PHASE II SUBMISSION – PROOF OF CONCEPT TRACK

Submission Fields (all answers must be in English language)

Overview of the solution/proposal: The non-technical overview of the proposed solution. Maximum 3600 characters (about 500 words)

This project aims to deploy a community network in the rural region of Gandiol, located in northern Senegal. The infrastructure is integrated within the vibrant social, working, and creative framework established by Hahatay (https://hahatay.org). Hahatay is a Senegalese association dedicated to fostering the creation of small businesses that focus on economic autonomy with a community and social perspective. They emphasize youth entrepreneurship and creativity, the exchange of experiences, and the use of culture and communication as tools to redefine narratives and support social change. Hahatay also advocates for the fundamental right to migrate and works closely with women entrepreneurs to enhance their initiatives, promote their visibility, and uphold their rights in the community.
The main goal of this community network is to provide Gandiol with free, stable internet connectivity. This includes linking various spaces within the Hahatay community and offering self-hosted services to support the association's daily activities. The network is built using cost-effective methods and open-source software, featuring mesh networks for WiFi coverage and point-to-point radio links for long distances. Additionally, we have implemented services like shared storage, VPN for remote access, and a monitoring and alerting system to ensure smooth operation and quick resolution of any issues.

A key aspect of our strategy is to document and share the entire development process, from deployment to maintenance, on platforms like GitHub (https://github.com/aucoop/hahatay-community-network) and a dedicated wiki (https://github.com/aucoop/hahatay-community-network/wiki). A website to disseminate information about the project is also under construction. By being transparent about the hardware and software used, we aim to inspire others in the community networks sector to undertake similar projects and address connectivity needs in rural areas worldwide.

This initiative is powered by the volunteer efforts of students from the Polytechnic University of Catalonia and members of the AUCOOP association. These volunteers contribute their skills and time to ensure the project's success and sustainability. The project also receives support from Labdoo, a global network that donates second-hand laptops. Labdoo has already provided over 30 laptops, which are actively used within Hahatay. Additionally, the Internet Society Catalan Chapter has supported the project financially through the Beyond-the-Net small grant program, further enhancing its impact and reach.

In conclusion, the community network project in Gandiol aims to be a model for empowering rural areas through technology. Supported by the collaborative efforts of Hahatay, volunteers from the Polytechnic University of Catalonia, and organizations like Labdoo, this initiative not only enhances connectivity but also serves as an inspirational blueprint for similar projects globally. By fostering digital inclusion and community empowerment, it highlights the transformative power of technology in driving social change.

Solution details: The technical and/or solution-specific details. As part of your response, if this is a technical initiative, please share more about the architecture that is underway. Is

there/would there be open architecture? Does/can/will the initiative take advantage of open source models? Maximum 5000 characters (about 1000 words)
The technical objectives for the project are mainly:

1. High-range WiFi coverage in open spaces using Mesh Networking
2. Deployment of cloud infrastructure within the community network to provide shared storage and communication services to users.
3. Resilience of the community network to Internet Service Provider (ISP) outages by implementing a ‘multi-homing' system where outgoing Internet traffic is balanced across more than one carrier.

Internet Access:

Currently, internet access in Gandiol relies on cellular connectivity, as it is the only way to connect to the internet in this rural area. This dependency presents challenges in terms of cost and bandwidth limitations. To that end, the internet gateway are 3G/4G routers, meaning that all the traffic for the whole network leaves to the internet through these cellular routers.

High-range WiFi Coverage using Mesh Networking

The access network is made up of an interconnection of mesh networks based on the IEEE 802.11s standard. A WiFi Mesh network comprises a central router and multiple interconnected access points, also known as nodes or satellite access points. Unlike traditional networks that rely on repeaters, nodes in a Mesh network can connect to each other, allowing for enhanced coverage and more efficient network management.

Mesh networks autonomously decide the best access point at any given time by considering factors such as proximity, network saturation, and signal strength. This intelligent and transparent connection management ensures users experience minimal outages and broad coverage areas. Although powerful commercial options are available from well-known vendors, these solutions can be prohibitively expensive. Therefore, we opted for basic commercial hardware with OpenWRT firmware installation.

Also, since the network is slowly increasing the size (currently we have around 40 access points) we are implementing an SDN solution based on OpenWisp (https://openwisp.org/).

Deployment of Cloud Infrastructure

To provide shared storage and communication services to the community network's users, we are deploying a cloud infrastructure within the network. This setup includes local servers equipped with simple yet useful storage solutions such as SMB shared folders for file sharing and collaboration tools. By hosting these services locally, we can ensure faster access times, greater data sovereignty, and reduced reliance on external internet services.

