such as smartphones, printers [12]

It allows users to offer and use services such as device synchronization, file sharing, instant messaging, audio and video communication, sharing and remote desktop control in a local network.

Zeroconf mainly uses multicast DNS protocols (mDNS) and automatic DNS-based service discovery (DNS-SD). This pair protocol allows to automatically discover and select services available in a local network.

DNS multicast works on hosts making DNS requests on a multicast group. All network nodes that are members of the multicast group receive all DNS requests. If the incoming DNS request matches the node name request, the node responds to the requester. The service discovery by Zeroconf uses the multicast IPv4 address 224.0.0.0.251.

This address 224.0.0.0.251, used by Zeroconf to broadcast messages on available services, is part of the block of addresses reserved by IANA under the name of "Local Network Control Block"[13].

The DNS Discovery Service (DNS-SD) is complementary to the mDNS service. Thanks to the DNS-SD protocol, hosts offering services, publish details of these services such as service type, domain name and configuration settings [14].

Many network software for Mac OS X, Windows and Linux, such as the Blink Unified Communications Client, use DNS-SD to locate peers on a local network, and allow users to communicate via audio-video, instant messaging, file transfer, screen sharing, and conference while remaining in a local network [15].

Other cross-platform software such as VLC also uses zeroconf to stream videos in a local network without any configuration[16].

F. OpenVPN

Openvpn is a solution for deploying a VPN network that can operate in tunnel mode as well as in bridge mode.

In terms of TCP/IP architecture, the tunnel works at the Internet layer, while the bridge works at the network access layer.

1) VPN operating in tunneling mode

In tunneling mode, a VPN client that connects is placed in a logical IP network dedicated to the VPN other than the local IP network. The VPN server acts as a router to relay network packets between the VPN client and the local network. Thus, any packet coming from the VPN client and going to the local network will have its TTL decremented by one unit by the VPN server[17].

2) VPN operating in access mode

In bridge mode, the VPN client connects directly to the local network. It is as if the VPN client connects directly to a switch on the local network. The configuration in this case requires creating a virtual interface called a bridge interface on the VPN server, and connecting the physical network interface of the server and the interface created by the VPN server to this bridge. Thus, any packet coming from the VPN client and going to other machines on the local network will always keep the same TTL value. In this mode, Zeroconf messages from the VPN client will be received by the machines on the local network. Similarly, Zeroconf messages from local network machines will be received by the VPN client[18].

III. PROPOSE ARCHITECTURE

A. Acces network architetcure

Figure 3 describes the final architecture of the broadband network deployed in conflict areas using TVWS technology.

A TVWS base station is deployed in a humanitarian-held area allowing surrounding villages to be connected to the distance learning system based in the capital city.

CPEs installed in refugees camps allow users connected to the local WIFI network to join the equipment of the e-learning platform located in Bangui.

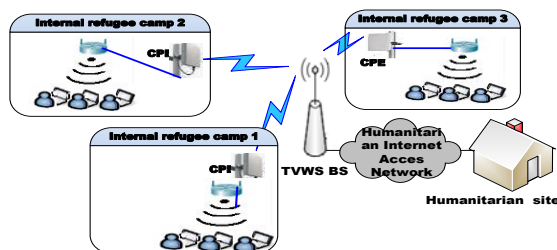


Figure 3. Proposed architecture of the access network

To demonstrate the feasibility of our software architecture, we are replacing the TVWS access network by a wireless network and the wide area network part is implemented using real routers.

B. Simulation architecture

Our simulation architecture shown in Figure 3 consists essentially of three routers, computers used as student access tools on which the blink unified communication tool using the zeroconf protocol is installed and a VPN server in Bangui. From home, teachers from Bangui University or

other universities connecting to our platform's VPN server can deliver their courses in real time using blink.

