Project Title

Libre Router

IDRC Project Number-Component Number

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Carlos Rey-Moreno
University of the Western Cape, South Africa

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Background and Justification

Community Networks have been depending since their inception on modifying existing off-the-shelf routers to adapt them to their particular needs. Software development that originated in Community Network groups and the Free Software movement as a whole, has pushed the barrier of innovation and helped commercial enterprises develop new products over the years. This virtuous relation between hardware vendors and the community has been threatened by new regulation from the US Federal Communications Commission (FCC) which has led hardware manufacturers to globally close up their routers to third party modifications, hindering open innovation and effectively closing the door to Community Networks in terms of access to the hardware they depend on.

At the same time, the challenge presented by the FCC lock-up represents also opens opportunity for different groups and organizations to realize that they can join forces, take action and confront the situation from a creative perspective.

So, the Libre Router will provide a reliable platform to ensure that Community Networks, in general, and the Zenzeleni Networks[1], with whom UWC has been collaborating for more than 6 years, and AlterMundi[2], in particular, can keep evolving, and contribute to bridge the affordability barrier in the access to communications.

Project Objectives

The Libre Router is an interregional project between Latin America and Africa, being Altermundi[3], from Argentina, the Latin American partner.

The main objective of this Interregional project is the development of the first Libre Router prototype: a high performance multi-radio wireless router targeted at Community Networks needs. Altermundi is the main driver behind this objective. The project has other sub-objectives which aim at targeting the Global South realities in terms of power consumption, ease of deployment and use, and respect for oral communications. In particular, UWC is responsible for the following sub-objectives:

1. Creation of a WiFi Calling application that allows the provision of voice services in networks using LibreRouter.
2. Development of software and/or hardware solutions to reduce the power consumption of the router.
3. Assemble of a community network management suite, called LibreServer, that facilitates the installation and provision of services in the community networks using LibreRouter.

1http://www.zenzeleni.net/
2http://altermundi.net/
3 http://altermundi.net/

Project Narrative

Below a summary of the activities under the project during the reporting period of each objective specified in the grant agreement, including the general objective:

1. Development of the first Libre Router prototype

Technical specifications document: The technical team carried out six iterations until arriving to the final version containing the technical specifications of the project. This document was handed to Dragino, the company chosen to manufacture the hardware. This was a complex process given the nature of the project, the high number of partners involved and the different time zones among them. The technical specifications contain the basic functionalities of the router and those specific to the objectives included in the FRIDA, FIRE and Interregional grants. The last version of this document can be found at: https://librerouter.org/document/specifications-sheet-v6/

Power efficiency requirements definition & main board modifications: The technical team maintained a conversation parallel to the general technical specifications documents in order to add the minimum modifications needed to the general board for allowing later to include the power efficiency module. The whole definition of the module, the use cases allowed for it, the minimum hardware required for the prototyping part and the specifications were made during this phase of the project.

Board Schematic: Dragino provided a first version of the board based on the technical specifications received. This version was exhaustively reviewed by the LibreRouter team, and handed back to Dragino. In turn, Dragino produced a new version of the schematics which was reviewed again by the LibreRouter team. With the new schematic approved, Dragino worked in creating the Gerber file necessary to produce the prototypes.

First prototype production: Both prototypes of the 5GHz WiFi radios and the LibreRouter itself have been manufactured. Pictures of the prototype are available in the following link: https://librerouter.org/article/first-prototype-is-out-of-the-factory/ Both are currently being extensively tested by the team, with positive initial restults. A report with the performance of the radios can be found here: https://librerouter.org/article/first-outdoor-radio-and-antenna-test/ The testing team is made of five experts from different places in the world. Each of them has received a prototype and are evaluating the behaviour of the hardware according to their expertise. The current tests conducted can be found at: https://github.com/libremesh/librerouter-testing

Second iteration of prototypes: Once the testing is ready and a it is clear the changes in the design that are required, a second batch of prototypes will be produced. Dragino, the LibreRouter manufacturer, has committed to cover the costs of this second round of manufacturing, without any additional cost to the project. This batch will allow ensuring the benefits of the the modifications made to the first prototype.

Final production process and delivery: Given the intrinsic complexities around the production from scratch of a new hardware, specially one developed from many stakeholders with different perspectives, the execution times of the project have gone beyond those initially anticipated. Dragino, the manufacturing company, who has long term experience with similar projects - it manufactures the Mesh Potato hardware - has committed to deliver the first batch of 200 LibreRouters during Q1 2018. In this regard, it has been agreed with the FIRE and FRIDA program officers that the funds allocated to the first batch production are transfered to Dragino in full. This funds include the cost of delivery to Argentina and South Africa. Delivery time to Argentina by sea is estimated in 45 days.

Certification: In parallel with the production of the first units, Dragino will obtain the CE and FCC certificates, including DFS operation, requested by most regulators to allow the commercialization and operation of radio apparatus. Although more expensive than anticipated, obtaining these certificates is cheaper if done directly by the manufacturer, as it is used to working with the laboratories issuing them.

