RadioMarché: Distributed Voice- and Web-Interfaced Market Information Systems under Rural Conditions

Victor de Boer[1], Pieter De Leenheer[1], Anna Bon[2], Nana Baah Gyan[1], Chris van Aart[1], Christophe Guéret[1], Wendelien Tuyp[2], Stephane Boyera[3], Mary Allen[4], and Hans Akkermans[1]

[1] Department of Computer Science, VU University, Amsterdam, The Netherlands
{v.de.boer,pieter.de.leenheer,n.b.gyan,
c.j.van.aart,c.d.m.gueret}@vu.nl, hans.akkermans@akmc.nl
[2] Centre for International Cooperation, VU University, Amsterdam, The Netherlands
{a.bon,w.tuijp}@vu.nl
[3] World Wide Web Foundation
stephane@boyera.net
[4] Sahel Eco, ACI 200 Rue 402, 03 BP 259, Bamako, Mali
mary.saheleco@afribonemali.net

Abstract. Despite its tremendous success, the World Wide Web is still inaccessible to 4.5 billion people - mainly in developing countries - who lack a proper internet infrastructure, a reliable power supply, and often the ability to read and write. Hence, alternative or complementary technologies are needed to make the Web accessible to all, given the limiting conditions. These technologies must serve a large audience, who then may start contributing to the Web by creating content and services. In this paper we propose RadioMarché, a voice- and web-based market information system aimed at stimulating agricultural trade in Sahel countries. To overcome interfacing and infrastructural issues, RadioMarché has a mobile-voice interface and is easy to deploy. Furthermore, we will show how data from regionally distributed instances of RadioMarché, can be aggregated and exposed using Linked Data approaches, so that new opportunities for product and service innovation in agriculture and other domains can be unleashed.

Keywords: market information system, voice-based interfaces, linked data approaches, service innovation, generativity.

1 Introduction

The World Wide Web connects millions of people and organizations, empowering them to socialize, express opinion, and co-create at a scale and speed never seen before. It was not a carefully top-down planning, but a set of elementary internet technologies designed for de-centralized use that allowed for a Web with such a dramatic level of complexity and scale to emerge in less than two decades. Examples of such technologies are W3C-recommended open standards such as HTTP or HTML. By carefully excluding features that are not universally useful these technologies became easily adopted

J. Ralyté et al. (Eds.): CAiSE 2012, LNCS 7328, pp. 518–532, 2012.

on a massive scale and gave the Web a *generative* character, that is, the capacity to produce unanticipated change through unfiltered contributions from a broad and varied audience [1].

An upcoming trend is to publish structured data from different sources such as governments[1] and organizations[2]. More specifically, we follow the Linked Data guidelines and provide HTTP URIs for the resources (persons, places, products etc.) and describe the relations between them using the W3C-recommended open standard Resource Description Framework (RDF) [2]. In RDF, information is represented using Subject-Predicate-Object *triples*. The data is stored in a RDF databases, also known as a *triple store*. The Web of Data emerging from interlinked triple stores is an extension of the Web: it serves the data using Linked Data approaches so that machines can process them, rather than merely publishing them for human consumption [3]. By treating data as an asset, by sharing and trading it, an *open innovation* platform for all kinds of services will flourish, linking and augmenting data across domains [4].

Despite its success so far, the Web implicitly assumes a wide availability of high-bandwidth Internet infrastructure and reliable power supply. Interfacing the Web requires Personal Computers and various skills of which the most pertinent are reading and writing abilities. According to the Web Foundation[3], there is an estimated 4.5 billion people, mostly living in developing countries, that cannot benefit from the Web for one or more of these reasons. This limits the Web's generative character per se. For our case study in Mali, only 1.8% of the population has Internet access[4], only 10% has access to the electricity network [5], and only 26.2% is literate[6].

For a truly worldwide diffusion of innovations brought forward by the Web, we must devise new types of technologies immune to these infrastructural and interface problems. Hence, complementary or even alternative technologies to the ones we know are needed. Moreover, to guarantee these technologies will be applied and content will be contributed on a large scale, we have to identify value propositions that are interesting enough for a wider audience.

The proposition we consider in this paper is targeted at reducing poverty and hunger in Sub-Saharian Africa through better agricultural and rural development. According to the International Food Policy Institute, small subsistence farmers account for more than 90% of Africa's agricultural production and are usually at the very bottom of the pyramid [5]. In Africa, agriculture is the primary source of livelihood for about 65% of the population, it represents 40% of Africa's GDP and 60% of Africa's total export. Farmers who can count on different sources of income are less vulnerable in periods of

[1] e.g., `http://data.govandhttp://data.gov.uk`

[2] such as public transport schemas, scientific results, etc.

