Publication avant LAFMC

Titre	Pastoral Mobility Optimization based on a Mobile Geographic Information System (GIS) for Rural Development
Auteurs	Ibrahima Niang, Demanou Cerille, **Samba Ndiaye**, Papa Dame Ba
Référence	Proceeding of the 3rd International Conference on Information and Communication Technology for the Moslem World (ICT4M) 2010
Editeur	IEEE
Pages	
Année	2011
DOI	10.1109/ICT4M.2010.5971897
URL	https://ieeexplore.ieee.org/document/5971897
Index	https://www.scopus.com/authid/detail.uri?authorId=6701604512
ISBN	978-1-4244-7922-1
Encadreur	Non
Extrait d'une thèse	Non

Pastoral mobility optimization based on a mobile Geographic Information System (GIS) for rural development

4 Author(s) Ibrahima Niang ; Demanou Cerille ; Samba Ndiaye ; Papa Dame Ba View All Authors

Abstract:
This paper explores the use of mobile Geographic Information System (GIS) computing in its application in water point management. Applications based on mobile GIS are the best way to provide appropriate solutions for rural populations such as breeders in Senegal. In fact, the breeders have many problems to find water points for their cattle group. So far, the potential geographic location of water points is transmitting orally between breeders. It is worth noticing that this knowledge, in rural areas, is not stored for instance in databases and depends only on the availability of breeders that own these information. Many solutions for setting up rural information systems have been proposed, but most of them are either PC-based, or rely on proprietary software, or do not take into account electricity constraints which are crucial in rural areas. In this paper, we present an information system based on Short Message Service (SMS) technology and mobile GIS for pastoral mobility (breeders) in Senegal. The system is based on Scalable Vector Graphics (SVG) format, adapted to mobile phone. Our proposed solution is able to keep up-to-date water points status as well to optimize the seasonal migration of breeders.

Published in: Proceeding of the 3rd International Conference on Information and Communication Technology for the Moslem World (ICT4M) 2010

Date of Conference: 13-14 Dec. 2010
Date Added to IEEE *Xplore*: 04 August 2011
ISBN Information:
Electronic ISBN: 978-1-4244-7922-1
Print ISBN: 978-1-4244-7920-7
INSPEC Accession Number: 12170860
DOI: 10.1109/ICT4M.2010.5971897
Publisher: IEEE
Conference Location: Jakarta, Indonesia

Pastoral Mobility Optimization based on a Mobile Geographic Information System (GIS) for Rural Development

Ibrahima Niang
Universite Cheikh Anta Diop de Dakar, Senegal
iniang@ucad.sn

Demanou Cerille
Universite Cheikh Anta Diop de Dakar, Senegal
cyrte@yahoo.fr

Samba Ndiaye
Universite Cheikh Anta Diop de Dakar, Senegal
samba.ndiaye@ucad.edu.sn

Papa Dame Ba
Universite Cheikh Anta Diop de Dakar, Senegal
papadam83.ba@ucad.edu.sn

ABSTRACT

This paper explores the use of mobile Geographic Information System (GIS) computing in its application in water point management. Applications based on mobile GIS are the best way to provide appropriate solutions for rural populations such as breeders in Senegal. In fact, the breeders have many problems to find water points for their cattle group. So far, the potential geographic location of water points is transmitting orally between breeders. It is worth noticing that this knowledge, in rural areas, is not stored for instance in databases and depends only on the availability of breeders that own these information. Many solutions for setting up rural information systems have been proposed, but most of them are either PC-based, or rely on proprietary software, or do not take into account electricity constraints which are crucial in rural areas. In this paper, we present an information system based on Short Message Service (SMS) technology and mobile GIS for pastoral mobility (breeders) in Senegal. The system is based on Scalable Vector Graphics (SVG) [1] format, adapted to mobile phone. Our proposed solution is able to keep up-to-date water points status as well to optimize the seasonal migration of breeders.