Type Approval in South Africa: Ellipsis Regulatory Solutions, Zenzeleni Networks regulatory advisor has committed to submit the application to ICASA once the the CE and FCC certificates for the LibreRouter are ready. This allow commercializing the product in South Africa.

Software: During the first phase of the project, the LibreMesh team published a version of the firmware based on OpenWRT (Community Chaos (16.07)), which prepares the transition path to the LibreMesh version to be used in the LibreRouter. All code, including some subsequent pre-releases is published at: https://github.com/libremesh). In order to become familiar with this distribution, Zenzeleni Networks started to migrate their networks to this version of LibreMesh. This included a field visit of two weeks to Mankosi (South Africa) from one of the AlterMundi members, and one of the LibreMesh developers. The experience resulted very positive, and Zenzeleni local technicians agreed on porting the network to LibreMesh.

Additionally, LibreMesh 17.06 Dayboot Rely, the LibreMesh release that will be installed in the LibreRouter it is currently being deployed in the AlterMundi networks to evaluate the stability of its performance, so it is stable by the time the first batch of LibreRouters is produced. Finally, and in order to test the compatibility of the LibreRouter hardware with OpenWRT/LEDE, the LibreMesh team compiled a customized firmware that was successfully tested in the hardware. Note that a core developer from OpenWRT/LEDE is directly involved in this process.

First deployments: A partnership between the University of the Western Cape, Zenzeleni Networks and Departments of Science and Technology (DST) and Telecommunications and Postal Service (DTPS) is currently being drafted to extend the current footprint of Zenzeleni Networks to the all communities in the Mthatha River Valley (100,000 users). Once available LibreRouter/LibreMesh will be the platform of choice for the meshes to be deployed in the communities in that area.

2. Creation of a WiFi Calling application that allows the provision of voice services in networks using LibreRouter.

The bulk of the work in the accomplishment of this goal has been conducted by EyeSeeTea Ltd.

Before starting coding the WiFi Calling application, the following activities took place:

- First using a shared document to brainstorm from the community and later through intense working sessions, diagrams with the whole operation of the system were created: https://drive.google.com/open?id=0B8KIRhh6kcl6c3MwenUyRFEzWVk)
- A wireframe was created using the diagrams above to define screen by screen and functionality by functionality how the application was going to behave independently from its graphic design: https://drive.google.com/open?id=0B8KIRhh6kcl6d20zSHJhc0VUTlk)
- Once approved, an interactive mock-up of the WiFi calling was created and available at (https://marvelapp.com/1d00fg0/screen/18236337).
- Additionally, a trial server was created to start the development of the app and test the web services it requires using Flask and Python technologies. This server exposes an interface emulating the real Web Service that was later implemented and it is accessible at http://dev.eyeseetea.com:5000 from a REST client. Its source code and documentation can be publicly found in the follow URL: https://github.com/EyeSeeTea/FIRE-MockServer. In order to implement the mock web server and while defining the wireframe and mockup for the app it was necessary to create the data model for the application. This is documented in the README.md file of the FIRE-MockServer code repository

The following components have been developed during the implementation of the project:

- Partial development of a WiFi Calling Mobile App following feedback obtained from the community. It uses hybrid technologies, and it is multiplatform, so it can be used in any device or even a web browser. Its source code is available here: https://github.com/EyeSeeTea/FIRE-WiFiCalling. A beta version of the application can be downloaded here: https://play.google.com/store/apps/details?id=org.eyeseetea.wificalling
- The Web Service (WS) architecture coded consists of a modular backend written in python that is presented to the application as a Rest API. It carries out the functions of coordination and auto-provisioning logic and it is extensible via “drivers” that implement each of the three interfaces exposed by the system:
    - The VoIP subsystem: A SIP server connecting users between them and eventually, to the PSTN. Currently implemented with a Kamailio driver for interoperability with other community network projects, but Asterisk or other VoIP subsystem could be used instead with a minimal development effort.
    - The Auth subsystem: Open Source system providing users authentication (i.e. Radius/OpenLDAP). It is implemented, but currently the authentication is made via the Kamailio server itself.
    - The billing subsystem: A voucher-based pre-paid methodology is implemented, where the admins can decide the network pricing and invoicing.

The WS contains an internal database that manages via an ORM written in python and that allows different actions such as: network registration, differentiated user and admin roles in the app, so the uses can request to join the service from the app itself and the admin is the one managing those requests, as well as communicating broadcast with the users to send announcements. The source code of this back-end architecture is available here: https://github.com/EyeSeeTea/FIRE-WS/tree/development.