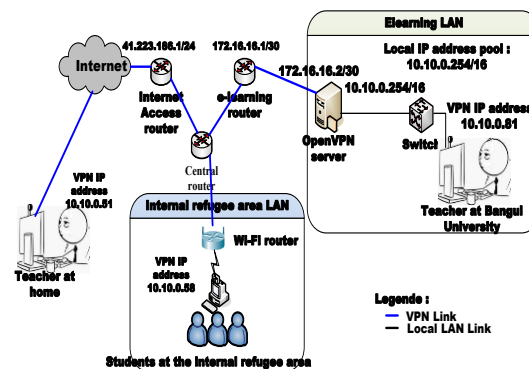


Figure 4. Proposed simulation architecture

IV. RESULTATS

With the solution implemented we simulated several scenarios thanks to blink a software using zeroconf.

Before starting the course sessions, students in refugees camps and remote trainers first connect to the VPN server using a VPN client.

Thanks to the VPN server judiciously configured in bridge mode, students and teachers who connect to the VPN server are placed in a local network at Bangui University. The TTLs of IP datagrams exchanged between remote actors are not decremented, thus allowing to benefit from all the functionalities of zeroconf in terms of audio, video, screen sharing and file transfer which are normally only accessible in a local network.

The screen below shows the logs of a successful connection with IP address assignment of the Bangui local network 10.10.10.50.

```

"i Jul 26 16:16:08 2019 ROUTE: CreateIpForwardEntry succeeded with dwForwardMetric=10 and dwForwardType=4
"i Jul 26 16:16:08 2019 Route addition via IPAPI succeeded [adaptive]
"i Jul 26 16:16:08 2019 C:\Windows\system32\route.exe ADD 0.0.0.0 MASK 128.0.0.0 10.10.0.254
"i Jul 26 16:16:08 2019 ROUTE: CreateIpForwardEntry succeeded with dwForwardMetric=30 and dwForwardType=4
"i Jul 26 16:16:08 2019 Route addition via IPAPI succeeded [adaptive]
"i Jul 26 16:16:08 2019 C:\Windows\system32\route.exe ADD 128.0.0.0 MASK 128.0.0.0 10.10.0.254
"i Jul 26 16:16:08 2019 ROUTE: CreateIpForwardEntry succeeded with dwForwardMetric=1=30 and dwForwardType=4
"i Jul 26 16:16:08 2019 Route addition via IPAPI succeeded [adaptive]
"i Jul 26 16:16:08 2019 MANAGEMENT: >STATE:1564150568,ADD, ROUTES...
"i Jul 26 16:16:08 2019 C:\Windows\system32\route.exe ADD 224.0.0.0 MASK 240.0.0.0 10.10.0.254
"i Jul 26 16:16:08 2019 ROUTE: CreateIpForwardEntry succeeded with dwForwardMetric=1=30 and dwForwardType=4
"i Jul 26 16:16:08 2019 Route addition via IPAPI succeeded [adaptive]
"i Jul 26 16:16:08 2019 C:\Windows\system32\route.exe ADD 0.0.0.0 MASK 0.0.0.0 10.10.0.254 METRIC 1
"i Jul 26 16:16:08 2019 ROUTE: CreateIpForwardEntry succeeded with dwForwardMetric=1=30 and dwForwardType=4