Keywords

Pastoral mobility, Geographic Information System, Mobile GIS

1. INTRODUCTION

In the Agro-Pastoral areas located at the East of Senegal, the goal of the *Pastoral Unit* (PU) was to improve daily life of breeders and farmers. PU are characterized by a low population density and populations are dispersed overall the region. In such case, it is difficult to share information between breeders or people that are living in these areas. Many Pastoral breeding systems in Africa are based either on dry season or raining season. This approach incorporates local knowledge that takes into account two complementary strategies: the mobility and the geographic localization of resources that should be used.

In order to mitigate the impact of the scarcity of resources (e.g water, grass) breeders practice cattle's mobility. This geographic mobility, called transhumance, appears as a strategy for finding resources during both seasons. During the dry season it is necessary to go towards good pasture areas. Nevertheless, this transhumance still presents several problems.

Firstly, breeders should avoid to cross farmers' areas that lead quite often to conflicts between them. Therefore, finding good routes that do not cross farms is mandatory. Secondly, the management of water point is crucial. Missing information either about the lack of water and/or the overload of potential water points, or the existence of routes that cross farmer's area should be solved.

Despite the existence of local knowledge, the endogenous information system is poorly structured and has no traceability [2]. Ancey et *al.* in [3] have shown that oral communication is the most common way to access or to share information in PU. The traditional information system used by these populations has reach its limits. Indeed, in order to sustain high productivity, breeders should have a distributed geographic information system.

Nowadays, solutions based on Information and Communication Technologies (ICTs) can overcome these limitations. ICTs like Geographic Information System (GIS), can be used to transmit and to keep up-to-date information between people that live in pastoral areas. Existing systems, called PC-based, use Global Positioning System (GPS) and Internet mapping information. In so doing, they enable to track and manage pastoral resources. The goal is to improve the coordination of breeder's movements and to protect soil and water resources during the dry season. Due to the lack of skill and economic reason, this PC-based approach is not

appropriate for rural areas.

Currently, we notice the use of GIS over mobile phone. This technology, called mobile Geographic Information System (mGIS) [4, 5, 6], is useful for managing geographic distributed databases. In other words, mGIS is the use of geographic data in the field on mobile devices. It should be noted that during the last seven years, the number of mobile phones has largely exceeded the number of wired phones [7]. We remark also a high penetration rate in rural areas even if quite often these populations have low incomes. According to the penetration rate of mobile phone in our studied area, we design an approach based on SMS and that uses GIS. SMS system is primarily a service that tends to overcome the Voice service of mobile telephony and the SMS price is cheaper than a communication call.

This paper presents a new approach for information systems management in pastoral areas. The goal is to setup a dynamic platform management of water points. Therefore, at each moment, breeders are able to know the water points status. It should be noted that water points can have three status either not available, or overloaded, or free. These information are sent to breeders' mobile phones by SMS from a server which has gathered data from different collectors (e.g radio station, selected persons, breeders, etc.) designated in each rural area.

In fact, we design and implement a mobile Geographic Information System (mGIS) which includes transhumance routes and water points on each mobile phone. Put simply, this platform enables dynamic management of information with respect to pastoral resources (water points, tide, etc.), and the management of transhumance trails by taking into account difficulties that may arise in certain areas (disease, failure of boreholes, etc.) To overcome the barrier of language the output messages of mobile phone are translated into two local languages.

The rest of this paper is organized as follows. Section 2 reviews the related works approach-based GIS and on information systems in pastoral areas. Section 3 presents our approach based on mobile geographic information systems. Afterwards, we discuss in Section 4 the penetration rate of our approach with respect to the breeders that live in the studied area. Finally, we conclude and present some research perspectives in Section 5.

2. RELATED WORK

At present, mobile GIS, Internet GIS and wireless Web application are increasingly playing important roles through the entire geo-information application. In this paper we focus on mobile GIS. Mobile GIS can be defined as an integrated software or hardware framework for the access of geospatial data and services through mobile devices via wired or wireless networks [4]. Although a lot of research work has been done on the use of mobile GIS technology, not much had been done in the field of environmental monitoring, by use of dynamic information management.

