

Use Case and Requirements Analysis in a Remote Rural Context in Mali

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Abstract. [Context & motivation] Few studies have reported on a systematic use case and requirements analysis of low-tech, low-resource contexts such as rural Africa. This, despite the widespread agreement on the importance of Information and Communication Technologies (ICT) for social and rural development, and despite the large number of ICT projects targeting underprivileged communities. [Question/problem] Unfamiliarity with the local context and differences in cultural and educational backgrounds between end-users and software engineers are the challenges for requirements engineering (RE) we encountered. [Principal ideas/results] We describe a systematic approach to RE in developing areas, based on the Living Lab methodology. Our approach is supported by extensive field research and based on co-creation within a multi-disciplinary and multi-cultural team of developers and users. This approach creates a shared understanding of the problem and its local context, and optimizes communication. [Contribution] We illustrate the approach using a case study of web- and voice-based communication services, that we developed for a rural context in Mali.

Keywords: Use case analysis, African context, Living Lab methodology, market information systems.

1 Introduction

ICT services are commonly regarded as an important tool in furthering social and rural development in developing economies. Economic growth, socio-economic development and poverty reduction have been attributed to the adoption of ICTs [1]. Information and Communication Technologies for (social) Development (ICT4D) have therefore attracted the attention of international development organizations over the past twenty years. At the United Nations World Summit on the Information Society,

goals were set for developing a “*people-centered, inclusive and development-oriented Information Society so that people everywhere can create, access, utilize and share information and knowledge*”[2].

In recent years the adoption of mobile telephony by rural communities has been extremely rapid. This has opened new opportunities for information and knowledge sharing and associated services in rural areas. Many ICT services have been developed and deployed over the past decade, of which a large number has been technology - rather than demand - driven, supported and financed by international donors. Many ICT4D projects have not survived after the end of the pilot phase [3]. Amongst the myriad of factors that make implementation of ICT services in low-tech, low-resource areas fail, we argue that the lack of a systematic use case and requirements analysis and a user centred approach is an important factor. Detailed descriptions of how use case and requirements analysis was actually done in rural contexts is necessary, especially since ICT4D projects are mainly initiated and led by technologically skilled teams that are usually unfamiliar with the local context.

We present a case study of a systematic use case and requirements analysis in a rural African context, by a multi-disciplinary and multi-cultural team, collaborating over an extended period of time. Given the initial unfamiliarity of the developers team with this local context, much time was spent on studying the environment, building trust relationships, and identifying the problem. Development was done in several phases, in which feedback led to new requirements, and new use cases. Every stage was characterized by extensive brainstorming, focus group discussions, demonstrations and co-creation sessions. In our approach we experienced that a typical use-case centric, incremental (spiral) development is only a starting point, when doing RE in low-tech low-resource settings. We start from the large generic problem, gradually narrowing down, towards specific use cases. By reducing the bigger issues to specific use cases, we avoid generic solutions that do not fit the context and the user’s needs. This process takes several iterations, in which we are informed by field research, and several phases of requirements validation. Each step helps the further elicitation of the use case and brings new requirements, as soon as an intermediary mock-up, pilot or production system has been tested and evaluated in the local context. Experiences in sustainable land management projects in developing areas, by part of our multi-disciplinary research team, made us aware of the importance of openness, co-creation, ownership, sustainability and realism. This aligns well with key principles from the Living Lab methodology.

There are several variations in the definition of Living Lab (LL), but generally speaking, LL refers to a user-centred, open-innovation environment [4], [5], integrating concurrent research and innovation processes [6]. In the LL approach users are seen as co-creators and action research takes place in a real-life environment. Sustainability and value are often key principles in LL, as well as influence (co-creation), realism (real-life environments) and openness (open communication and innovation) [7].

Bergvall-Kreborn et al. give the following definition: *A Living Lab is a user-centric innovation milieu built on every-day practice and research, with an approach that facilitates user influence in open and distributed innovation processes engaging all relevant partners in real-life contexts, aiming to create sustainable values....*[8]

Many studies have reported Living Lab as a valuable approach for innovation. LL has been applied for innovations in less privileged communities. The Meraka Institute in South-Africa founded Living Lab South Africa (LLISA) and described in detail the approach of e-health development for rural communities [9]. Van der Welt et al. reported on the Soshanguwe Living Lab in a rural township in Tshwane, and the Venda Living Lab in Thohoyandou[10]. Both labs were set up for the co-development of ICTs, especially in the fields of health and agriculture. These two case studies were mentioned as part of an extensive framework description of the Living Lab approach. No description of the actual use case analysis is given in this paper, nor the specific services that were co-created in these labs. Hewlett Packard Corporation (HP), in India, has done a three year i-community programme aimed to bring access to ICTs and resulting benefits to rural citizens of Andhra Pradesh [11]. However, no reports of their detailed approach of use case analysis have been given. Despite the variety of papers that mention Living Lab as a valuable methodology in a development context, we could not find any literature describing a detailed approach.

