COWShED: Communication Within White Spots for Breeders

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***Abstract*—Livestock transhumance in Senegal is done in several areas and more specifically in Sylvo-pastoral areas located in the Ferlo's region where it is difficult or impossible to communicate with terrestrial communication systems. The main reason is due to the existence of white spots. The lack of communication between breeders does not allow the dissemination of vital information such as water points location, bush fires geographic location, epidemic area, and available pastureland. However, in undeserved areas, satellite communications are very expensive for rural population. Therefore, we propose a low-cost communication based on $LoRa$ transmission that enables different services like short message text, voice messages, status of a water points, geographic location. The deployed architecture is a delay tolerant ad-hoc network that can cover a large area with a mesh system.**

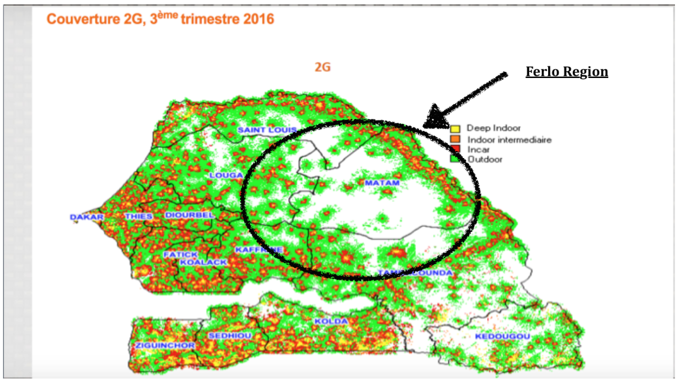

Fig. 1. 2G Cellular network coverage of "ORANGE" Senegal in 2016

I. Introduction

Sylvo-pastoral region in Senegal is one of the most less populated areas, and thus, telecommunication operators do not see investment impact. Therefore, several areas in $Ferlo$ Desert in northern Senegal for herders (or herders), are not covered by terrestrial communication networks. For instance, Fig. 1 illustrates $ORANGE$ operator network coverage according to $2G$ [2]. A couple of areas within $Ferlo$ region colored in white are considered as white spots which means a lack of cellular network coverage. In Senegal, the amount and geographic distribution of rainfall are a big concern according to either water points and boreholes availability or pasture during the long dry season which occurs during 8 months. Therefore, pastoral mobility over large areas is one of the best strategies for breeders to adapt with respect to a fragile environment. Pastoralism has an important socioeconomic role in Senegal, and in particular in the Ferlo region, by providing many goods and services for the rural population. For instance, $SPAIF$ project [4] was launched in order to manage livestock transhumance. Nevertheless, breeders within these white spots have at no time possibility to use their mobile phone in real time to communicate or transmit useful information such as water point status, situation in boreholes and pasture, epizootic diseases (local and neighbouring countries), cattle rustling along transhumance transit roads.

Availability of information about the situation in boreholes and pasture can secure the herd by reducing the number of animals which would be severely affected by drilling failure and / or by lack of pasture, as well as for managing theft and recovery of stolen animals. It is worth noticing that livestock theft is a significant risk in $Ferlo$ and the existing insurance systems do not yet take charge of it. Therefore, $COWShED$ which enables the communication within white spots for breeders [3] can reduce the asymmetries of information on the terms of trade between animals and cereals. It enables increased income margins by animal type and season. This will increase the bargaining power of herders with intermediaries in the markets. Moreover, it can also lead to an increase in revenues by anticipated sales. $COWShED$ aims at collecting various information and disseminate that into the network. Information can be categorized into 5 areas: environmental, pastoral activity, animal health, organization and management of pastoral lands, and agriculture.

The technical solution for our architecture system is based on technologies for challenged networking scenarios such as Opportunistic Networking, Internet-of-Things and Device-to-Device communication. A mesh-based proof-of-concept network is built for communication between herders based on $LoRa$ transmission within ISM bands for areas without cellular coverage. Low Power Wide Area Networks (LPWAN) enables radio-communication based sensing, gathering, and dissemination of various information [1], [6]. Currently, $LoRa$ is one of the most used and reliable technology about large coverage with respect to $LPWAN$ [1].