The integration of mobile GIS technologies and wireless telecommunications was the key focus of this paper [4]. Tsou in [4] proposes to combine mobile GIS application software, global positional systems (GPS), and wireless networking technologies for an application based on mobile GIS and dedicated to natural habitat conservation.

Noriyuki et *al.* in [6] introduce geographic information system using a mobile phone that is equipped with a camera and a GPS and its exhibitions. Authors aim to provide a social information spaces for local communities or towns. Users can annotate not only text notes but also photos to physical spaces by sending emails with photos and location information by GPS attached from mobile phones.

The authors of [8] present a new mobile GIS application, based on Mobile SVG [1], called TinyLineSVG, which is intended for heavily resource constrained hand held devices. This application is a tourism-oriented map application of the Shenzhen territory for mobile phone. This application was designed to perform satisfactorily on devices (mobile phones) with low processor speed, and small memory for the GIS application and GIS data. Memory requirements are kept low by using Mobile SVG.

Nyamuga et *al.* in [5] propose a method for constructing an extensive wireless GIS network by utilizing Java cellular phone as GIS terminal for environmental monitoring through dynamic location disaster-emergency notification management of spatial databases. The main objective of this paper is to assess the use of Java cellular phone as a GIS terminal for environmental monitoring through the dynamic location of disasters-emergency notification management of spatial databases.

In [9], authors proposed ICT tools for Mapping Pastoral Movements. The overall objective is to enable Sahelian populations to access pasture resources and use them more effectively during the dry season with the help of new information and communication technologies (ICTs). The proposed solution is Webmapping based on geographic information systems (GIS) with the use of global positioning system (GPS). Based on the results obtained, effective methods of livestock farming incorporating ICTs was identified and confirmed, not only to help reduce conflicts between growers and breeders and animal pressure on pasture lands, but also to enhance the productivity of traditional livestock farming, with the direct consequence of increasing family income.

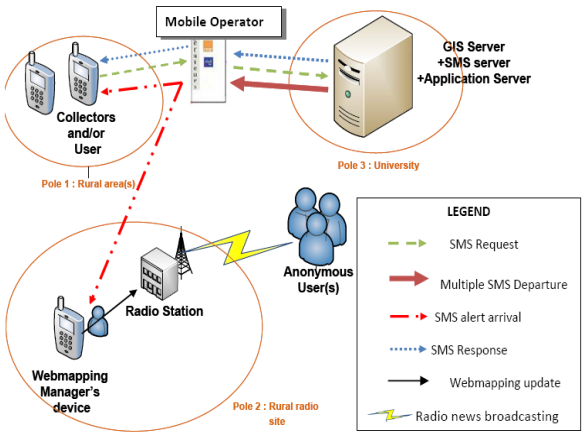


Figure 1: Our mobile GIS middleware.

3. AN APPROACH BASED ON SMS AND MOBILE GIS FOR PASTORAL RESOURCES MANAGEMENT

3.1 An overview of our GIS architecture

Figure 1 illustrates our Two-tier approach and shows the interactions that exist between different poles (sites). It describes the different communications phases that should be established in order to have an operational geographic information system. The different sites depicted in Figure 1 are the University area, the rural area (Pastoral Unit), and the rural radio station. In the University site, we have our GIS server which embeds a SMS server that is able to handle and process SMS messages sent by the collectors and/or users located in the Pastoral unit zone. For instance these SMS messages are used by breeders in order to find either the geographic location of water points, or retrieve the status of water points, or seek the shortest path towards a given water point. Note that the goal of the radio station in Figure 1 is to send information to users that have not got mobile phone.