The contributions of this paper are: (1) a pragmatic approach to requirements engineering, adapted to fit a low-tech, low-resource environment within a development context; and (2) a detailed description of two case studies of the development of mobile web-based information systems for an African rural context.

This paper is structured as follows: In section 2 our approach is described in a detailed case study. In section 3 the sustainable businesses and ecosystem are discussed. In the last section we discuss how the approach differs from traditional RE, and we sketch the road ahead for further work.

2 The Approach

The case study is located in a specific low-tech, low-resource rural context in Sub-Saharan Africa. It differs from a use case and requirements analysis in a traditional setting, in the sense that we start by studying and observing the generic, global scale problem, in the first stage of the project. Therefore, an important phase preceded the actual requirements elicitation, which consisted of a systematic context analysis.

The main challenge was to create a shared understanding of the context, especially because part of the team of (European) developers, was unfamiliar with the specific environment, whereas the envisaged users had low levels of (computer) literacy, and they had little idea in which way technology might support their local needs.

For this study extensive field research was done by a broad team. Borrowing from Living Lab, we especially aimed at co-creation in a real-life environment, where the problem was elicited and the (ICT) solution was developed in cooperation with the end-users. We held informal workshops, focus group discussions, brainstorm sessions and interviews, we showed storyboards and scenarios, involving all stakeholders. These stakeholders were local community radio journalists, ICT entrepreneurs, rural extension workers and small-holder farmers. Many field trips were organized to rural regions in Mali, Burkina Faso and Ghana. Small radio stations were visited and small-holder farmers were interviewed in their fields. This was all carried out locally by this multi-disciplinary, multi-cultural team.

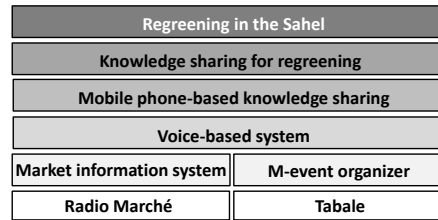


Fig. 1. The problems and solutions stack: from a generic problem to very specific use cases.

Our approach is visualized in Fig. 1 as a problem stack, where we started from the big global problem, gradually narrowing down in several cycles of subsequent and recurring problem and use case elicitation, user verification and validation, development, co-creation and adjustment. The iterations coincided with our several field trips, as summarized chronologically in Fig. 2. In the next sections, we will give detailed descriptions of these field trips and development cycles.

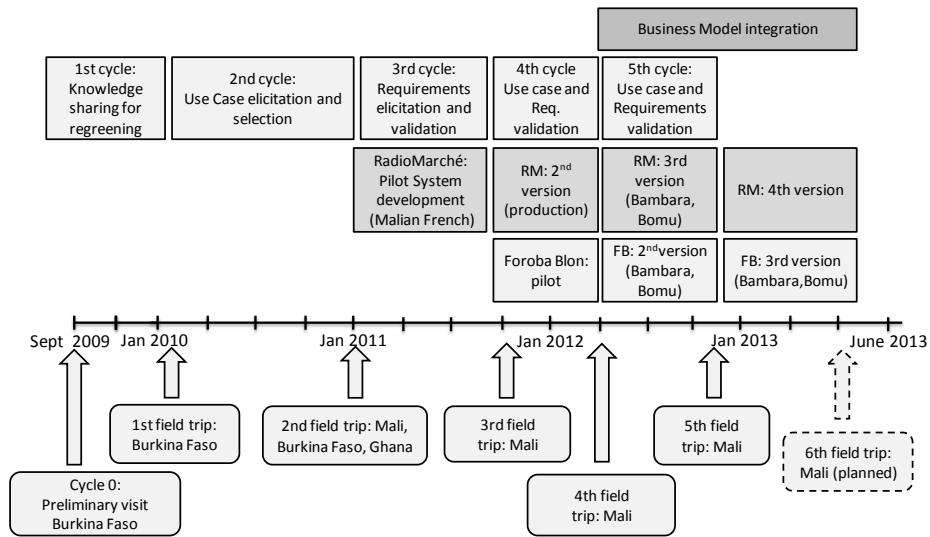


Fig. 2. Chronology of the different phases leading to Radio Marché and Foroba Blon

2.1 Cycle 0: Understanding the context

The case study starts from a global scale problem of poverty and the need to fight desertification in the Sahel. The use case and requirements analysis in this paper targets people living in small rural communities in Mali. Mali is one of the poorest countries

in the world ⁵. The main source of income in our target region is agriculture [12]. The production is mainly for subsistence, and the average income here is estimated to be between 1-2 dollars a day.