3. Development of software and/or hardware solutions to reduce the power consumption of the router.

In order to achieve the reduction of power consumption aimed in this sub-objective, the solution was divided into two components: a) be able to turn the routers off during expected periods of inactivity, b) enabling a mechanism to turn them back on in case of emergency. For a) a common time reference among all routers was necessary (via Real Time Clock – RTC-, or GPS). For b) a parallel network that was on at all times and allowed both user-to-router communication to send the "Turn on" signal, as well as router-to-router communication to propagate the "Turn on" was needed. This parallel network can, in turn, be used for a parallel communication channel.

Initial work for achieving this work was conducted by EyeSeeTea Ltd and Digital Understorey and included:

- Testing the functionality of different components. The code for these tests are available at: https://github.com/EyeSeeTea/FIRE-PowerEfficiency. In particular, the following tests were conducted:
    - Test the functionality of a RTC to turn off an entire Librerouter network for the periods when it is expected to be unused has been conducted
    - Test the functionality of a parallel control network using LoRa to turn on the network back again if required within the off periods established in the RTC
    - Test the functionality of a Bluetooth module to interact with the LibreRouter and propagate messages via the control network.
- Defining the different use cases for which the energy saving modes would work for, and the technical specifications that needed to be added to the main LibreRouter board and would contain the power efficiency module. A draft for this auxiliary module was depicted and the base for a real prototyping using Arduino and other commercial boards. A first prototype was created for testing purposes.

Coincidentally, half way through the project, and via the interaction with Management Automation, the company developing the LibreServer, we were introduced to the work from ManMakeMachine (M3), a South African company that had developed a similar LoRa+Bluetooth module to the one we required for "b)" above. At the time of the introduction, M3 was looking for a manufacturer for its module, and introductions to Dragino, who had already worked with LoRa and had showed interest in developing the initial prototype we were working on for the LibreRouter, were made. Conversations fructified, and Dragino and M3 merged their developments. Since then, M3 has been contributing to the testing of LibreRouter to ensure interoperability between both pieces of hardware. The repository with the hardware schematics is available at: https://github.com/telenordigital/ee0x-hardware. The code for the core firmware, and the application has been released by Telenor (M3's contractor) under a BSD licence.
Needless to say, with the funding available the LibreRouter project could not have gone that far in accomplishing this goal.

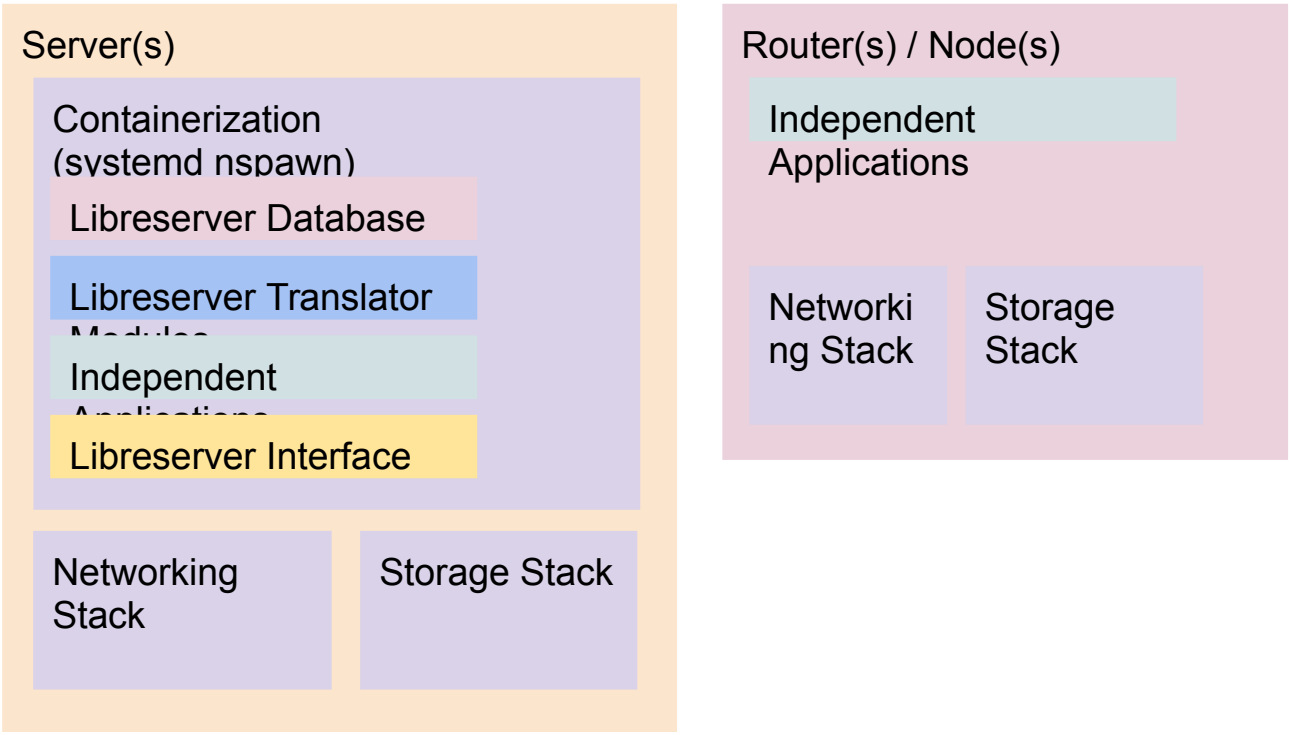
4. **Assemble of a community network management suite, called LibreServer, that facilitates the installation and provision of services in the community networks using LibreRouter.**

The bulk of the work to achieve this goal has been conducted by Management Automation Pty.