[3] `http://www.webfoundation.org`

[4] source: `http://www.internetworldstats.com/` Internet World Statistics, Miniwatts Marketing Group.

[5] source: `http://www.developingrenewables.org/energyrecipes/reports/genericData/Africa/061129%20RECIPES%20country%20info%20Mali.pdf`

[6] source `http://www.indexmundi.com/facts/indicators/SE.ADT.LITR.ZS` Index Mundi 2011.

drought. Trading is the best way to increase their income; to this end, better communication and access to customers and market information are key challenges. Our focus now lies on non-timber forest products (NTFPs) because they have a very long tradition and their production involves leadership by men as well as women.

According to the United Nations Food and Agriculture Organisation, *market information systems* (MISs) play an important role in rural agricultural supply chains and are the key to lower food cost and to raising producer and trader incomes [6]. MISs are information systems that gather, analyze and publish information about prices and other augmented information relevant to stakeholders involved in handling agricultural products and services. Indeed, farmers have to know the trends in demand to adapt production, find out where to find customers, and be able to determine a reasonable price by comparing with prices from other markets. Hence, there is an urgent need for effective and fair marketing delivered by transparent information [7]. Moreover, costs related to logistics are usually ignored. However, farmers at remote locations have to focus on products that can weigh up for such high prices implied by production as well as transportation costs. Opportunities for innovation through new cultivation techniques, new types of seeds, or by-products remain under-exploited due to a lack of market information needed to deal with the higher production costs.

In Africa, mobile telephony has become the primary mode of telecommunication [8]. In 2006, an estimated 45 percent of Sub-Saharan African villages were covered by a mobile signal[9]. And in 2009, Africa showed the fastest rate of subscriber growth, introducing 96 million new mobile subscribers in a period of only twelve months [10]. The widespread availability of mobile phones and increasing level of coverage creates great opportunities for new services.

RadioMarché is being developed within the context of the VOICES (VOIce-based Comunity cEntric mobile Services) project[7].

The contributions of this paper are :

- The introduction of RadioMarché (RM), a MIS concept adapted for rural conditions in the African Sahel.
  Regarding the above mentioned challenges, RM is not dependent on Internet infrastructure, and has voice-based and sms-based interfaces. By exploiting the upward trend in (first-generation) mobile phone usage and the traditionally central role of radio in these areas, we believe in the generativity; hence a wide adoption of the RM concept in many regions of the Sahel.
- The proposition of a Linked Data model to address data integration issues across different regions.
  On a large scale, we deal with the issue of aggregation and management of distributed market data by adopting Linked Data approaches. We show how our design choices offers opportunities to link aggregated market information to datasets from other domains. The resulting "Web of Data" provides an open innovation platform to develop services with augmented reasoning capabilities for *e.g.* NGOs, governments, policy makers, traders and scientists.
- A report on a first deployement of RadioMarché conducted in Mali, along with the explanation of the Living Lab approach applied to drive this activity.

[7] `http://mvoices.eu`

The structure of this paper is as follows. In Section 2, we discuss related work. In Section 3, we describe RadioMarché and discuss the instantiation of one single RadioMarché instance in the Tominian region in Mali. Next, we describe a scenario where there are multiple RM instances in different regions. In Section 4, we discuss how we apply the Living Lab methodology for a non-disruptive deployment of RM under rural conditions, and report on the current status of the implementation and the technical setup. Finally, in Section 5, we outline the next steps including validation and the economical sustainability assessment of RM.

2 Related Work

Related work on voice technologies started in the 1930s in research on speech recognition. The first commercial deployments of voice-based services took place in the early 1970s. Major achievements on language recognition took place in the 1980s and 1990s, but this was mainly focused on English. While Text-To-Speech and Speech Recognition are key in voice application development, the creation of the VoiceXML standard by the W3C Voice Browser group, in 1999, further facilitated the development of voice applications [11].

Agarwal et al. from IBM Research India, developed a system to enable authorship of voice content for 2G phone in a Web space, they named the WWTW (World-Wide Telecom Web). A dedicated voice browser is hosted by the telecom operator and communicates on behalf of the end-user, and holds all user data about link history and e.g. user preferences. The system is not connected to the World Wide Web and does not allow indexing e.g. by third party search engines. The whole system creates a closed web space, within the phone network. Linking from one voice site to the other is done through a protocol HSTP, created by IBM. Especially the lack of open search possibility constrains its growth [12].

Several automated market information systems have been developed and built to support farmers and agricultural trade in developing countries. One of the well-known market information systems is ESOKO [13], an online market system, developed and built in Ghana. ESOKO enables sellers and buyers to exchange market information. The system is web-based and allows entry of market information and offers from farmers through SMS text messages. The ESOKO system is not an open source platform; the software is proprietary; licenses can be purchased. The existing platform that serves the market in Ghana is accessible for paying subscribers, mainly wholesale buyers. In contrast to RM, ESOKO does not target the poorest group of subsistence farmers in Africa, that account for 90% of Africa's agricultural production. The costs for subscriptions are relatively high and the system is not well-adapted for illiterate people. The scope of ESOKO is larger than the small-scale regional trading of small amounts of produce on local markets that RM targets.