In the 1970s and 1980s, periods of drought severely deteriorated living conditions for many rural communities in this region. Twenty-five years later conditions have improved through farmer managed natural regeneration (FMNG) of trees. Using simple but effective farming techniques and inexpensive tools, farmers have managed to restore an area of over 5 million hectares of formerly degraded land. (see e.g. [13], [14]).

The success of the re-greening activities in Africa is mainly due to the rapid exchange and spread of local knowledge amongst large numbers of farmers. Word of mouth and farmer-to-farmer visits are traditional means of knowledge diffusion, but recently also mobile and community radio communications have become important. ICTs can enhance communication: combining existing radio and other spoken content with novel ways for voice-based access and mobile Web services may enable further increase of speed and spread of knowledge sharing among farmers.

2.2 Cycle 1: Knowledge sharing for greening

Our first aim was creating an understanding of the actual generic problem, the local context and composing a general strategy for enhancing knowledge sharing in this context. This was done through a field trip to Burkina Faso in January 2010, and a two day workshop involving forty local stakeholders including representatives from farmer organizations, community radio stations, local NGOs in support of rural development, representatives from the local mobile telecommunication and internet providers, local ICT entrepreneurs and radio journalists. The European participants consisted of Web developers, information scientists, ICT4D experts, and experts in sustainable land management. The days before and after the workshop, the W4RA group visited several local villages and a number of small-holder farmers, and did several field visits to subsistence farms.

The main outcomes of the field trip to Burkina Faso were a better understanding of (i) the urgent need to improve knowledge-sharing in rural communities; (ii) the technical constraints such as no availability of internet connection or smart phones; (iii) the cultural conditions such as many different, under-resourced local African languages and low levels of literacy; (iv) the widespread availability and accessibility of (community) radio and mobile telephony in remote rural areas.

The core team, that worked together during three years, was composed of experts in different disciplines. Not only web developers, researchers in web, information science and business modelling, but also experts in agro-forestry. There latter are attached to Sahel Eco, a local Malian non-governmental organization in support of smallholder farmers and local rural communities. Sahel Eco's mission is to improve livelihoods through farmer-managed natural regeneration of trees, (FMNG). The team was temporarily joined, in several subsequent field trips, by experts from other disciplines, i.e. Living Lab experts, business experts, and computational linguists.

⁵ The Worldbank, Africa Development Indicators

A formal (EU-funded) pilot project was set up, in which we focused on the development of knowledge sharing tools through voice-accessible ICTs, as to address the local contextual issues of low-literacy and low-infrastructure. The following technologies were applied in our study: (i) an open source voice platform named Emerginov⁶, developed by Orange Labs, that enabled the deployment of voice-web services, and that integrated the GSM phone network and the Web, enabling the development and deployment of mobile web-based applications, and (ii) new language-packs for resourcing of under-resourced African languages, developed for this project by computational linguists from North-West University in South-Africa.



Fig. 3. Left to right: focus group discussion of developers and Malian farmers ; co-creation and validation and verification of the systems ; a journalist from local radio station Moutian in Tomian, Mali.

2.3 Cycle 2: Sixteen use cases

A second visit to the region was organized in January 2011 as a two week road show through rural regions of Mali, Burkina Faso and northern Ghana, involving the core developers group and many local stakeholders (radio journalists, farmers), who joined the team. The objective of this trip was to collect use cases through demonstrations of pilot software and mock-ups. Focus group discussions were held with groups of small-holder farmers, community radio stations and local ICT practitioners. Qualitative data and usability feedback was collected at each demonstration site. This was pooled in during open brainstorming sessions to expand the list of possible mobile voice-based services, and to collect new ideas from the local stakeholders. An example of a voice-based demonstration during the road show of January 2011 went as follows:

- *Synopsis*: the demo is a portal that offers three services: 1) listening by mobile phone to a radio program which offers: (i) a song and (ii) information on agriculture, in Malian and French language; 2) recording a message to be broadcast; 3) retrieving the messages that have been recorded.
- *Goals*: the demo shows how voice services work using a simple phone. In the field we also showed an FM transmitter that demonstrated that a recorded message could

⁶ Orange Labs Emerginov platform: <http://emerginov.org>

be directly transmitted on the radio and received by people with their own radio-sets.

All key learnings from the road show were gathered and consolidated into a set of new services. At the end of this two week road show, a large number of interesting use case ideas had been collected. We used a semi-structured approach to describe the use cases in non-technical terms, to create a shared understanding of the problem at this stage. The sixteen use cases and their key stakeholders are shown in Table 1.