A bulk of the work conducted into this sub-objective has led to the creation of a "Database of Community Network Software". It contains a grand overview of all software available in this space, and how it fits or can interact together, who is behind it, and what the codebase looks like, from the perspective of a network/community network/ISP/WISP. This will assist the LibreServer community - and anyone looking for software like this - in saving a lot of time in making an informed decision about where to best focus their efforts - rather than reinventing the wheel, making it part of something bigger as well as reusing the best bits of other projects so as to provide a comprehensive and compatible network management platform. This database, which is not yet advertised to the public, but will soon be, can be accessed here: https://dagelf.github.io/netsoftfind The biggest challenge in his activity has been coming up with a framework that can accurately represent diverse packages without becoming too complex to read. After extensive in-person consultation at various networking events, it became clear that two such databases are required - one more programmer focused, and another more user focused. Being development focused, we started with the former.

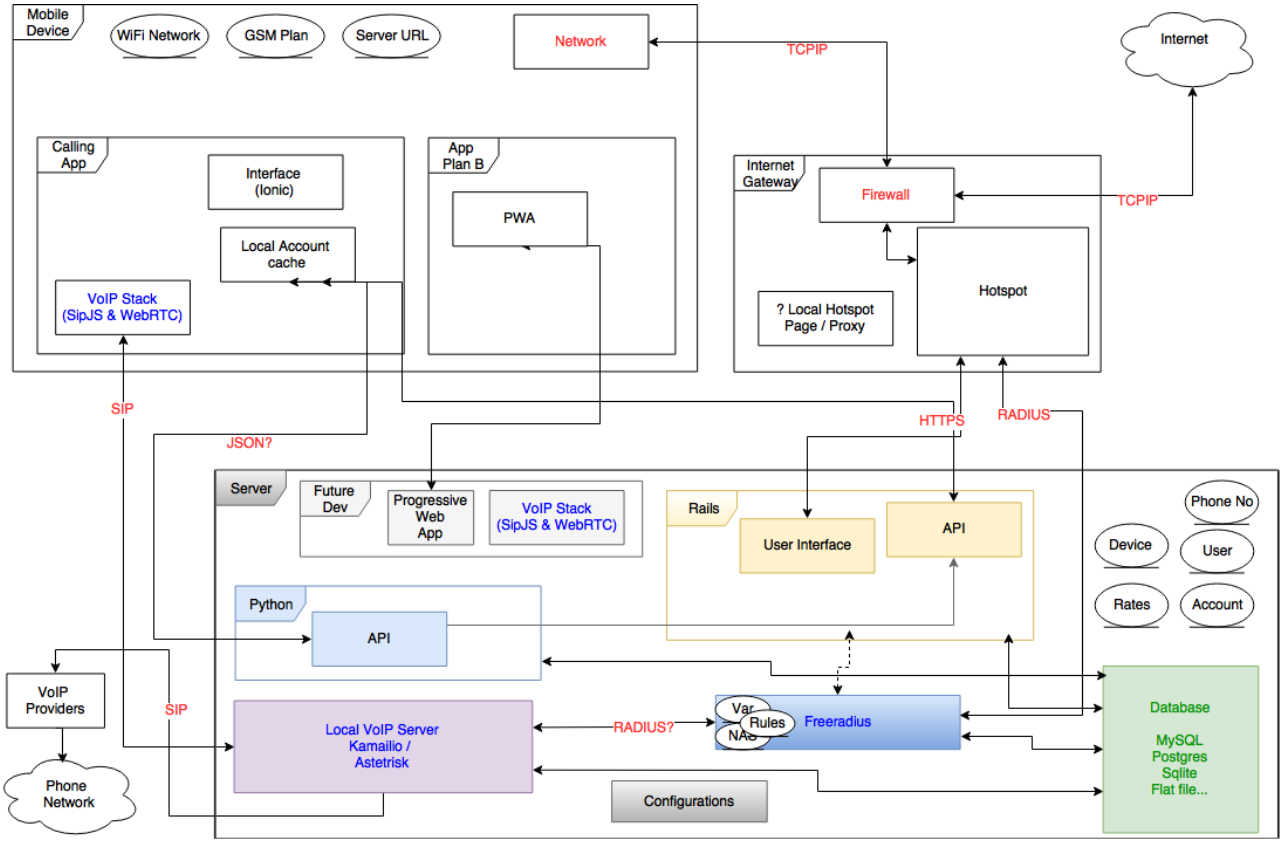
Using the database, which is an ongoing community project, the architecture several designs for the LibreServer were iterated through. Early on it became clear that a too restrictive architecture would limit interoperability with different components while a too open architecture would make it difficult to structure coherent connections between components and reduce duplication.