Multi-homing for Resilience

To enhance the resilience of the community network against ISP outages, we are implementing a multi-homing system. This system balances outgoing internet traffic across multiple carriers, ensuring continuous connectivity even if one ISP experiences downtime. The multi-homing setup

uses dynamic routing protocols and failover mechanisms to seamlessly switch between providers, maintaining an uninterrupted internet connection for users.

Technical Architecture and Open Source Integration

Mesh Network Architecture:

The technical backbone of our Mesh network is built on the 802.11s standard, supported by OpenWRT, an open-source Linux operating system for embedded devices. OpenWRT allows for complete customization and package management, making it an ideal choice for creating a scalable and robust Mesh network.

OpenWrt has several advantages:

* Customizability: OpenWRT supports extensive configuration options, allowing us to tailor the network settings to meet specific community needs.

* Community Support: OpenWRT is backed by a strong community, offering continual updates and improvements.

Hardware and Installation:

The default firmware of many commercal routers limits their capabilities, such as the creation of Mesh networks. By using OpenWRT, we overcame these limitations and enabled our network to cover extensive open spaces such as Sunukeur and Aminata. The hardware used includes mainly Xiaomi Mi routers (4C) (https://github.com/aucoop/hahatay-community-network/wiki/Install-OpenWrt-Xiaomi-Router-(1GB)) and Linksys routers (2500v4 E5400) (https://github.com/aucoop/hahatay-community-network/wiki/Installing-OpenWRT-in-Linksys-2500v4-E5400-Routers). Each router model has unique OpenWRT installation procedures, which are documented in the project's GitHub repository Wiki. In order to make it publicly available for everyone.

Detail design and/or schematic diagram (optional):

Video of your solution (optional)

Who will benefit from your solution and how? Maximum 800 characters

Beneficiaries include Hahatay staff and volunteers, local youth, women, radio presenters and listeners, artists, and students of Tabax Nité, Ndar Weesul, and JangKom, fostering growth and adapting to current and future needs.

More specifically, some of the beneficiaries are the following:

- Hahatay staff.
- Hahatay volunteers
- The young people who participate in current and future initiatives.
- The women of the community.
- The beneficiaries of the different services that are carried out in the town of Tabax Nite, Ndar Weesul and JangKom.
- The students of the training school Tabax Nité, Ndar Weesul and JangKom.

KPI'S
INNOVATION

Maximum 1500 characters (about 200 words)

Describe the degree to which the solution to an identified connectivity problem/issue is novel, unique, and original, in terms of its increase or improvement in connectivity, commercialization, or business models.

Our solution addresses connectivity issues in Gandiol with an original approach by leveraging open-source software for all components. This ensures not only cost-effectiveness but also fosters a culture of transparency and replicability. By openly sharing our methods and tools, we aim to create a blueprint that other communities can easily adopt and adapt, enhancing their connectivity solutions.

Our project stands out by adapting existing community network models to the specific needs and nature of Gandiol and Hahatay. We prioritize learning from other communities' experiences, incorporating their successful strategies while tailoring solutions to our local context. This adaptive approach ensures that our network is not only robust but also highly relevant to our users' needs.

Furthermore, our commitment to openness extends to rigorous project dissemination. We are dedicated to documenting and sharing our ongoing and future work, providing clear insights into our processes and outcomes. This transparency facilitates knowledge exchange, enabling other communities to benefit from our experiences and innovations.

By fostering a collaborative and open environment, we aim to improve connectivity, support local development, and contribute to a global movement towards accessible and sustainable community networks.

RELEVANCE *
Maximum 1500 characters (about 200 words)
Describe the degree to which the solution solves or addresses an identified connectivity problem/issue and the digital divide, particularly:
1) relevant to underserved communities in the targeted area;
2) delivering real value to its users in the targeted area; or
3) suitable for submission in the specific use case.
(whenever possible, please use numeric or quantifiable data with references)

Our solution effectively addresses the connectivity problem and digital divide in Gandiol, especially for underserved communities. In Senegal, the cost of internet access is relatively high, with data priced at approximately 1.5€ per GB (source: https://www.cable.co.uk/mobiles/worldwide-data-pricing/)—equivalent to the price of a main dish at a typical restaurant. This expense creates a significant barrier for many individuals and organizations.

Relevance to Underserved Communities:
Our community network targets these underserved populations by providing free internet access. By leveraging open-source software and existing hardware, we create a sustainable and cost-effective solution that opens the internet to everyone.