Nr. Use case title	Main stakeholders
1 m-Milk ordering and delivery service of Tominian	Milk producers and NGO
2 m-Tree protection alert service Sahel Eco	Farmers and NGO
3 mobile-web Event organizer for vaccination of herds	Farmers
4 m-Farmer-expert directory service	Farmer organization
5 NGO info-line about legal issues in several languages	Sahel Eco
6 Leave announcement or select your favourite song	Radio
7 Shea butter and honey trading service	Radio and Sahel Eco
8 Access radio programs and announcements on your phone	Radio
9 Gourcy seed producers seed certification service	Farmer organization
10 Radio questions and answers about agricultural issues	Radio
11 m-collective purchase organizing service	Local buyers
12 m-GIS regreening service	Sahel Eco
13 m-Farmer social network	Sahel Eco
14 mobile-web regional market system	Farmer organization
15 Sahel Eco portal to Regreening and access to m-services	Sahel Eco
16 m-event organizer for re-greening events	Sahel Eco, farmers

Table 1. Long list of use cases

Based on the priority given to each use case by the local partners, and the feasibility of the technical solutions, we selected two use cases to develop systems. (i) shea butter and honey trading service, to build a voice-based market information system, (ii) and m-event organizer, a voice-based mobile event organizer. The use cases are described in detail in the following section.

2.4 Cycle 3: A voice-based market information system

After the first round of use case elicitation, a pilot version of the shea butter and honey trading system was built, which was nicknamed Radio Marché. During the field visit in November 2011 this system was shown to the users in Mali, for requirements validation and verification. In the following section the use case and system is described, a UML model is shown (see Fig. 4a) and user feedback is given.

Radio Marché is a voice-based market information system, designed for farmers living and working in the area around the village Tominian, in Mali. Radio Marché is meant as

a tool to improve communication between the farmers and their potential customers. It is designed according to the requirements of the following use case, based on existing procedures. The use case is shown in Fig. 4a. Radio Marché is described in detail in [15].

In 2010 Sahel Eco started the Village Tree Enterprise Project, to create a paper based Market Information System (MIS) involving nineteen small rural villages in the Tominian area, and four local community radio stations. This legacy system was dedicated to promoting sustainable use of forest resources, and developing small businesses based on non-timber tree products. The main product focus of the MIS is on shea nuts, shea butter, honey, wild fruits and nuts. The original MIS distributed up-to-date market information via community radio in the area. Our envisaged system thus started from this already functioning market information system (see Fig. 4b).

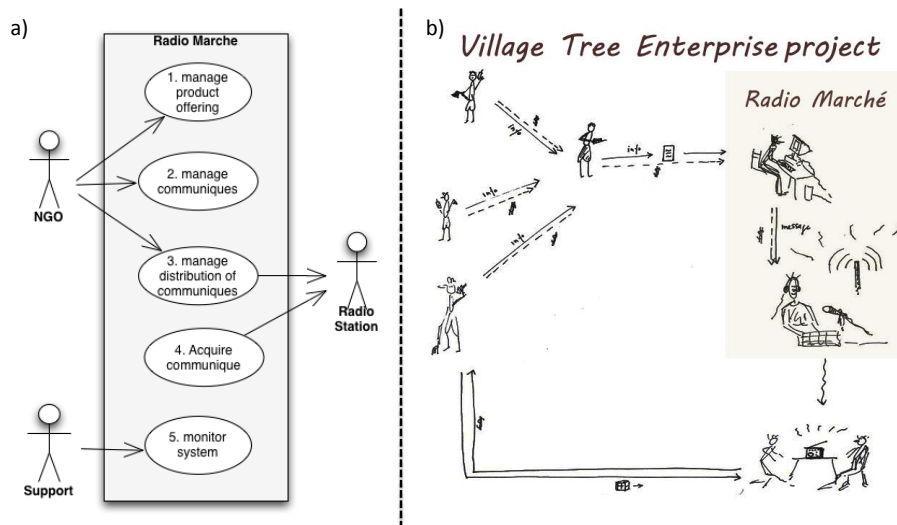


Fig. 4. The Radio Marché use case and systematic diagram

The original work flow was as such: An extension worker from Sahel Eco collects weekly market information from farmers in the villages near Tominian, about offerings of shea butter and honey. This information is communicated by the producers via sms or phone. The extension worker aggregates the data (product, quality, quantity, price, and contact phone number etc.) in an Excel sheet on his laptop. This document is then sent by email from a local community cyber-cafe to three community radio stations, whereas a hard copy of the information is physically brought to the radio that has no Internet. The radios broadcast the market offerings information including the phone numbers of the producers. Potential customers either phone Sahel Eco or phone the producer directly to negotiate a trade.