To use our GIS service, the mobile phone client sends requests to the server in order to acquire for instance the URL of target map files. The mobile phone client also has a SVG [1] parser (included by TinyLineSVG) to parse SGV files, and a TinyLineSVG to display the geographic information (Figure 2). In fact, TinyLine SVG gives almost all methods to display SVG document object and control it. It should be noted that some SVG files may also be placed on mobile phones. On the server side, some SVG files are pre-created, and java components are built to generate SVG files form database. When a request from mobile phone is received, the proper SVG file's URL is transmitted, otherwise the java components should generate SVG file,

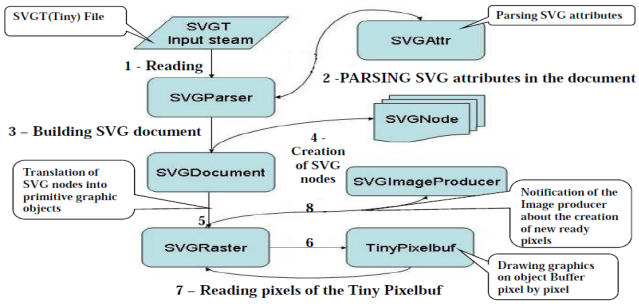


Figure 2: General Organization of a SGV technology.

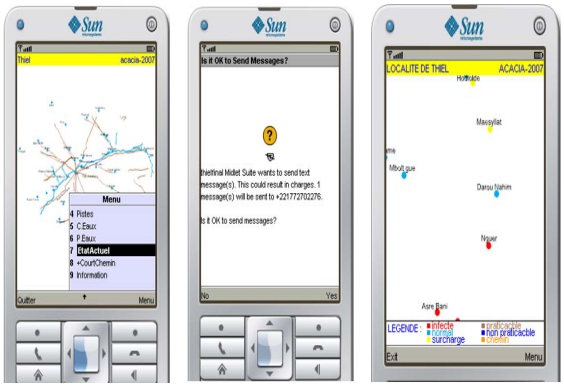
Figure 3: Study Material and Equipments for the SMS center.

and then transfer the file to mobile phone. In fact, SVG files or data source are placed on the web server.

3.2 Using GIS Application by breeders

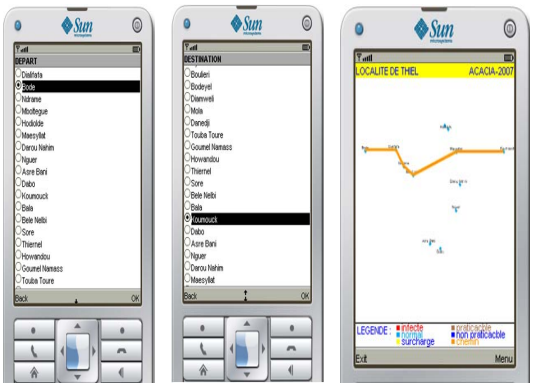
The information system implemented is based on SMS and GIS technologies and is freely available. This system consists of two servers and mobiles phones as illustrated in Figure 3. One server, located at the university, is used as SMS server and the other one as relay through the WebMapping application installed at the rural radio station of Koumpentoum which is a region located at 30 km from the study area (Kouthiaba PU). Mobile phones with open source softwares (*J2ME*) are distributed to 16 breeders which are involved in the study.

For our experiments we used as mobile devices the *Nokia N70* which is illustrated in Figure 3. Note that the map of Kouthiaba PU has been done in vector format. During the training, our results show that breeders have understood the applications functionalities and know how to use mobile device. For instance, we describe here two case studies. During the first one, the breeder seeks the status of different water points (Figure 4. For the second case study, the goal is to find the shortest path towards a given water point (Figure 5).



(a) Choice of the task (b) SMS validation (c) Graphic response

Figure 4: Access to status information.



(a) Source (b) Destination (c) Shortest path

Figure 5: Finding the shortest path towards a given water point.

Figure 4 shows the different steps that a breeder should follow in order to find the status of different water points. The breeder can select a given task by using a menu from its mobile device (Figure 4(a)). In fact, he sends a single SMS and then waits for response according to the availability of this task (Figure 4(b)).

For instance if the breeder would like to know a status of the available water points it will receive a map on its mobile phone as illustrated in Figure (4(c)). It is worth noticing that the status of a water point is indicated by using three colors on the geographic map of PU displayed on a given mobile device. The meaning of these colors are: *(i)* red color indicates the presence of a disease; *(ii)* yellow color means that the water point is dry; *(iii)* blue illustrates that the water point is usable.