Google started a project in Uganda in 2009, partnering with MTN and Grameen Foundation to develop mobile applications that serve the needs of poor and other vulnerable individuals and communities, most of whom have limited access to information and communications technology [14]. This system is based on SMS but does not allow voice access.

A related project on Linked Data for developing countries is described by Guéret et al. [15]. The SemanticXO is a system that connects rugged, low-power, low-cost robust small laptops (a.k.a. the XO promoted by the One Laptop Per Child organisation) for empowerment of poor communities in developing countries. This Semantic XO is based on the same Linked Data approaches as the data aggregation between instances of RM we will describe in this paper. Both systems are Open Source and use the Web to publish previously unpublished data.

3 Conceptual Design

In this section, we describe the overall design of the RadioMarché system. We first describe a single instance of the market information system for one single region, and discuss the opportunity for other services to reuse the market information within the region. Next, in Section 3.3, we extend the setting from one to multiple instances of RM across different regions and describe the distributed market data aggregation using Linked Data approaches. Finally, we describe how this aggregated market data can be linked with external data sets from other domains, leading to an open innovation platform for unanticipated services that consume this linked data. Figure 1, shows an overview of the system architecture.

3.1 Regional Instance of RadioMarché

Data. A local instance of RadioMarché has one data store with rudimentary market information such as product offerings (including product type, quality, quantity,

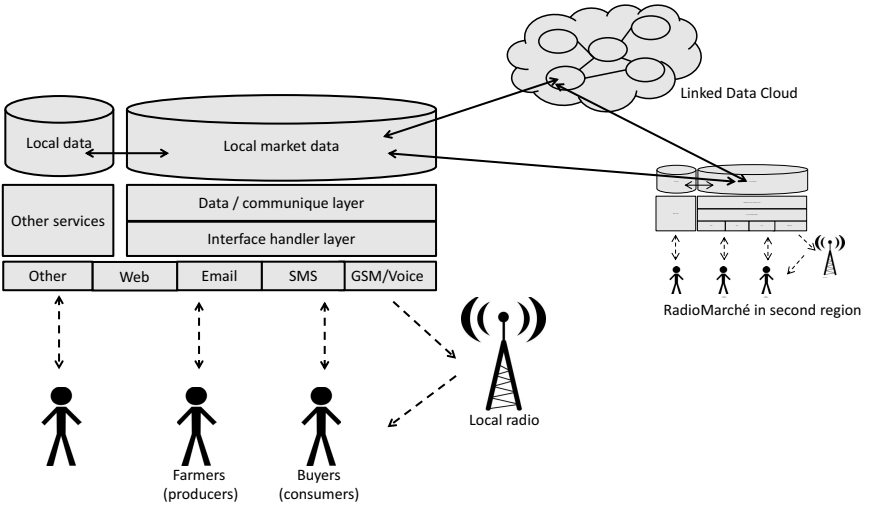

Fig. 1. Conceptual design of the RadioMarché system. The system provides alternative interfaces based on voice or SMS via phone or radio, enabling a wider audience to consume and contribute content. The data design is optimized for (i) effective aggregation with other RM instances and data sources from other domains in the Cloud; and (ii) reuse by other services.

location and logistical issues) and contact details from sellers and buyers. To maximize the reusability across different domains and regions and allow for automatic machine processing, we adopt Linked Data standards to represent the data. Linked Data approaches provide a particularly light-weight way to share, re-use and integrate various data sets using Web standards such as URIs and RDF [16]. It does not require the definition of a specific database schema for a dataset [17]. Our implementation methodology assumes that we start from a legacy system. Although the specifics of the locally produced data will differ from region to region, Linked Data provides us with a standard way of integrating the parts of the data that different regions have in common. Also, because we do not impose a single overarching schema on the data, data reuse for new services is easier, both within a region and across regions.

An additional advantage is that Linked Data is well-suited to deal with multiple languages as its core concepts are resources rather than textual terms. A single resource, identified by a URI (ie. http://example.org/shea_nuts) can have multiple labels (eg. "Shea Nuts"@en and "Amande de Karité"@fr). Other than textual labels, for our voice-services we add audio to the resources with language-specific voice snippets, also identified through URIs. Figure 2 shows an example of how a very small part of the data would be represented using RDF.