Summary of key requirements for Radio Marché The following requirements were collected in the first and second cycles of use case elicitation

- A web-based input-form for the extension worker to enter product offerings (honey, shea butter, nuts) received by phone or sms from producers;
- An automatically generated voice-based communiqué offering;
- Phone access to the voice communiqué for radio stations on a local phone line in Mali;
- The communiqué must be also accessible for radio station through web;
- The audio quality must be high enough for broadcasting over the radio;
- The service must be accessible through the internet, so that data can be entered remotely by the NGO extension worker;
- The voices in the message should sound familiar, i.e. local dialects or languages in the region of our project, the spoken languages are Malian French dialect, Bambara and Bomu;
- The voices of the radio journalists must be used to ensure trust and recognition of the system;

Radio Marché consists of several components: a web-form where the NGO extension worker enters the aggregated offerings which he receives from the farmers. This data, entered on the web-form is stored in a database. From this data a voice communiqué is automatically generated as an audio file. This audio file is accessible through mobile phone. The radio journalist calls a given phone number and hears the automated voice message. The voice message is generated using a local Malian voice. The language was one of the requirements collected during the early stages of use case analysis. In the pilot version we used a pre-recorded message spoken by one of our partners in French.

In our fourth cycle we did a new round of use case elicitation. This resulted in a use case for citizen journalism. The use case was a follow up of the Radio Marché system, and built on the experiences gained during the first three cycles. This use case will be described in section 2.8.

2.5 Cycle 4: Evaluation by the users

The fourth cycle started again with a field trip to Mali in November 2011. During this trip, the pilot system was demonstrated and deployed in Mali. At the same time, the use case and its requirements were validated. Additional requirements were identified as the results of end-user involvement and feedback:

- Phone access has to be on a local phone line in Mali. The phone lines have to be local, to save costs for the end-users. This is an important requirement for the voice platform if it is to be deployed locally in a production environment;
- The web-form has to be more user-friendly. The original design has been adapted in several cycles to make it more intuitive. The message is accessible for a certain period through phone, by phoning a local number. The audio quality must be OK, the voice must sound natural;
- The created communiqué has to be issued through voice in multiple languages. The original communiqué is in a Malian French dialect. However, it is very important from the end-user's perspective to create voice communiqués in local languages

such as Bomu and Bambara because many people, especially those targeted by the voice systems, do not speak French. There is need for a toolbox so that development of speech systems for under-resourced local languages becomes easier;

- Some radio stations do not have an Internet connection where others do. For the bigger stations a web interface where they can download the communiqué, is needed;
- User support, hardware and software maintenance are crucial. Local users will need training. Technical trainings are needed for local entrepreneurs of service providers who want to deploy voice systems.

The modified requirements were used to develop a second version of the Radio Marché system in this cycle. At the same time, the original pilot version remained deployed in its context.

2.6 Cycle 5: Enriching with speech in local languages

Cycle five started with another trip to Mali, this time to test the new Malian language packs and to evaluate the French version. This trip provided insight into a number of technical and social reasons for why the system was not used as much as expected.

One issue was that Malian phone numbers were not available in the period November 2011- April 2012, due to communication issues with the Malian telecom operator. This flaw was only noticed when the technical team visited Mali in November 2012, and spoke to the radio journalist from the local radios.

Another issue were the seasonal fluctuations in production of non-timber forest products - which were unknown to the developers. In some months, no communiqués were issued due to absence of tree products. During the harvest season, the farmers restarted their trading efforts and send new offerings to Sahel Eco.

Automatic speech recognition for Bambara and Slot and Filler Text-to-Speech (TTS) for Bomu and Bambara were introduced. These were specifically developed for this project by partners from North-West University in South-Africa and recorded by our Malian partners from Sahel Eco and Radio Segou and Moutian, who provided their speech as input. The language packs were added to the second version of Radio Marché. This was an important requirement because many people in this region do not speak French, but only the local languages Bambara or Bomu.

2.7 Evaluating the speech systems

A field trip in November 2012 marked the deployment cycle of Radio Marché. During this field trip, the text-to-speech system for all three languages was evaluated. The Bambara and French Malian dialect speech were found to be highly intelligible, although a few grammatical issues were detected. These language problems are currently being addressed, as a next version of the text-to-speech system is being prepared.

In the next deployment step, scalability, sustainability and business models will be addressed, such as the possibility of using phone credit for automatic payments of communiqués, and voice-based entering of offerings, directly by the farmers.