"i Jul 26 16:16:08 2019 Route addition via IPAPI succeeded [adaptive]
"i Jul 26 16:16:08 2019 WARNING: this configuration may/caché passwords in memory - use the auth-nocache option to prevent i
"i Jul 26 16:16:08 2019 Initialization Sequence Completed
"i Jul 26 16:16:08 2019 MANAGEMENT: >STATE:1564150568,CONNECTED,SUCCESS,10.10.0.50,192.168.0.183

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Figure 5. Connexion VPN successful

A. Getting to grips with remote equipment

Figure 5 shows the screen of the teacher who gives the course while visualizing the class.

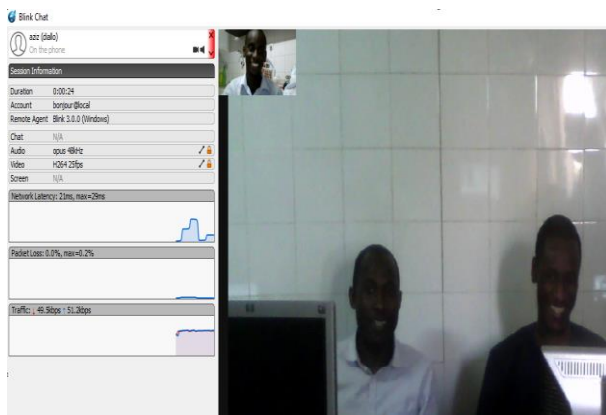


Figure 6. Teacher giving a course by visualizing the class.

B. Practical work on networks

To allow students and teachers to collaborate in real time on a practical work, the teacher uses the GNS3 cloud tool to connect the equipments in the simulation environment to the Bangui's local network.

The teacher allows students to access his or her computer using the screen sharing feature of the blink tool.

Students configure the GNS3 platform router as a DHCP server and can either use a virtual machine integrated into the platform or a machine from the Bangui University LAN to see the TCP/IP element assignment

Access to a physical machine on the local network is also possible with zeroconf.

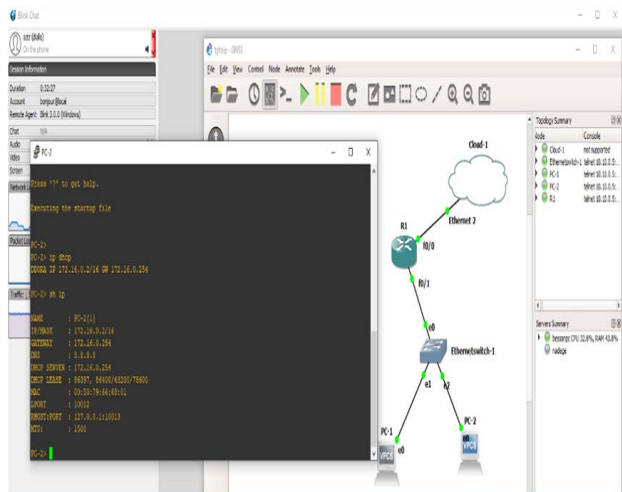


Figure 7. Remote hand-held test for a practical work network.

C. Practical work on IP telephony in a cisco environment

In this partical work as shown in Figure 8, the student accesses the teacher's GNS3 platform using the zeroconf protocol to be guided by audio to configure an IP telephony server. Thanks to the GNS3 cloud tool configured by the teacher on the VPN interface, the student's machine, the teacher's machine and the router are virtually in the same network.

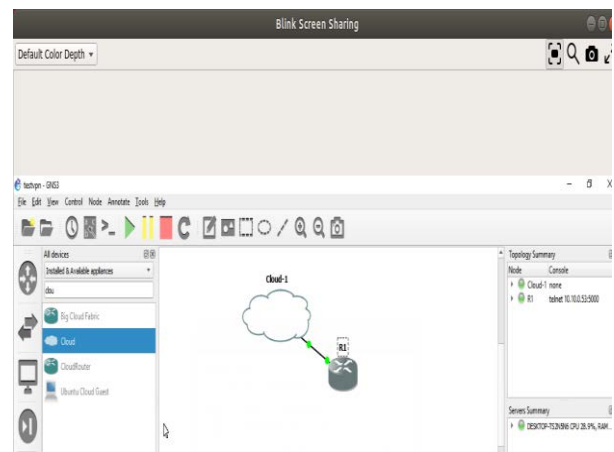


Figure 8. Architecture of practical work in IP telephony.

In Figure 9, using the teacher by audio or text, the student configures the router as a SIP IP telephony server.

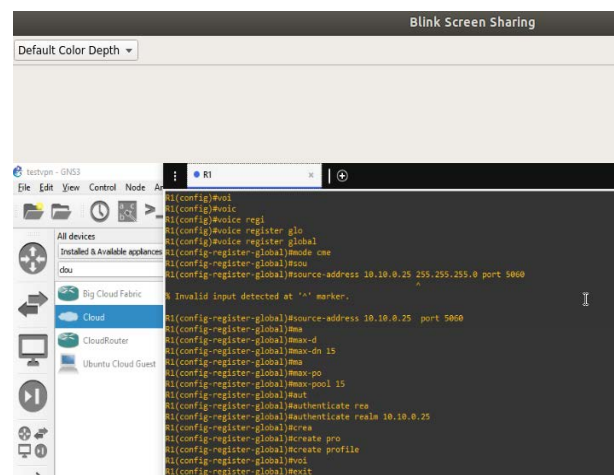


Figure 9. Configuring the router as a ToIP server.