Application Layers. The raw Linked Data is handled and aggregated into communiqués by the data/communiqué layer which interfaces with the RDF triple store using standard Linked-Data querying and data-posting APIs (for example using the SPARQL query language). This is where the market information is aggregated and it is decided what information is accessible to which user. In the interface handler layer, this information is represented in multiple views. It is here that the audio versions of communiqués are constructed. The interface handler layer is also used to process user input such as that of the NGO agent entering new market data through a web form or local producers doing the same through voice menus.

Interfaces. The interface layer is the technical layer consisting of the actual interfaces channels: each with its own limitations to user interface design. The RadioMarché design foresees multiple interfaces for producing and consuming market information.

1. The voice-based interface allows non-intrusive market information access for all users having a first-generation mobile phone. It allows farmers to navigate a voice-based menu and enter product offerings using a call-in service at a local telephone number. The voice service is available in the local languages relevant to the specific region. For the voice-based interface, we adopt the industry standard VoiceXML. Since we cannot assume that text-to-speech (TTS) libraries are available for the local languages, we currently use prerecorded phrases in the local languages for the voice menus.
2. The SMS-based interface provide for literate users a more effective way of adding and consuming market data.
3. Through the traditional Web channels or via e-mail, users can get weekly digests of the latest offerings or add their own using a predetermined and machine-readable mail format. Standard Web access naturally allows for users to access market data using web browsers.

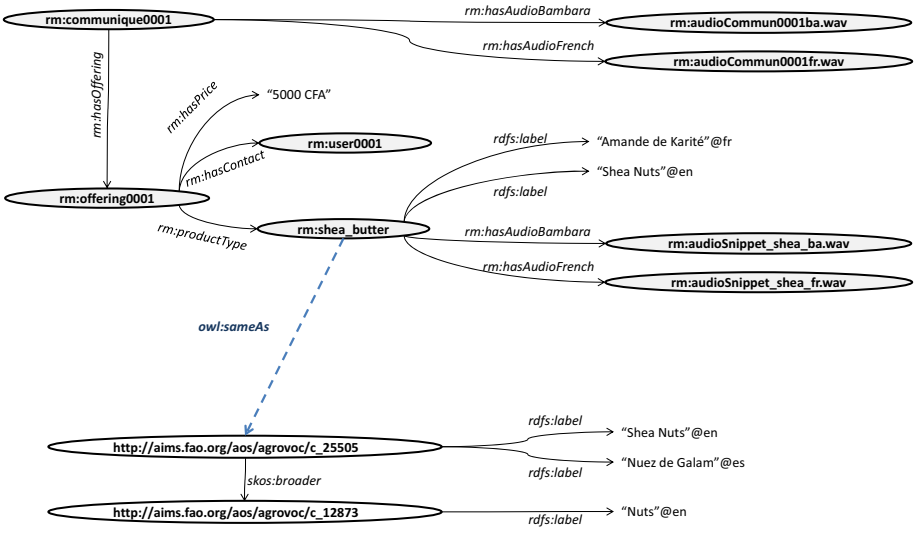

Fig. 2. Example of a snippet of RDF market information data in the RadioMarché triple store. Resources have URIs and are represented using ellipses, typed relations between resources and to literal labels are represented using arrows. "rm" is a shorthand for the namespace `http://radiomarche.com/`. The figure shows how multilingual audio resources are related to the communiqués. These are built up from audio snippets related to the content of the offerings making up the communiqué. The bottom part of the figure shows how the local market data can be linked to the Linked Data version of the Agrovoc thesaurus, opening up the possibility for mutual re-use and reasoning. Note that only a small part of the market data relating to offerings and product types are shown.

By offering multiple interfaces to RadioMarché, the system is open to contributions from a wider audience of users with less capabilities, both in terms of hardware as well as literacy; hence extending its generativity. The multi-interface approach also ensures that when local development causes new hardware and connectivity to become available to the users, they can access the same system in these new ways.

Radio. Although users can directly interface with RadioMarché using any of the interfaces described above, local radio stations provide an interface to potential market information consumers such as buyers. Every week, the market information is sent to local radio stations, that broadcast them to their listeners. Community radio is an important communication channel in rural agricultural areas with a recognized potential for change and development [18]. By integrating community radios explicitly in our system design, we aim to expand the range of potential buyers to users that have no access to mobile phones or web. The radio stations themselves access the system using each of the communication channels. Some radio stations have computer hardware and connections that allow them to receive the market data via the web. Radio stations that lack this infrastructure can use the voice channel, where they call in to the system and play the market information in audio form live on the radio.

These layers make up the market information system service on top of the data store. This system provides the ability to contribute market information by relevant actors, for example by producers wishing to add their offering to the system. The service also disperses the relevant market information to potential buyers.