2.8 Adding a new use case: a radio platform for citizen journalism

In Mali many community radio stations exist, some of them state funded and connected to the national broadcasting service ORTM (Office Radio Télévision du Mali), and others privately funded or completely self-supporting. According to their business, funding scheme, size and location some radio stations do have computers and the Internet, some have computers without an Internet connection and some do not have any computer facilities at all. All these radio stations are situated within the coverage area of mobile telephony. The wish of these radio stations is to have a system for citizen journalism, accessible through phone. Amongst the requirements are:

- User profiles, to control who is able to call the system;
- Voice menu prompts in local languages, where a citizen journalist (CJ) receives the menu in his or her language;
- Ability for CJs to retrieve, edit and delete messages;
- Ability for radio administrators to retrieve, edit, delete and broadcast messages through a Web interface;
- Ability for radio administrators to retrieve, edit, delete and broadcast messages through a Voice interface.

According to the use case, we proposed to build a radio platform, which was nicknamed Foroba Blon⁷. FB consists of a data store containing recorded voice messages and related meta-information.

The interface to the FB radio platform is the mobile phone, which is used for entering new voice-based content. Users of this interface are the listeners from the region entering letters-to-the-editor (LTE). These users only have mobile phones and no access to the Internet. Their calls are answered by the FB system with a pre-recorded welcome message in a local Malian voice inviting them to leave a message. For the sake of user-friendliness, the user interface and the dialogue for this category of users is kept as short and simple as possible, since the expected callers will be unfamiliar with interactive voice response systems and may not respond to a complex computer-generated dialogue asking to press buttons.

Another category of users of FB is that of registered village-reporters, calling from the field or from their village. They phone into FB and leave their spoken report for broadcasting. These users are previously registered, having their phone number, name, address and preferred language stored as a user profile in FB.

These users are trained to navigate the voice-menu, and use the interactive voice response system, asking to press a button on the phone to confirm or answer a question about their current location, subject of the message, etc. The FB system always answers the registered caller in his/her preferential language.

The voice messages are stored as audio files in the FB data store, together with meta-information being the date and time of the call, the length of phone calls in seconds, the phone number of the caller. Messages from registered, trusted users are linked to the owner, her address, and her preferred language.

⁷ Foroba Blon means a place where everyone may speak in front of the chief; the truth must be told respectfully, without insulting anyone.

In addition to the phone interface, the FB Radio Platform has a web interface, where internet-connected end-users/customers can access and upload a voice message. Depending on their customer relationship to the radio, they can log in to the radio-platform as (i) registered users such as well-known village reporters, or (ii) as unregistered users. There is an option to sign up and create a user account by registering the name, phone number, village and preferred language. Unregistered users can access former broadcasts, marked in the system as public information.

For the radio administrator user, FB provides a web-based interface, enabling him to manage the data in the data store. It provides a file list where they can access, listen, broadcast, delete files, and add/update/delete meta-information. The radio station that has no computer nor internet, has only a very limited interface to the FB platform, since this is the constraint of a voice interface. He receives a welcome message asking if he wants to hear the last ten messages, or if he wants to hear/update/delete the welcome messages to the end-users.

The FB radio platform is hosted either locally, on a stand-alone computer or in the cloud. The FB platform consists of a voice platform running an open source web server and a local voice browser that handles the voice interaction. The local FB radio platform uses a GSM gateway to process the calls over the phone network. This device handles incoming and outbound calls and streams the voice messages to and from the phone.

In theory the FB radio platform could be physically hosted anywhere in the world, on any web server that is connected to the Internet. However, in the actual Malian case this is not possible. Firstly, the radio platform has to be accessible using an inexpensive local Malian phone number. Secondly, the web service accessed over the Internet must be accessible locally. The local connectivity is usually of low bandwidth and high latency, making voice web services hosted at datacenters in the US or Europe too slow for proper deployment in Mali. For these two reasons, the system has to be hosted locally in Mali. In the absence of good and reliable datacenters and hosting providers in Mali, the radios can opt to deploy the service locally at their premises.

2.9 The system deployed locally

In July 2012, the pilot version of the Foroba Blon system was shown to the end-users. They received a short training in how to use the interface. Their feedback was collected. They were asked to test the system in a production environment.

A third system, named Tabale, based on use case nr 16: m-event, was shown to users for the first time. In this paper we do not expand on this use case. The following feedback was given for FB. Visual representation of the call-flow and other usability aspects: We observed early on during the field testing with Radio ORTM Segou that a visual representation of the call flow was the need of the hour to adequately train both the radio staff and the correspondents on the field. We designed such a call flow menu card in French and Bambara and distributed hard copies liberally across the radio stations and correspondents. A snapshot of this call-flow is shown below.