The remainder of the paper is organized as follows. Section II describes $COWShED$ communication architecture as well the different $COWShED$ components. Finally, Section III concludes our work.

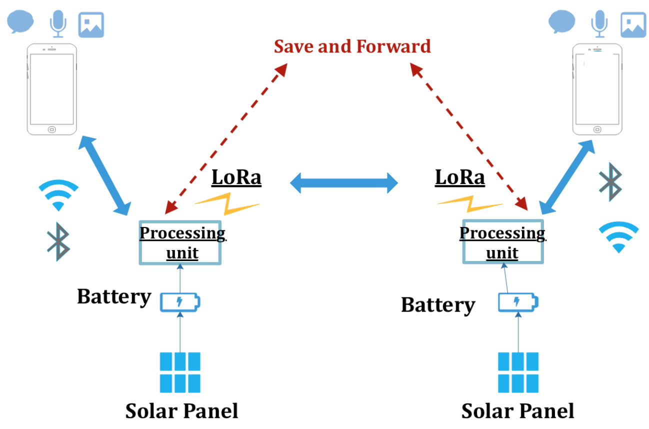

Fig. 2. COWShED communication Architecture

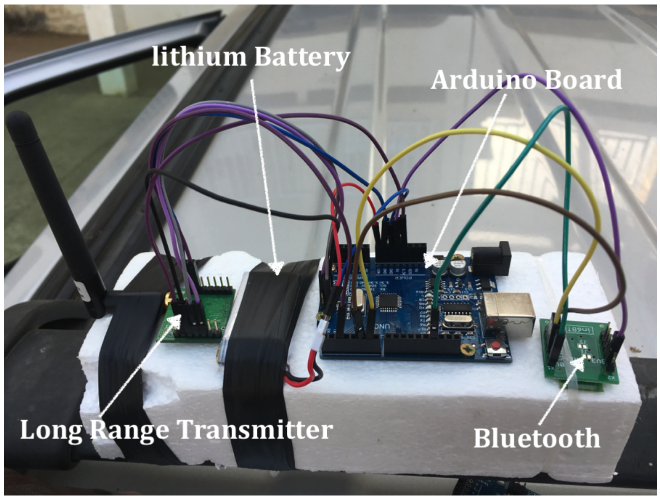

Fig. 3. Bluetooth-based communication prototype

II. COWSHED COMMUNICATION ARCHITECTURE

COWShED project is a mesh-based proof-of-concept network that is built for communication between breeders based LoRa transmission for areas without cellular coverage (white spot). Therefore, end-to-end communication between smart phones are done via relay boxes that exchange information through LoRa transmission protocol. A communication between a given mobile box (smart phone) and a relay box is done either by $Bluetooth$ or $Wi-Fi$. Afterwards, relay boxes are powered by solar panel. For instance, Fig. 2 illustrates a communication scenario with respect to COWShED architecture. By leveraging LoRa transmission between two relay boxes, Fig. 2 depicts a end-to-end communication between two mobile boxes (smart phone).

In order to enable a geographical information system, we considered an offline maps which is deployed in breeder's smart phones. It is worth noticing that our device can get data from remote connected devices using LoRa network. Therefore, geolocation service can be used in order locate available water points and boreholes. According to our application, herders geographic location are retrieved from a GPS, and thus, we are able to send geographic location. These coordinates can be displayed by considering an offline maps like $maps.me$. Furthermore, $LG01$ box is able to store herders geographic location (longitude, latitude) along transit transhumance roads.

In fact, extensive measurements test were performed between end-to-devices in real environment. According to urban areas (Dakar, Senegal) end-to-end mobile devices can communicate up to $10km$, whereas in rural areas (Namarel - Ferlo Region, Senegal we reached $15km$. The main reason is due to presence of obstacles in urban areas. Indeed, we noted a better line of sight in Namarel village which is due to a lack of urban infrastructure.

A. COWShED communication components

$Ferlo$ is one of area in Senegal where solar irradiation is very important. Sunshine duration ranges from 7 to 12 hours overall the year. Therefore, we plan to use solar power systems with replaceable batteries of $7.4V$ and $5200mA$ which have 8 hours of autonomy. The battery is recharged by a $4W$ solar panel. We consider two prototypes which are based on $LoRa$ transmission.