A diagram of the final architecture is presented in the Figure below.



Thirdly, coordinating activities took part to make ensure that the development of the WiFiCalling suite was compatible with the architecture above. This included the development of the billing

system component of the WiFiCalling sub-objective. The repository for the billing system code is available at: https://github.com/jaredleechristians/Fikelelo



In the above diagram, the Mobile Device and Internet Gateway are separate nodes. The Server is a LibreServer base and each block is an independent application. The main Libreserver Database and Interface are placeholders that can be taken up by either the Fikelelo billing server Rails app, or the WifiCalling WebServices Server component. Work on this is ongoing, which will serve to inform a first draft standard that will be circulated for comment in a wider community.

In addition, coordination work with other similar initiatives in the Community Networks movement have been explored, in order to integrate existing developments in one single platform. In particular, work has been done with Inethi – University of Cape Town - and Shikamoto -Media Monitoring Africa. Efforts to align developments with other project like Cloudy – Polytechnic University of Catalunya – have also taken place.

Additionally, on top of these activities directly related to the objectives, a considerable amount of time has been spent on coordinating and bringing together a wide array of community network activists and experts, not only from the two institutions co-ordinating the interregional grant, but from others like Guifi.net (Spain), Freifunk (Germany), VillageTelco (Canada), EyeSeeTea (United Kingdom), and ManMakeMachine, Management Automation and Inethi (South Africa), plus consultants from Australia, Italy. China and Argentina, who are actively contributing to its development.

Finally, during the UN's Global Internet Governance Forum, both regional coordinators met with both with the SEED Alliance team, and with Steve Song, founder of Village Telco, to discuss the sustainability strategy of the project.

Project implementation

Project activities	**Input**	**Outputs**	**Timeline**	**Status**
Actions taken, work performed.	Financial, human and material resources	Result and/or deliverable produced as a direct result of the project activity. Outputs are under direct control of the project team.	Dates where the listed activity was developed.	Indicate when the activity started, on-going or completed.
Libre Router prototype development				
Technical specifications document		Technical specifications completed and handed to manufacturer: https://librerouter.org/document/specifications-sheet-v6/	15 March 2017	Completed.
Board Schematic		Initial board schematic provided Feedback provided. Board schematic approved	15 May 2017	Completed.
Software		LibreMesh released and published at: https://github.com/libremesh	13 September 2017	Completed.
Prototype production		1st batch of prototypes ready	20 September 2017	Completed
LibreRouter production		200 LibreRouters produced	Q1 2018	In progress
LibreRouter Type Approved		CE / FCC certificates	Q1 2018	In progress
LibreRouter delopyed		First deployments LibreRouter in Argentina and South Africa	Q2 2018	In progress
Creation of a WiFi Calling application that allows the provision of voice services in networks using LibreRouter				
Requirements definition		Community consultation produced diagrams for the operation of the system https://drive.google.com	15 Feb 2017	Completed.

		/open?id=0B8KIRhh6kcl6c3MwenUyRFEzWVk		
Functionality defined independently from graphic design		Wireframe created and approved by UWC and interactive mock-up of the WiFi call created https://marvelapp.com/1d00fg0/screen/18236337	31 March 2017	Completed.
Prototype Server Development		The source code of this back-end architecture is available here: https://github.com/EyeSeeTea/FIRE-WS/tree/development.	31 October 2017	Completed
Prototype App development		Source code & documentation at https://github.com/EyeSeeTea/FIRE-WiFiCalling. A beta version of the application can be downloaded here: https://play.google.com/store/apps/details?id=org.eyeseetea.wificalling	31 October 2017	Completed
Development of software and/or hardware solutions to reduce the power consumption of the router.				
Test functionality of components: RTC, LoRA, Bluetooth		https://github.com/EyeSeeTea/FIRE-PowerEfficiency	1 Feb 2017	Completed.
Module development		Module Designed by M3, funded by Telenor. Hardware design available at: https://github.com/telenordigital/ee0x-hardware Tested integration with LibreRouter	31st October 2017	Completed.
Software development		Software developed by M3	31st October 2017	Completed
Assemble of LibreServer for installation and provision of services using LibreRouter				
Software overview for network operators, community networks, ISPs and/or Wireless ISPs (WISP)		Database of Community Networks Software: https://dagelf.github.io/netsoftfind	30 June 2017	Completed
Development Libreserver Architecture		LibreServer Architecture	31 August 2017	Completed
Integration of WifiCalling and LibreServer		LibreServer prototype created, including billing system module: https://github.com/jaredleechristians/Fikelelo	31 October 2017	Completed