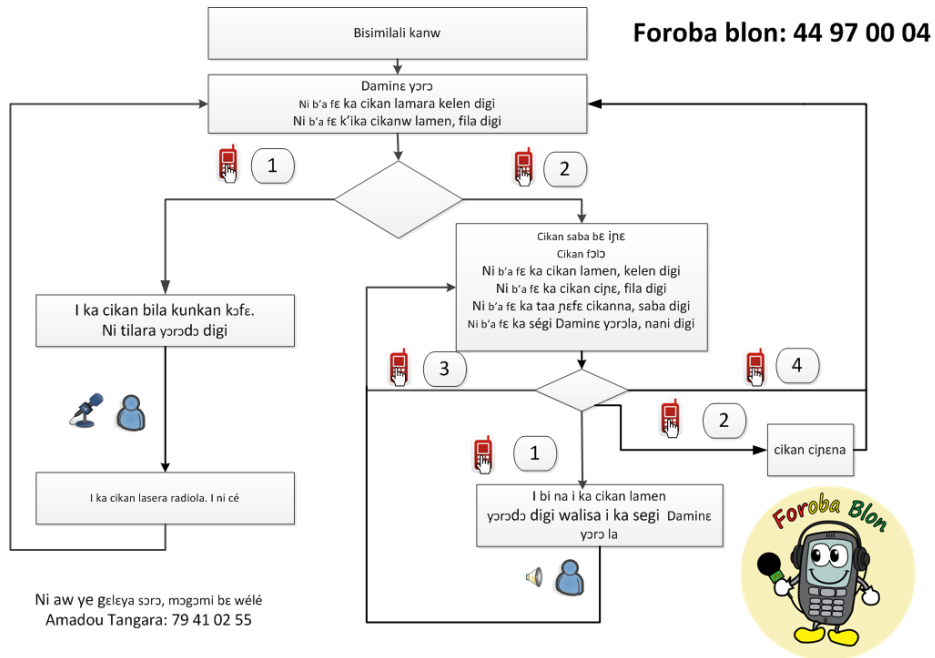


Fig. 5. Flow chart in the Bambara language for the Foroba Blon voice menu

3 Sustainable Business and Ecosystems

During our most recent field trip in November 2012, our systems were again tested and validated. We received more feedback, now based on real production tests. This feedback has not yet been processed at the time of writing this paper.

One of the key principles of the Living Lab approach and one of the conditions for successful deployment of ICT services in a low-resource environment is the emergence of new businesses to ensure sustainability beyond the pilot phase. The affordability of the service is critical, as well as the business models that have to sustain an ecosystem.

At the start of our use case and requirements analysis, we were aware of the importance of sustainability, and we tried to include elicitation of existing trading systems, and tried to model this. However, during the first 20 months this proved to be very difficult. The users were still not able to explain us how business would take place involving these newly developed services.

Only since the summer of 2012 the first systems were tested in a production environment. The radio stations started broadcasting market information and trade took off as a consequence of the radio broadcasts. The surprising outcome for Radio Marché was that the demand highly exceeded the supply of shea butter and honey, that was offered regularly over the radio. This showed us an unexpected flaw in Radio Marché from its business perspective. The ICT service was technically successful, but the underlying

value chains were not yet in place. Our partners made suggestions and discussed how to better organize the sale of tree products. This was far beyond the scope of our project.

The surprising outcomes of the Radio Marché production test show how unexpected effects of technologies may occur after the kick-off of the production phase, through social uptake.

Next steps identified for this cycle are:

- Implementing the new speech TTS and ASR systems as voice prompts in Bambara and Bomu for the current voice services;
- Expanding the scale of Radio Marché across more villages, creating new instances of the service;
- Applying Linked Data principles to connect market information to other resources on the Web (of Data);
- Sustainability: Identifying business models for voice services that are feasible from a local business prospective;
- We are still using the voice-platform Emerginov, developed by Orange Labs and hosted by France Telecom in Senegal and Mali. We are working to find a more generic solution for this platform, to avoid dependency on one telecom provider, and to have other robust and inexpensive technical solutions, that can be deployed locally.

4 Conclusion

We have described a use case and requirements analysis in a low-tech, low-resource context in rural Mali. We did not find similar studies in the literature. Lack of a systematic use case and requirement analysis may explain the failure of certain ICT4D projects. The absence of voice-based systems in the majority of ICT4D projects in e.g. rural African contexts - voice interface being one of the most important requirements we found in our study - can be explained by a lack of proper requirements analysis. From the methodological and RE point of view, we argue that our approach, although starting from a typical use-case centric, incremental (spiral) development, has pragmatically included several elements from the Living Lab methodology [7] to fit this specific context:

Realism Understanding the big picture and the real-life environment of e.g. African farmers is crucial to understand the context before identifying use cases. All development cycles must depart from the real-life environment.

Influence The involvement of the users is more than just a user-centric approach. Examples of co-creation are e.g. the recording of Malian speech and voice-prompts in local dialects, by our Malian users. We argue that the only way to develop appropriate systems for this context is by engaging users and have them contribute to development, during all the cycles.