3.2 Information Re-use Within a Region

Our data design allows to integrate the market information with other types of information thereby increasing its value and potential for reuse by other services. One additional service that is planned as a second case study in the VOICES project is a meeting scheduling system. Such a system would provide local NGOs with a more effective way to transfer agricultural knowledge about non-timber forest products to their farmer community. The services developed in this case study provide voice access to personal and scheduling information. By integrating this information with the market information from RadioMarché, personal profiles can be enriched with information about the type of products that specific farmers have been producing within a given period. Here a new scheduling and notification service can re-use the market information within a region.

A second use case that is currently under development is a voice-based journalism platform, which allows both professional and citizen journalists to send voice-recorded news items to local community radios. The target region for this use case consists of agricultural communities and there is a large possibility for re-use of both technical infrastructure as well as data.

To do this, the re-usable resources (e.g. person data, geographical or product information) in the market information data are linked to the relevant resources in the target data set using Linked Data standard relations.

3.3 Information Aggregation across Regions

Consider the setting where there are multiple RM instances running across different regions. This brings the opportunity to aggregate very large volumes of market information and link it with other data services, increasing its value for potential buyers but also for other stakeholders.

An example is the following scenario. In the Tominian region, farmers and buyers use local RM to express their offers and demand for shea butter. The RM's historical data learns us that there is an average supply-demand ratio of 5/1. The same is done in the more urbanized region of Bamako, where the RM instance informs us there is a ratio of 1/5. Given the low demand for shea butter in Tominian, it makes no sense to spend radio time to communicate the offer. However, having a global picture of the ratios across regions, the oversupply in Tominian could be offered in Bamako where there is no production of shea butter at all. This augmented capability allows farmers to think more commercially; hence finding new markets to increase their income on excess production.

The role of RM as a concept has now been implemented specifically for market information for NTFPs. The distributed and aggregated information services enables producers and consumers of NTFPs across regions to connect more efficiently. It also

enables producers to adapt their prices comparing with price information from other markets available in the MIS. The concept however is generic enough to be applied for harvesting data on supply-demand ratios for other (innovative) products such as new types of seeds or processing tools; and even services including trainings in advanced cultivation techniques and transport. E.g., the fact that the farmer learnt from RM that he can sell his excess shea butter production on far-away markets in Bamako, creates opportunities for optimizing transportation services.

Ultimately, by reproducing the simple RM concept on a large scale, a web of high volumes of aggregated data about supply-and-demand ratios for many different types of services or products contributed by different regions may emerge. This allows us to model and analyze the actual *value networks* in the Sahel using our *e*^{3}*-value* [8] ontologies [19]. From this semantically enriched knowledge we can apply our *e*^{3}*service* technology to automatically discover desirable or undesirable patterns in exchange of tangibles as well as intangibles, and build customer and product catalogues accordingly [20]. E.g., when the value networks for two different products are isomorphic and they can be produced by one source farmer (or cooperative); one may decide to publish innovative offerings combining these products for better prices at higher volumes. For our recent survey on service network approaches, see [21].

At the same time, local and national governments as well as NGOs can exploit the aggregated market information for analytic purposes, monitoring the trade in NTFPs within and across regions. By linking the market information to existing agricultural vocabularies such as FAO's Agrovoc thesaurus[9], the CAB Thesaurus[10], or the USDA's National Agricultural Library NAL[11], the aggregated market data can be used for specific analyses for government or NGO purposes.

In the example shown in Figure 2, the RadioMarché resource representing Shea Nuts is linked to the same concept in the Agrovoc thesaurus. Through the Agrovoc hierarchy, a reasoner can now infer that the offering in the example concerns a type of nut.

4 Deploying RadioMarché in the Tominian Area, Mali

We are currently in the process of implementing a specific instance of the described system in the Tominian Area in Mali, Africa. This use case was identified within the VOICES project.

4.1 Living Labs-Based Approach

Our methodology for developing, testing and deploying the RadioMarché system is based on the Living Labs principles. Living Labs (LL) are experimentation and validation environments of ICT-based innovation activities. They are characterised by the early involvement of user communities, by openness in establishing a close cooperation between developers, users and other stakeholders, and by the creation of rapid learning

[8] http://www.e3value.com
[9] http://aims.fao.org/website/AGROVOC-Thesaurus/sub
[10] http://www.cabi.org/cabthesaurus/
[11] http://agclass.nal.usda.gov/

cycles accelerating the innovation process. As highlighted by [22], LL are a good match for deploying information and communication technologies in rural areas.

As part of our LL-like approach, we employ a strategy of first explicitly analysing the current situation and identifying use cases. We selected a paper-based system as the initial system. In the next step parts of the system are augmented with ICT, which is then analysed with respect to the effectiveness and local acceptance. The results of this first cycle determine the content of the next development-test cycle. By employing this iterative methodology rather than deploying a single end-application at once, we aim to promote local ownership of the system through early involvement and ensure that we understand and are able to meet all local requirements. A recent global research report by UNICEF on mobiles for development (M4D)[23], state that among the reasons why many M4D projects fail is the lack of local content. By starting with an existing system, our development strategy presents a way of surmounting this challenge.