Integration of management and user services		Management and user services software integrated in LibreServer	Q1	In progress
Technical community articulation and collaboration (events)				
Information sharing, collaboration and follow-up		Workshop proposals, grants proposals, IGF presentations	Through project implementation	Completed
Hackathon		Community consultation, software development	March 2017	Completed

Communication and Dissemination

The project is still in its design phase, so there is no yet tangible outputs from it. Still, the project has attracted considerable attention which has been captured in different media:

- GlobalVoices, translated in 5 languages: https://es.globalvoices.org/2016/12/12/hackers-trabajan-en-un-router-para-redes-comunitarias/
- Interview in BBC radio: http://www.bbc.co.uk/programmes/p04rcyz2

In terms of our own efforts to disseminate the project, several digital outputs have been created:

- Librerouter website: http://librerouter.org
- Blogpost in AlterMundi's website : http://blog.altermundi.net/category/librerouter
- Article in Guifi.net https://guifi.net/ca/node/90285

In addition, the project has been presented at:

- Barcelona Free Software, Barcelona, Spain: https://www.meetup.com/es-ES/Barcelona-Free-Software/events/234809892/
- 2nd Summit of Community Networks in Africa, Nairobi, Kenya: https://www.youtube.com/watch?v=ppQ7JNTLib4&list=PLi2ljTGe63GIB_WMlbKsz8Rym95uvqbR_&index=18
- Global Access to the Internet Workshop for All session at IETF-99, Prague, Czech Republic: http://etherpad.tools.ietf.org:9000/p/notes-ietf-99-gaia
- Digital Citizen Summit 2017, Delhi, India: http://dsummit.defindia.org/tentative-agenda/
- Workshop "Advocacy and Regulatory Polity for Community Networks", Buenos Aires, Argentina.
- HackIt 2017, Val di Susa, Italy.
- Klimacamp 2017, Germany: http://www.klimacamp-im-rheinland.de/en/
- Radical Networks, New York, USA, http://radicalnetworks.org/participants/nicolas-pace
- BattleMesh v10, Vienna, Austria: https://www.youtube.com/watch?v=7gUvNM8Zbqs&list=PL3bvPCw5QCLJ-VJPamVeQx-UPNBVyaopj&index=13

Although not directly related to the LibreRouter, but as a necessary step for its sustainability, members of the LibreRouter team have been very active in international and regional fora raising awareness about community networks. This includes:

- The 1st and 2nd Summit on Community Networks in Africa: http://www.internetsociety.org/events/summit-community-networks-africa/2016 https://www.internetsociety.org/events/summit-community-networks-africa/2017
- Several interventions in the United Nation's Global Internet Governance Forum, in particular in coordination with Dynamic Coalition on Community Connectivity: http://people.ac.upc.edu/leandro/docs/igf2016.pdf
- The GAIA Community Networks: Sustainability & Regulation Workshop: https://www.cl.cam.ac.uk/~al773/gaiaworkshop/agenda.html
- The Mozilla Foundation's Equal Rating Innovation Challenge: https://equalrating.com/winning-teams/
- Stockholm Internet Forum, Stockholm, Sweden, http://www.stockholminternetforum.se/parallel-session-1b/
- Community Network Exchange, Delhi, India, http://cnxapac.org/index.php/agenda/
- Hackmitin 2017, Mexico DF, Mexico: https://calc.mazorca.org/parillanodoshm17.html
- Technology and Revolution, Mexico DF, Mexico: https://outreach.mayfirst.org/civicrm/event/info?id=19

- Indigenous Connectivity Summit, USA: https://www.internetsociety.org/events/indigenous-connectivity-summit/agenda
- World Telecommunication Development Conference, Buenos Aires, Argentina: http://www.itu.int/en/ITU-D/Conferences/WTDC/WTDC17/Pages/default.aspx

Finally, members of the team have conducted Libremesh/LibreRouter workshops with the communities themselves:

- La Quintana, Argentina, in coordination with AlterMundi: http://blog.altermundi.net/article/hackathon-en-la-quintana-15-30marzo/
- Mankosi, South Africa, in coordination with Zenzeleni Networks
- Kerala, India, in coordination with space-kerala
- Bombay, India, in coordination with Grammarg
- Sarantaporo, Greece, in coordination with Sarantaporo.gr: https://photos.libre.ws/?f=Sarantaporo%2Fkids+workshop+1.jpg
- Exarcheia, Athens, Greece
- unMonastery, Greece

Project Management and Sustainability

1. **Challenges and Opportunities**

1.1 LibreRouter Main Objective

The first challenge identified during the implementation of the project was to coordinate the work of such a diverse and geographically distant group. The weekly meetings during the specification design phase had to rotate to accommodate the different time zones of the stakeholders -there are 10h differences in between some team members.