Figure 5 illustrates how to find the shortest path between two given water points. In such case, we need to select the first (source) water point (Figure 5(a)) and the second (destination) water point (Figure 5(b)). After the selection, the breeder sends a SMS in order to retrieve the shortest path between the source and the destination. Indeed, he received a response by SMS and the response is shown as a map on its mobile device (Figure 5(c)).

The transcription from SMS format to graphical map on mobile device is done by using the Scalable Vector Graphics (SVG) [1]. As results, mobile phone GIS based on mobile SVG may easily display the map on a phone screen and do simple operation on the phone. In our study, this benefits breeders too much.

4. DISCUSSION

In this section we discuss and analyze the penetration rate our GIS infrastructure with respect to the users located in the Kouthiaba village. We take into account different metrics such as the degree of usability, the incomes of population, and the efficiency of the GIS architecture.

4.1 Socio-geographical aspects

Kouthiaba village, which is a pastoral unit, host telecommunication infrastructures which enable the use of GSM technology. Since the village is covered by wireless network, it can be possible to introduce a geographic information system based on ICT. Since Kouthiaba is located in the Sahel region, during the dry season many pools can be infected leading to many diseases that can affect cattle. Therefore, a GIS application and a WebMapping can contribute to reduce the risk of diseases in rural area like Kouthiaba.

The literacy rate in the Sahel region is very low. Therefore, the utilization of mobile device by these populations is limited by this issue despite the fact that we translate the output on mobile's screen in their mother tongue. To overcome the barrier of language we use different menu like environmental and sanitary. In such case, users do not need to write a SMS in order to retrieve a given information. Despite these facilitation, it remains difficult to expect full appropriation of mobile GIS based on SMS among illiterate person.

4.2 Training and testing usability

Each breeder has been formed during 28 hours for using mobile phone and related applications. Nevertheless, the duration of the training cannot be considered as a probable cause of no appropriation of applications. In fact, at the end of the training, the insight received from breeders shows that they have got a deep understanding with respect to use SMS technology, start applications and consult of the various interfaces.

4.3 Content distributed in Applications

Our Mobile GIS architecture takes into account two

key elements in the pastoral area: the status of pools (drinkable or not), and the routes that lead to these pools.

- Firstly, the status of pools is considered as strategic by the breeders in the Ferlo region. Ancey et *al.* in [3] have shown that the breeders in the Ferlo travel following the geographic localization of weekly markets. Therefore, the mobile GIS is therefore designed as a structural element for accessibility and information availability in pastoral areas. However both in the endogenous system in the modern information systems, information has lifetime, knowledge of the status of pools in Kouthiaba PU has a temporal validity spread over two or three months of the rainy season; this season after the draining of pools in seven months makes the tools obsolete.

- Secondly, finding the shortest route between two pools can be benefit for breeders living in the pastoral unit. Note that shortest path means a given route that permits to avoid sanitary obstacles (infected area, drained pool), and to cross farmers' areas. This information enables to secure the mobility of breeders. It is worth noticing that during our test with breeders, this functionality was not enough used. Perhaps it is due to the innovative feature of this application.

4.4 Usability of our GIS-based applications

The appropriation of ICT with respect to a given population is considered achieved when the following conditions are noticed : (*i*) a low cognitive control of ICT by users; (*ii*) a significant social integration of the use of this technology in the daily life of the human being; (*iii*) the possibility that an innovative solution was built by using ICT.

- The satisfaction survey conducted after the training has not revealed a major complexity of the mobile GIS according to users; No personal investment has been provided by the breeders to come into possession of the mobile GIS, which excluded the hypothesis that the cost of innovation would work within the meaning of non-compliance.

  In fact, the power network in the PU is not totally operational, sometimes painfully farmers continue to walk 8 km to reach the solar panel of some individuals of the PU to recharge their phones, but we realized that the farmers were deprived of ensuring permanent autonomy of their phones because of the attraction of multimedia features in voltage consumption.