4.2 Local Situation

The RadioMarché system in the Tominian area starts from an already running "legacy" MIS that was set up by our project partner Sahel Eco[12] in 2010. Sahel Eco is an NGO dedicated to promoting sustainable use of forest resources and develop small businesses based on NTFPs. The main product focus of the MIS is on shea nuts, shea butter, honey, wild fruits and nuts. The MIS is currently used to distribute up-to-date market information via community radio in the area.

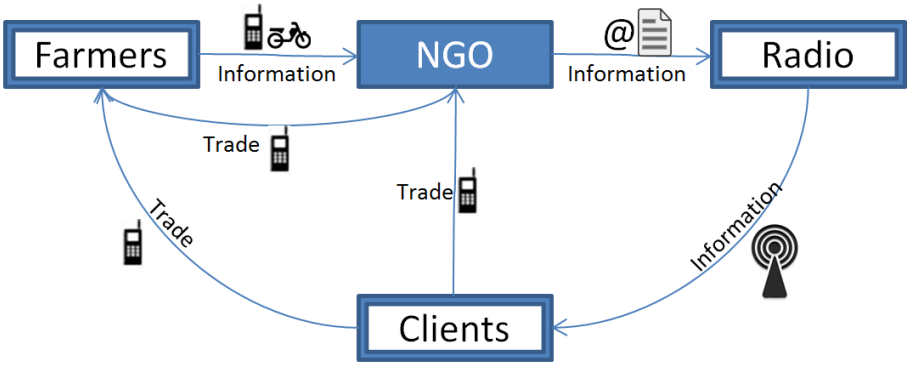

Fig. 3. Model of the current value network for the MIS in Tominian, Mali

In the current situation (shown in Figure 3), a Sahel Eco staff member receives offerings from local farmer's representatives in the form of an SMS text message, containing info about offer, quantity, quality, price, name of the seller, village, phone number, etc. The SMS info is entered manually into the system. Every week, a "communiqué" is drafted by the staff member and from a cyber cafe sent to three radio stations (ORTM Ségou, Koutiala, ORTM Mopti). Only ORTM Ségou is connected to the internet, the

[12] http://www.saheleco.net

INFORMATION SUR LES PRODUIT FORESTIER NON LIGNEUX DU CERCLE DE TOMINIAN

Zone de production (commune)	Villages	Nom du produit	Unité de mesure	quantité disponible	qualité du produit	prix au kg en F CFA	contacts
Mafouné	Soutè	amande de karité	kg	1800	amande ébouillantés	200	Mandiakuy Philippe TEL: 78
	Bokuy-Mankoina	miel	Litre	72	miel non brulé	000	Zakari DIARRA TEL: 76
	Bokuy-Mankoina	Beurre de karité	kg	60	beurre issu des amandes ébouillanté	000	Zakari DIARRA TEL: 7
KOULA	Tiéblénikuy	Beurre de karité	kg	165	beurre issu des amandes ébouillanté	200	Gérard TRAORE TEL: 77

NB : Pour plus d'information contactez Monsieur Amadou TANGARA SAHEL ECO TOMINIAN TEL. 79 ou le point focal de la radio que vous écoutez

Fig. 4. Example of a communiqué. Phone numbers are blurred for privacy reasons.

other two radio stations receive their message by going to a nearby cyber cafe and printing out the email attachment. A fourth radio station, Radio Moutian in Tominian, has no internet access whatsoever. The staff member worker prints out a hard copy of the information which is physically brought to that radio station. Figure 4 shows a recent example of such a communiqué.

The radio stations each have an employee that reads the communiqués live on the radio multiple times per week. The radio stations are paid a fee for the broadcast. The potential buyers listen to the community radio and contact the sellers to buy.

4.3 Current Status

In the current situation, we augmented the current MIS in a number of ways. First, we designed and deployed a web form, which allows registered users to add and edit market information to a database. Currently, this is used only by the Sahel Eco staff member. The system stores all communiqués allowing for aggregating and analysing historical market information.

The Sahel Eco staff member can generate a new communiqué from the current market information. At that moment, the communiqué is available for the radio stations that have web connection in text form. Alternatively, this text version can be sent via email or printed on paper. At the same time, an audio version of the communiqué is generated from pre-recorded voice fragments. These fragments have been obtained during local recording sessions. During separate sessions the quality of the automatically generated communiqués was evaluated by local radio producers. Figure 5 shows such a session.