The communication with the manufacturer (Dragino) during the design phase was also a challenge due to both internal and external setbacks that introduced some delay in the process. Although initially those delays could have put the project at risk, the team showed respect and understanding to Dragino's reasons, which in turn built a trust relationship that has been key over the last stages of the manufacturing (see below). Fortunately, the period until those obstacles were solved was leveraged to advance the work with the software and the additional hardware modules.

The delayed in the hardware production made it impossible to carry out the LibreRouter hackathon as it was expected: bringing the team together to evaluate the hardware. However, the hackathon in Quintana carried out by AlterMundi, was restructured and reoriented to push for the software work that could be carried out without the prototypes. Once the final prototypes are available a second phase of the Hackathon it is expected to be celebrated simultaneously in Argentina and Europe. This will allow using the travel funds (which were partially used for the first phase of the hackathon) to leveraging the momentum created during the hackathon to increase the synergies with local communities.

The final manufacturing times given by Dragino are longer than those estimated initially, so the project's timeline had to be adjusted. In coordination with the implementation team and the Program Officers from FRIDA, FIRE as well as the Seed Alliance, an agreement was reached that allows meeting the main goal of the project, manufacturing the first batch of LibreRouters despite the many delays in the project.

1.2 FIRE and sub-objectives

The participation of an academic partner such as the University of the Western Cape, in a software and hardware development project. The tense situation with the #feesmustfall protests in South Africa affected the beginning of the project, as the campus was closed and situation went only back during Q1 2017. This tension, together with interdepartmental changes, mainly related to financial management, caused considerable delays in the project. So, although some of the work was advanced voluntarily in some of the sub-objectives described in this document, first payments to the service providers could only be made in May 2017.

The delay on receiving the second payment of the grant from FIRE, as we only received at the beginning of September despite having submitted the interim report at the end of April, had additional influence in the implementation of the project. Note that internal procedure at the university requires, additional official documentation from the service providers, as well as four signatures to approve a payment from an international grant, which guarantees full transparency and accountability, but obviously, introduces further delays.

One last challenge was related to the fiscal policy that UWC has to follow on imported services. This expense was not considered in the original budget of the project as it was only brought to the attention of the project manager when compiling the interim financial report. As communicated to the FIRE and Seed Alliance managers, this could affect, and has affected, the implementation of the project. Expenses were already allocated on the budget, and included in an SLA, with a foreign company, EyeSeeTea Ltd, responsible of developing the WiFi Calling and the Power Efficiency module. This VAT amounted to more than 2,000 USD. Pressure that was somehow relieved by an additional contribution of 1,000 CAD from ISIF.

This amount could have made a difference in making additional progress on the WiFi Calling application, whose development was influenced by other factors. At some point in the implementation and due to several interactions with the community, some possible synergies were found with other development teams, notably with Rizhomatica web app, who is trying to implement a similar solution only web based. That made the team change their first idea for the implementation technology from native Android to hybrid technologies (concretely Ionic).This change to this technology, that is developed using the widely extended web technologies and translated into Android/iOS/Windows Phone native languages, provides the application a bigger impact, and allows the interoperability with other community efforts, but it has had a with a non-neglectable cost in terms of developing time and efforts. In order to finalize this development, funding is being sought. An application for additional funding to complete the work has been submitted to: https://www.opentech.fund/requests/internet-freedom-fund. Another one in coordination with the Rhizomatica team to complete the integration of both parts has been submitted to: http://www.osc.dial.community/.

Due diligence at UWC also delayed the reception of the Interregional Grant funds to be used in the LibreServer sub-objective, and both the payment coming from these funds and the one coming from the second payment from FIRE, were only made effective to Management Automation in October. Once the database has been created, and the architecture designed, those funds are supposed to be used for bounties to adapt or develop software components required by the community. Given the short time remaining after the payment was made, this could not be done. The existence of an SLA between UWC and the company ensures that the work will be conducted but it will not be possible to do it in time to include it in this report.

The participation of UWC in the project has had additional positive influences in the project. For instance it has contributed in kind with the cost of the project management as well as with the

adaptation of the Solar Kit it was working on, with funding from the Technology Innovation Agency of South Africa (TIA), to become another add-on module in the LibreRouter ecosystem. Additionally, TIA at its “Innovation Bridge”, the biggest innovation saloon in South Africa, awarded Zenzeleni with the “Best Social innovation Award”. This is turn triggered a meeting with the Deputy Minister of the department of Telecommunications and Deputy Director General of the Department of Science and Technology. The first one is interested in supporting scale up of community networks in the country, which will make use of LibreRouter, the second one, in supporting technology development within the LibreRouter ecosystem to facilitate uptake from communities.

The University of the Western Cape is not the only one who has contributed financially (or otherwise) to the LibreRouter ecosystem. The interest and momentum generated from the project has created opportunities for others to see its value and contribute. Below a list of this contributions is included:
Internet Society has contributed extensively to the dissemination of the LibreMesh/LibreRouter project and to fund software and documentation development.
Telenor and M3 have made available their hardware design and software, which will be merge with that of Dragino
Rhizomatica has partially funded the costs for obtaining the CE and FCC certificates for the LibreRouter.
Dragino has contributed partially to the costs for obtaining the CE and FCC certificates for the LibreRouter, as well as committed to fund the second batch of prototypes for the LibreRouter.
Disaster Relief and http://MeshPoint.me expressed their interest in merging their initiatives with LibreRouter.