- While the use of mobile phones and SMS can cope with local practices of communication as pointed out, the fact remains that this is hardly noticeable when innovation is not a service whose value does not provide a direct economic profitability. The successful example of the Grameenphone in Bangladesh [10] in the economic profitability of the phones was that it was proposed to women they buy at wholesale minutes of communication they sell at retail so they were able to repay the loan and generate income.

4.5 Quantitative indicators Analysis

Two quantitative elements allowed us to characterize the appropriation in this study: efficiency and intensity of use.

- Penetration rate: Twelve months after the system deployment and the training of breeders, the results show that more than 50% of breeders have used the system.

- Mobile GIS efficiency: The mobile phone is nowadays one of the more accessible ICT to the base population and the project has enabled people to receive free phones that cost on average 200 Euros / unit for Nokia N70; applications built from free and open source software, do not require an update and thereby the purchase of a license. These factors have undoubtedly contributed to reduce the digital lack of some breeders in Kouthiaba PU.

5. CONCLUSION

We have proposed a two-tier architecture based on mobile Geographic Information System in order to overcome the lack of information in the Sahel region. In fact, breeders are confronted to many problems such as finding water points and route that do not cross farms. We design an application based on mobile GIS and have done real experiments with the breeders located in the Kouthiaba village.

The obtained results show that more than 50% of breeders have used our application despite the low literacy rate noticed in this village. The apprehension that some breeders can have about this new technology can explain this percentage.

This study shows also that the process of appropriation of ICT is not linear. It can take much time for a given population to adopt an innovation based on the use of SMS to access to information following their needs.

We investigate the possibility to give the amount of water usable in a given water point. It can be useful for breeders to know if it is necessary to reach a water point according to the size of its cattle. We plan to use sensors technologies to monitor the different water points in order to update our database dynamically.

6. REFERENCES

[1] W3C, "Scalable vector graphics (svg) 1.1 specification," 2003. [Online]. Available: http://www.w3.org/TR/SVG/

[2] V. Ancey, "Theme n°4: Perception and risk management by pastors: how to improve designs and interventions to help?" 2003. [Online]. Available: www.virtualcentre.org/fr/ele/econf_01_pasto/download/t4_doc_intro.doc.

[3] V. Ancey and D. Astou, "Information on natural resources in pastoral areas," XI World Congress Sociology, Trondheim, Norway, 2004.

[4] M. hsiang Tsou, "Integrated mobile gis and wireless internet map servers for environmental monitoring and management," *Information Science*, vol. 31, pp. 153–165, 2004.

[5] A. Nyamugama and D. Qingyun, "Design and implementation of framework of mobile gis based on phone terminal for environmental monitoring," *Geo-Spatial Information Science*, vol. 8, pp. 45–49, 2005.

[6] U. Noriyuki, N. Yasuto, M. Shohei, and M. Masashige, "Developing a gis using a mobile phone equipped with a camera and a gps, and its exhibitions," *Distributed Computing Systems Workshops, International Conference on*, vol. 3, pp. 414–417, 2004.

[7] ARTP, "Dashboard 2007," 2008, agency for Regulation of Telecommunications and Post. [Online]. Available: http://www.artp-senegal.org/telecharger/document_Tableau_de_bord_2007_58.pdf

[8] W. Binzhuo and X. Bin, "Mobile phone gis based on mobile svg," IEEE International Geoscience and Remote Sensing Symposium, IGARSS'05, 2005, pp. 414 – 417.

[9] Y. Kaboret, "Use of ict in monitoring livestock by nomadic communities as a basis for sustainable management of pastoral resources in the sahel," Ecole Inter Etats des Sciences et Médecine Vétérinaire de Dakar, Senegal, Tech. Rep., 2003.

[10] J. Adam, "Introducing information and communication technologies in rural areas of developing countries," *Horizons Bancaires*, vol. N° 326, 2005.