Firstly, we design a Bluetooth-based prototype which enables a communication between breeders that are located within white spots. Our Bluetooth-based communication prototype is formed by two components. The first one is illustrated in Fig. 3 and formed by: (i) a Loge Range transmitter (LoRa chip $Sx1272$) card which acts as relay and can either broadcast received information from breeder's smart phone towards next hops or transmits received information from neighborhood to breeder's smart phone; (ii) an $arduinoUno$ card which acts as processing unit; (iii) a Bluetooth Low Energy (BLE) card which either transmits received information from LoRa card to smart phone, or from smart phone to LoRa transmitter. It should be noted that the considered smart phone is considered as our second component. Indeed, both components communicate through their Bluetooth interfaces. In so doing, a mobile application is deployed within each smart phone and enables to send information (message text or emoticon) from breeder's smart phone to our gateway (Fig. 3).

Secondly, we consider a WiFi-Based prototype as depicted in Fig. 4 where the communication, between both previous components, is based on $IEEE802.11n$. We can remark an evolution with respect to the gateway device as depicted in Fig. 4. We consider a $LG01$ box which contains a LoRa chip ($Sx1276$) transmitter, an $arduinoYun$ card), and a $IEEE802.11n$ card. The same communication architecture than a Bluetooth-based prototype is considered.

For instance, Fig. 5 shows a herder wearing a bag which contains our $LG01$ box which is powered by a solar panel as well its smart phone that enables to establish end-to-end

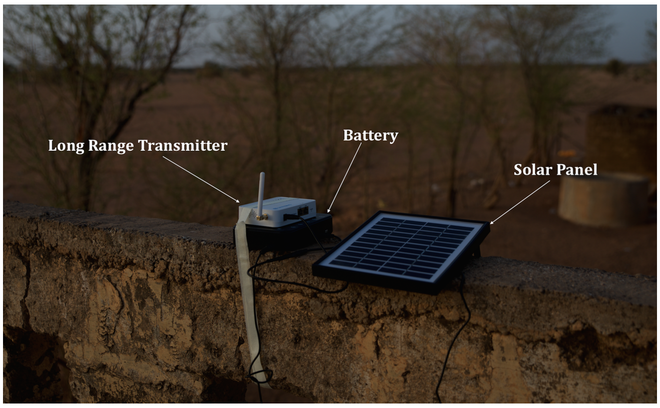

Fig. 4. WiFi-based communication prototype

Fig. 5. Breeder in communication through COWShED architecture

communication within white spots. In fact, extensive measurement were performed with our WiFi-based communication prototype in $Namarel$ village.

Table I illustrates a brief comparison between both designed prototypes. During our test, we found that Bluetooth communication between our two components is unstable. In order to enable an efficient communication between herders, is it mandatory to have a good link quality between relay box and herder's smart phone. Indeed, Bluetooth transmission consumes less power than WiFi transmission. Nevertheless, WiFi range is upper than Bluetooth. It is worth noticing that the smart phone is charged by our solar power system. It is worth noticing that Bluetooth-based communication prototype is useful for text messages service, warning system or other IoT applications that not require to transfer big amount of data with LPWANs. In contrast, WiFi-based communication prototype is more relevant when we consider a store-and-forward transmission scheme. In case of voice messages or pictures, it will be more suitable.

TABLE I
PERFORMANCE EVALUATION

Device	Range	Bit rate	energy consumption	Storage
Bluetooth Based	-	-	+	-
Wi-Fi based	+	+	-	+

III. CONCLUSION

According to COWSHED project, we deployed an architecture that enables a communication between breeder's within white spots. A mesh-based proof-of-concept network is built for communication between herders based on $LoRa$ transmission that enables to share vital information during breeder's transhumance. The COWShED project built relays to explore new services for rural citizens and/or herders.

In on-going work, we are dealing with the dissemination of information in an opportunistic manners. Therefore, we plan to consider fixed collector boxes that are located at points of interest such as water points or boreholes, Afterwards, fixed relay box will be deployed in order to improve coverage and relay information towards smart phones that are carried by herders and provide opportunistic communication as well as an access point for smart phones as user interface. In addition, we should take into account the possibility to send voice messages within COWShED network.

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