Delivering Real Value:

The infrastructure already deployed significantly enhances the activities of Hahatay and its beneficiaries. For instance, the deployed infrastructure eliminates the need for the association to buy pre-paid vouchers from the ISP for every worker. Now workers can simply connect to the WiFi network. Moreover, we are planning to implement solutions that allocate fixed bandwidth to the community radio, enabling them to transmit via streaming using the community network

SUSTAINABILITY *
Maximum 1500 characters (about 200 words)
Describe how your solution is planning to achieve sustainability including both financial/business (e.g. investment/revenue streams) and technical (e.g. implementation aspects). In answering financial/business sustainability, it would be helpful if you can address the following questions:

- **Is there broader support for the initiative beyond your organization, either financially or otherwise? Does any of this support come from industry partners or government entities? If so, can you highlight details on this?**
- **Is this a market-based model or are subsidies required to achieve ongoing progress?**
- **Has this been commercialized and if not, are there plans for commercialization that you can share? Can you comment on any impending business model and anticipated fees? Do you believe that the product/service can (or should) reach commercial sustainability?**

Financial Sustainability:
Currently, the network is completely open to anyone who wants to use it. In the future, our goal is to operate as a small ISP, offering connectivity at a cost that is at least one-third of the cheapest cellular plan. This pricing strategy aims to make internet access more affordable while generating revenue to support ongoing operations.

Technical Sustainability:
Our solution leverages free and open-source software, making it cost-effective and adaptable. The hardware, including Ethernet cables and routers, can be easily bought from Senegalese commercials. The technical team has remote access to the infrastructure via VPN, allowing for efficient monitoring and maintenance to ensure everything is functioning as expected.

Broader Support:
Currently, financial support primarily comes from the University of Catalonia (UPC) and the Internet Society Catalonia. In the future, we aim to engage Senegalese universities and operators who might be willing to provide connectivity or other forms of support to enhance the project's sustainability and impact.

Market-Based Model or Subsidies:
In the short to medium term, we plan to continue relying on subsidies to sustain our operations. However, our long-term goal is to achieve self-sustainability. By transitioning to a market-based model, we intend to generate revenue through affordable service fees, ensuring the network's financial viability without compromising accessibility for underserved communities.

SCALABILITY
Maximum 1500 characters (about 200 words)
Describe the capability or potential with which the implementation of a particular solution can be easily scaled up, within and without the targeted geography/demographic, to benefit/potentially benefit a broad number of people and/or support areas with demonstrated lack of connectivity or usage. In answering this, please be sure to indicate what indication you have of beneficiary buy-in and interest level.

Our solution is designed for easy scalability. The community network can seamlessly integrate new nodes, making it straightforward to extend coverage and include more users. As the demand grows, additional access points can be added without significant infrastructure changes, ensuring that more people can benefit from reliable internet access.

Regarding the internet gateways, we have already implemented a load balancer, which facilitates the easy addition of new internet gateways. This means that as new technologies or internet sources (e.g., satellite networks) become available, they can be incorporated into the network with no disruption. This flexibility ensures that we can continuously improve and expand our connectivity offerings.
The initial deployment has received positive feedback from the community, demonstrating strong beneficiary buy-in and interest. The immediate enhancement in connectivity has significantly improved the activities of local organizations like Hahatay and their beneficiaries. This success indicates a high level of community support and a readiness to embrace further expansions.
Finally, given the modular nature of our network and the positive community response, our solution has the potential to be replicated in other regions facing similar connectivity challenges. By leveraging local partnerships and maintaining a focus on sustainability, we can extend our impact to underserved communities beyond the initial target geography.

EFFICACY

Maximum 1500 characters (about 200 words)

What is the cost/benefit ratio of the solution? (The efficacy of a solution can be measured by its cost/benefit ratio, which is calculated as the cost of the solution per person or service it benefits.) How does this compare with other existing or comparable solutions, to the best of your knowledge? Also, do you believe that the cost of the initiative would be reduced if your initiative achieved greater scale or would they be likely to stay the same?

READINESS

Maximum 1500 characters (about 200 words)

Describe the readiness and maturity level of the team for solution development/deployment including achieving necessary scale. Have you filed patents where appropriate? What is the experience and expertise of the team? What is the team's growth vision? How does the team plan to get the support and buy-in from the community?

The team is well-prepared and mature, starting very small, but working every year in this proeject since 2020. The team lead has been involved since the project's inception, providing consistent direction and expertise. Additionally, we have two dedicated workers from Hahatay who maintain regular communication with the team lead, ensuring smooth collaboration and on-the-ground support. As part of the Polytechnical University of Catalonia (UPC), our team benefits from a robust academic ecosystem. This affiliation provides access to a wealth of resources, knowledge, and innovation. The project also continuously attracts new students, bringing fresh ideas and energy, which enhances our capacity for development and problem-solving.

Our vision for growth is centered on sustainability and community impact. We aim to expand the network to reach more underserved areas while maintaining good-enough service quality. Also, gaining support from the community is crucial for our success. Our close collaboration with Hahatay ensures that the solution is tailored to the community's needs. We actively involve workers in the planning and implementation phases, fostering a sense of ownership and commitment.