Once the router configuration is complete, Figure 10 shows the student's screen setting up a softphone to connect to the telephony server. The teacher also uses a softphone to connect and enters into SIP communication with the student.

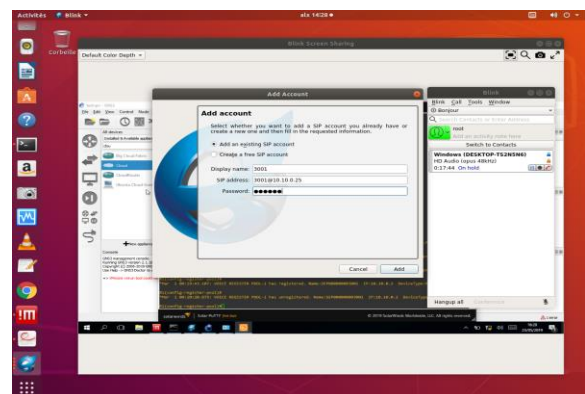


Figure 10. Setting up of the softphone by the student.

The following figure 11 shows the connection status of the two softphones on the telephony server.

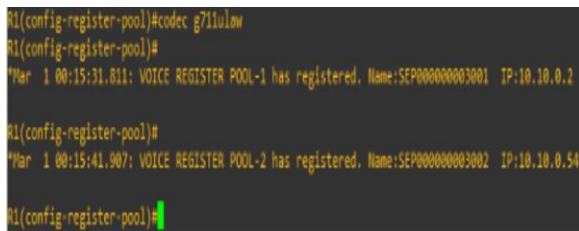


Figure 11. Connection status of the softphones.

D. Practical work of English courses

Figure 12 shows an English class session where the teacher gives the student a text to read to measure his pronunciation ability.

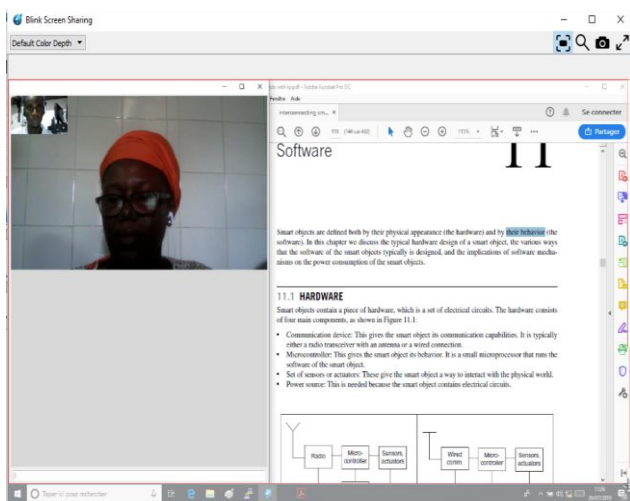


Figure 12. Learning session in English.

V. CONCLUSION

In this article, we have shown that communication and collaboration solutions provided by zeroconf in local networks can be extended to be used by geographically dispersed actors. This extension of zeroconf into extended networks is of crucial importance for countries in conflict such as the Central African Republic, thus providing the opportunity to train young people at a distance in conflict areas as if the actors were not geographically dispersed.

The judicious choice of the VPN mode proposed allowed the various players to use the functionalities of real-time communication in audio, video, screen sharing, remote control, so that things happen as if they were in person.

This real-time collaboration and communication between students in conflict areas and teachers will help to restore hope to young people who will no longer have integration into armed groups as their only alternative for success, thus breaking the spiral of repeated crises.

The TVWS technology to be used in the final architecture of the broadband network that we propose allows the State to fill the gap in telecommunications infrastructure due to the reluctance of telecommunications operators to redeploy networks in conflict areas.

Beyond solving the problems of the digital divide in conflict areas, our solution allows the use of e-learning

platforms to not only fight against geographical inequalities, but also to develop professional skills.

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