2. Sustainability and scale

The LibreRouter project was initially conceived as a project to build a router, and has evolved into a hardware and software ecosystem. This ecosystem is composed by a diverse and skilled community that actively interact in the different areas and processes to make the ecosystem work. This is one of the greatest successes of the project, which has gone beyond what it initially set for, and is key for scale and sustainability and scale.

Given the interest reported by so many institutions across the world, we understand that the project will scale beyond the production of the first 200 LibreRouter units that it initially aim at manufacturing. The scale will guarantee next manufacturing rounds via collective purchase, something that AlterMundi, and other initiatives have used already in the past. Another alternative is the use of crowdfunding campaigns.

This interest and prospective scale also provide some initial parameters for the sustainability of the initiative. The momentum generated, together with the strength of the whole team, will ensure that additional funds are secured to continue supporting and upgrading the solutions developed here. As a sample, it is important to consider the numerous in-kind contributions the project has received even before existing. The potential partnership with Disaster Relief and http://MeshPoint.me also point in this direction.

Among the challenges to this process is to find the most efficient way to make the router available in the communities wanting to install them. A solution that is being currently explored by the team is to decentralize the production of the router, something allowed by its open design. Conversations are taking place already with partners in South Africa and India for this to take place.

Project Outcomes and Impact

The LibreRouter project has had a significant impact in the community networks, and similar, movements, even without having released yet a piece of hardware that communities can interact with.

The project has contributed enormously to increase the coordination across a considerable amount of stakeholders from the community networks movements. More than 20 individuals and organizations worldwide, including software developers, hardware designers and manufacturers, community practitioners and researchers have been involved in the process, collaborating in a coordinated manner despite distances, shortage of funds and challenges inherent to creating a product from scratch, in less than 12 months. Consequently, this project has contributed to strengthen the movement and the consolidation of a dependable working team for future projects.

There is a wide consensus around the fact that community networks are one of the main alternatives in the “Connecting the Next Billion” debate. The LibreRouter project, apart from contributing to the strengthening of a core development team, has contributed to reinforce that alternative, by a) making available a hardware and software kit that facilitates the deployment of community networks, and b) raising awareness among many institutions and individuals of the potential that the solution developed has to meet their own communication needs. As a metric for this impact, it is important to note that collectives and organizations from the following countries have expressed their interest - through direct contact in events and through the project's communications channels - in using LibreRouter in their community networks projects: Argentina, Austria, Brazil, Colombia, Democratic Republic of Congo, Ecuador, Germany, Ghana, Greece, Honduras, India, Italy, Kenya, Namibia, Nicaragua, Nigeria, Mexico, Portugal, Spain, South Africa, South Korea, Switzerland and United States of America. Additionally, initiatives working in several countries like NetCommons, or the the International Federation of Library Associations have shown interest on using the technology developed here.

Overall Assessment

The project has been a constant lesson learning experience. From the hardware development point of view, it has been important that the team was composed of people from different backgrounds and experiences (engineers, software developers, consultants, practitioners, hardware manufacturers, lawyers), as well as facilitating constant collaboration among them. Without this collaboration the team would not have been able go through the different obstacles that appeared during the specification, design, prototyping and testing phases of the project. The coordination of such a multidisciplinary and geographically dispersed team required more time and effort than anticipated and it would be good to consider it for better time management in similar projects.

We also learned that in the process of manufacturing hardware, there are many variables that remain on the manufacturing company itself. It has been identified as a critical success factor assigning a single, responsible and dependable interface to keep a good communication channel in between the project and the manufacturer.

Although the creation of synergies between projects that look initially similar is a goal worth pursuing given its long-term benefits, we learned that it requires more resources than initially anticipated.

We finally learned that passion is contagious, and that the passion of LibreRouter team has not only allowed to realize the ambitious goal that was set at the beginning of the project, but to broader the scope of the project and inspire others that want to contribute to, use, upgrade, etc the solutions developed in this project.

The use of agile development techniques, through the guidance of experienced facilitators that walked us along the process of agile software development, was a key element that allowed the team to maintain rhythm, adapt to changes and produce results on time and aligned with the needs of our communities.

Recommendations and Use of Findings

The main recommendation is to keep financing interregional projects like this one. It has been challenging and the full impact of the project is still to be realized, but the outcomes of the partnerships established between the different stakeholders in this project goes beyond the output of the hardware created and the software developed.

With respect to the particular experience of UWC and FIRE the only recommendation is to try to make the payment of the second instalment earlier, as it is not always possible to keep developers contributing on a voluntary basis for such a long period of time.