Regular feedback loops with the community help us make necessary adjustments and maintain alignment with their expectations.

Finally, while we have not filed patents, our focus on open-source solutions ensures that the technology remains accessible and adaptable.

RISK LEVEL
Maximum 1500 characters (about 200 words)
In addition to discussion of standard business risk elements like operations, compliance, economic/financial, please describe your analysis of the risks of the proposed solution, based on factors such as its complexity, regulation, stringent technology/implementation/market requirements, community or beneficiary buy in, intermediaries or partners, or vulnerability to local or regional geopolitical changes.

Our solution faces some risks across operational, compliance, and financial dimensions, as well as challenges specific to its complexity and the need for community and partner engagement.

First, the deployment of the network relies heavily on the availability of volunteers to travel to the site. In-person validation of configuration options, materials, and future maintenance is crucial. Travel restrictions or logistical challenges could significantly impact the implementation and ongoing support of the network and new services.

Furthermore, our reliance on subsidies from third-parties presents financial risks. Although we do not request much money and assume to work with humbe budgets, some changes on the policies from third parties could affect the project's sustainability. However, transitioning to a market-based model will require careful financial planning and execution to ensure long-term viability.

SOCIAL IMPACT

Maximum 1500 characters (about 200 words)
Describe the potential positive impacts on or contributions to society your solution has made in terms of citizens' quality of lives (e.g. equality, employment) if your solution succeeds. Additionally, if you anticipate that your solution could have wider benefits (e.g. healthcare, education, agriculture, etc.) then please indicate (but only where this can be attributable to your solution, etc.). If your solution is targeted towards an intermediary (like an ISP or Telco operator), what evidence do you have that the benefits (such as lower prices, etc.) are passed on to the end user?

The main goal of the "Hahatay Network" is to reduce the digital divide in the rural area of Gandiol, empower the knowledge of women and young people in new technologies with the aim of promoting socio-economic systems that benefit local growth, thus discouraging certain activities such as migration.

The main objective, which is partially achieved, is to establish a stable internet connection with decent bandwidth, sufficient for comfortably loading static pages and supporting a considerable number of users.

Regarding wider benefits, the existing ICT infrastructure could support other anticipated side projects:

- Solar Energy Monitoring: Hahatay’s is fully powered by solar energy. Implementing a system to record data on solar energy production and consumption would be very helpful in order to monitor the status of the solar system.

Automated Water Pumping: Developing a system to automate water pumping from a well based on its salinity levels. In Gandiol, where both the soil and water are very salty, they have discovered a relatively less salty well. The water from this well can be reused if it is pumped twice: first to a reservoir, and then from there to another. Currently, this process is done manually, requiring a wait for salinity levels to drop. Automation could be achieved using an Arduino, a relay, and a conductivity sensor.

INCLUSION

Maximum 1500 characters (about 200 words)
Describe the inclusivity of your solution with respect to the target audience/beneficiary. Is your solution able to address underserved user communities such as women, children, elderly, low income, accessibility challenged, LGBT+ etc., or help them overcome the digital divide? Please also address whether your solution can reach people where it is more convenient and/or where they will feel safe (such as in their homes)?

Hahatay promotes a women's empowerment project called "The House of Women of Gandiol (-Jiggen ju jook-)". The objective is to create a safe, welcoming, and diverse space that represents the plurality of women and addresses their basic needs and strategic interests. To this end our contribution of installing a computer system will help facilitate technological training courses for both men and women, and economic training to help them become more independent, thereby promoting gender equality.

ANTICIPATED CHALLENGES/OBSTACLES
(Maximum 800 characters)
Please indicate what impediments/challenges exist, and any anticipated barriers to adoption. This may include, but is not limited to, technological, market-based, cost, socio-cultural issues, compliance, etc.

The primary challenge is the cost of internet connectivity. The only connectivity available is cellular, and Hahatay cannot afford the cheapest unlimited data plan, which costs around 150€ per month for 20Mbps. This plan would provide almost three times the current bandwidth, significantly improving network performance.

Another challenge as stated previously, is the dependency on volunteers traveling to the site for deployment and maintenance. In-person validation of configuration options, suitable materials, and ongoing maintenance is crucial. If travel becomes impossible due to logistical or other reasons, the implementation and upkeep of the network and new services will be adversely affected.

STANDARDS (OPTIONAL)
Would you like your application reviewed by the IEEE Standards Association for potential standardization projects?

OBSTACLE
(maximum 800 characters)

Describe any aspect of current standards that represent an obstacle for your solution (N/A if not applicable)

SUPPORT
(Maximum 800 characters)
Describe any potential standards that need to be introduced to support your solution (N/A if not applicable)