Currently, this audio communiqué can only be produced in the Malian dialect of French, but we are developing these services for local languages such as Bambara[13] and Bomu[14]. The audio communiqué is created using local Malian voices. Two of the

[13] http://en.wikipedia.org/wiki/Bambara_language

[14] http://www.ethnologue.com/show_language.asp?code=bmq

Fig. 5. Implementation of the RadioMarché system in Tominian, Mali. On the left, an audio recording and evaluation session is shown. The right part of the image shows part of the hardware setup, including the OfficeRoute GSM gateway.

local radio stations journalists' voices have been recorded and are used for the audio communiqués. By using local voices, we intend to increase recognisability and trust.

The audio communiqué is also accessible to the radio stations from the web as well as through a voice channel. As soon as a new communiqué is generated, the radio station employees can call a local telephone number. After identifying the radio-station through a voice-menu, the latest audio communiqué specifically created for that radio station is played. The audio can be played directly on the radio, or recorded using local equipment for later broadcasting.

4.4 Technical Setup

The above system was realized using two separate technical implementations. In one version, we use cloud-based services to host the web form and database. The local telephone company provides the system with voice-based access by linking a number of local telephone numbers to this system. This is done using France Telecom Orange Emerginov platform[15].

The second version of the system is entirely local. This version has the web form and database running on a dedicated laptop. Radio stations that have internet connection can access this network directly via the web. The voice channel is provided by a voice browser (currently using the prophecy VXML browser by Voxeo[16]) and a GSM gateway (2N OfficeRoute) device that allows phone calls to be handled by the RadioMarché system on the laptop. The OfficeRoute is connected to the laptop. Figure 5 shows the GSM gateway as well as the ethernet switch used to connect it to a local laptop as it is currently installed on location.

The local version has the advantage that the system can be updated and is accessible through the voice channel even in the absence of an internet connection. The fact that the

[15] `http://www.emerginov.org`
[16] `http://www.voxeo.com`

system is completely localized might also improve local ownership and makes the set-up less dependent on telecom partners. The cloud-based version on the other hand has the advantage that it comes with extensive support, robustness and scalability. The two versions of the system are currently both being tested in the field. Moreover, one version can act as a backup to the other in a redundancy-based setting, increasing robustness of the system.

5 Discussion and Next Steps

In the previous section, we described the first steps of implementing the conceptual design of Section 3. More specifically, we have implemented the web-based interface that the NGO agent can use to enter market information into the system and and the email- and voice-based interface channels for radio stations to receive the new communiqués. The current system, shown in Figure 3 is therefore augmented in a limited number of places. Over the next period, we will be evaluating this setup. Evaluation will focus on:

usability: Is the system usable for the proposed users? More specifically, are the web forms adequate and convenient. Although initial evaluation on the sound quality of the GSM voice interface have been very positive, longer term usage will be evaluated over the next period of time. When more information becomes accessible to the users, human-computer interaction issues such as voice-menu design will become more prevalent.

robustness: The current system, with its redundant setup, is designed for robustness. This will be tested over the next period, particularly with respect to local conditions particularly with respect to local conditions such as unreliable Internet connections and power-outages. At the same time, technical maintenance of the system should be feasible by local operators.

efficiency gain: Do the new interface channels, the web access and the digitized database actualy improve the efficiency of the market information system? Are more people reached, are more products traded and is this done with less resources?

The next development cycle will include the implementation of the Linked Data layer, which will be populated with historical communiqué data (based on archived communiqués such as the one displayed in Figure 4) as well as the current market information data, as entered in our system via the new interfaces. This data will be represented using RDF and linked to a number of data sources, specifically geographical thesauri such as GeoNames [17] and the agricultural thesauri noted in Section 3.3. In this way the local data, created in rural development areas can become part of the growing Linked Data cloud[18]. At the same time, we will be developing the meeting scheduler use case that was described in Section 3.1, linking all common classes and instances, including places, people and products.

The current system is only equipped to produce audio communiqués in French. An important step is to record the required audio fragments in other, regional languages

[17] `http://www.geonames.org`
[18] `http://linkeddata.org/`

such as Bambara and Bomu as well, and to adapt the audio communiqué construction methods to be able to deal with these languages. At the same time we will open the system to non-radio users, allowing arbitrary potential buyers or sellers to receive the latest market communiqués.

Another dimension that will be further investigated is the economic sustainability of the proposed distributed market information system. This includes assessing local situations, stakeholder analysis and cost models for developing rural regions such as the Tominian area. RadioMarché is designed to be a low-cost, easy-maintenance system. Early results of the market analysis suggest that it can be economically sustainable even with a limited number of users. Moreover, the system can be easily replicated across regions and application domains and therefore is designed to scale up well.