Value and sustainability Only by understanding the local business ecosystems, sustainable solutions can be sought to ensure local deployment.

Openness This is the experience that open communication and trust relationships lead to better solutions. This key principle of Living Lab is built on the idea that requirements are not just hidden information, waiting to be elicited by RE experts, but rather social constructs [8]. We have seen use cases and requirements emerge through creative interaction amongst this multi-cultural and multi-disciplinary team of developers, extension workers, local radio journalists and farmers producing non-timber tree products such as honey and shea butter.

We are reporting about work in progress, so no final conclusions can be drawn on the sustainability of the systems. In 2013 we expect to continue the development of more innovative voice web-based services for rural communities in Mali. We will test and do more requirement validation and verification of Radio Marché with the users in their production environment. The following points are still open for further development:

- We want to transfer the experiences and methodology from this research project to a broad global community of ICT and Web developers, researchers and civil society, and local stakeholders.
- We want to support scaling up these innovations in the benefit of knowledge sharing for empowerment of the less privileged.

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References

1. UNCTD 2007 Science and technology for development: the new paradigm of ICT. Information Economy Report 2007-2008, United Nations Conference on Trade and Development.
2. WSIS (2005) Declaration of Principles. World Summit on the Information Society. United Nations, New York. <http://www.itu.int/wsis/tunis>.
3. Unwin, T. (ed.) 2009 ICT4D Information and Communication Technology for Development. Cambridge University Press.
4. von Hippel, E. (1986). Lead users: a source of novel product concepts. *Management Science* 32, 791805.
5. Chesbrough, H.W. (2003). *Open Innovation: The new imperative for creating and profiting from technology*. Boston: Harvard Business School Press.

⁸ W4RA, Web Alliance for Regreening in Africa <http://www.w4ra.org>
<http://w4ra.few.vu.nl>

6. Bilgram, V., Brem, A., Voigt, K.-I. (2008). User-Centric Innovations in New Product Development; Systematic Identification of Lead User Harnessing Interactive and Collaborative Online-Tools, in: *International Journal of Innovation Management*, Vol. 12, No. 3, pp. 419-458.
7. Ståhlbröst, A. (2008) Forming Future IT - The Living Lab Way of User Involvement. Doctoral Thesis Luleå University of Technology Department of Business Administration and Social Sciences. Division of Informatics. <http://epubl.ltu.se/1402-1544/2008/62/LTU-DT-0862-SE.pdf>
8. Bergvall-Kåreborn, B. Ihlström-Eriksson, C., Ståhlbröst, A., Svensson, J. (2009) A milieu for innovation. Defining Living Labs. 2nd ISPIM Innovation Symposium http://pure.ltu.se/portal/files/3517934/19706123_paper.pdf
9. Ruxwana, N.L. Herselman, M.E. and Conradie, P.D. 2010 ICT applications as e-health solutions in rural healthcare in the Eastern Cape Province of South Africa. *Health Information Management Journal* Vol. 39 No 1, 17-29.
10. Welt, van der J., Buitendag, A., Zaaiman, J. Jansen van Vuuren, J.C. 2009 Community Living Lab as a Collaborative Innovation Environment. *Issues of Information Science and Information Technology* Vol. 6, pp 421-436.
11. Schwittay, A. 2008 A Living Lab, Corporate Delivery of ICTs in Rural India. *Science Technology Society* September Vol. 13-2 175-209.
12. FAO: Financing agriculture and rural development in Africa: Issues, constraints and perspectives. In: *Twenty-third Regional Conference for Africa*, Johannesburg, South Africa, 1-5 March 2004.
13. Reij, C., Tappan, G., Smale, M. Agroenvironmental Transformation in the Sahel, Another kind of Green Revolution. IFPRI Discussion paper 2009.
14. Akkermans, N. The Role of ICTS in Knowledge Sharing within Rural Communities in Ghana. Internship MA International Relations. University of Groningen. <ftp://akmc.biz/ShareSpace/W4RA-VOICES/Stageverslag>
15. De Boer, V., De Leenheer, P., Bon, A. Gyan, N.B., Van Aart, C., Guéret, C., Tuyp, W., Boyera, S., Allen, M., Akkermans, H. Radio Marché: Distributed Voice en Web Interfaced Market Information System under Rural Conditions, *Proceedings CAiSE 2012*.
16. Akkermans, H., Grewal, A., Bon, A., Tuyp, W., Allen, M., Gyan, N.B.: W4RA-VOICES field report. Tech. rep., Web Alliance for Regreening Africa (2011), http://www.mvoices.eu/2011/03/25_Voices-W4RA_Public_Report.pdf