Part of the Living Labs development methodology is that we starting off with an initial prototype, which will be used to get the local community involved in co-creating next development steps and new services. The developed software will be published as an open source toolkit, including the local language resources and voice interfaces. Local entrepeneurs will receive training to maintain existing services as well as develop new applications using this design. Other than the meeting scheduling and citizen journalism services desribed in Section 3.3, we will investigate developing voice-based services regarding social networks, yellow pages, medical services, weather services etc. Through this effort we are developing building blocks for a Web of Data accessible through voice for users in developing countries.

Acknowledgements. This research is partly funded by the European Union through the 7th Framework Programme (FP7) under grant agreement Num. 269954.

References

1. Zittrain, J.: The Future of the Internet and How to Stop it. Yale University Press (2008)
2. Berners-Lee, T.: Linked data - design issues (2006), http://www.w3.org/DesignIssues/LinkedData.html
3. Fischetti, M.: The web turns 20: Linked data gives people power. Scientific American Magazine (2010)
4. Chesbrough, H.: Open Services Innovation. Wiley (2011)
5. International Food Policy Research Institute, I.: Ending hunger in africa, prospects for the small farmer (2004), http://www.ifpri.org/sites/default/files/pubs/pubs/ib/ib16.pdf
6. FAO: community-based tree and forest product enterprises: market analysis and development manual (2011), http://www.fao.org/docrep/014/i2394e/i2394e00.pdf
7. FAO: Financing agriculture and rural development in africa: Issues, constraints and perspectives. In: Twenty-third Regional Conference for Africa, Johannesburg, South Africa, March 1-5 (2004)
8. UNCTD: Science and technology for development: the new paradigm of ict. Information Economy Report 2007-2008, United Nations Conference on Trade and Development (2007)
9. ITU: Telecommunications/ict markets and trends in africa. International Telecommunications Union report (2007)

10. Economist, T.: Mobile marvels. Special report on telecoms in emerging markets. The Economist (September 2009)
11. W3C: Voice extensible markup language (voicexml) version 2.0. W3C Recommendation, March 16 (2004), http://www.w3.org/TR/voicexml20/
12. Agarwal, S.K., Jain, A., Kumar, A., Rajput, N.: The world wide telecom web browser. In: Proceedings of the First ACM Symposium on Computing for Development, ACM DEV 2010, pp. 4:1–4:9. ACM, New York (2010)
13. ESOKO: Esoko (2011), http://www.esoko.com/
14. AppLab, G.: Google sms to serve needs of poor in uganda (2009), http://blog.google.org/2009/06/google-sms-to-serve-needs-of-poor-in.html
15. Guéret, C., Schlobach, S.: SemanticXO: Connecting the XO with the World's Largest Information Network. In: Yonazi, J.J., Sedoyeka, E., Ariwa, E., El-Qawasmeh, E. (eds.) ICeND 2011. CCIS, vol. 171, pp. 261–275. Springer, Heidelberg (2011)
16. Bizer, C., Heath, T., Berners-Lee, T.: Linked data - the story so far. International Journal on Semantic Web and Information Systems 5, 1–22 (2009)
17. Domingue, J., Pedrinaci, C., Maleshkova, M., Norton, B., Krummenacher, R.: Fostering a relationship between linked data and the internet of services. In: Domingue, J., Galis, A., Gavras, A., Zahariadis, T., Lambert, D., Cleary, F., Daras, P., Krco, S., Müller, H., Li, M.S., Schaffers, H., Lotz, V., Alvarez, F., Stiller, B., Karnouskos, S., Avessta, S., Nilsson, M. (eds.) The Future Internet. LNCS, vol. 6656, pp. 351–364. Springer, Heidelberg (2011)
18. Fraser, C., Restrepo-Estrada, S.: Community radio for change and development. Development 45, 69–73(5) (2002)
19. Akkermans, H., Baida, Z., Gordijn, J., Peiia, N., Altuna, A., Laresgoiti, I.: Value webs: using ontologies to bundle real-world services. IEEE Intelligent Systems 19(4), 57–66 (2004)
20. Razo-Zapata, I., Gordijn, J., De Leenheer, P., Akkermans, H.: Dynamic service bundling: a value-oriented framework. In: Proc. of IEEE Conference on Commerce and Enterprise Computing (CEC), Luxembourg. IEEE Press (2011)
21. Razo-Zapata, I., De Leenheer, P., Gordijn, J., Akkermans, H.: Service network approaches. In: Barros, A., Oberle, D. (eds.) Handbook of Service Description: USDL and its Methods, pp. 45–74. Springer, New York (2011)
22. Guzman, J.G., Schaffers, H., Bilicki, V., Merz, C., Valenzuela, M.: Living labs fostering open innovation and rural development: Methodology and results. In: Proceedings of the Conference on International Conference on Concurrent Enterprising, ICE (2008)
23. Boakye, K., Scott, N., Smyth, C.: Mobiles for development. UNICEF Technical Report p65-66 (2010)