The Web, Speech Technologies and Rural Development in West Africa

– An ICT4D Approach –

Nana Baah Gyan

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The Web, Speech Technologies and Rural Development in West Africa
An ICT4D Approach

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geboren te Manso-Wassa, Ghana

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Acronyms

ACDEP Association of Church Development Projects. 40
ACM Association for Computing Machinery. 102
AOPP Association des Organisations Professionnelles Paysannes. 30
API Application Programmer Interface. 42
ASR Automatic Speech Recognition. 5, 15, 16

CIS Centre for International Cooperation. 36
CNOP Coordination nationale des organisations paysannes du Mali. 30
CRCR Comité Régional de Concertation des Ruraux. 30

DTMF Dual Tone Multi Frequency. 15, 20, 92

ENoLL European Network of Living Labs. 105

FAO Food and Agriculture Organisation. 36
FENAFER Fédération Nationale des Femmes Rurales. 30
FP7 Seventh Framework Programme for Research. 6

GBC Ghana Broadcasting Company. 40
GIS Geographic Information System. 29, 37, 45, 47–49
GSM Global System for Mobile Communications. 4, 16, 54, 55, 64, 65, 78, 79, 89
GUI Graphic User Interface. 14

HCI Human-Computer Interaction. 65

ICT Information and Communication Technology. 2, 3, 5, 6, 8, 14, 27–30, 36–38, 41, 74, 78, 86, 87, 89–91, 94, 95, 97, 100–104, 106
ICT4D Information and Communication Technology for Development. 1, 3, 4, 9, 50, 71, 83, 88–93, 95–97, 99–101, 103–105, 107
ICTD Information and Communication Technology Development. 3, 4, 101
IEEE Institute of Electrical and Electronics Engineers. 21, 102
IT Information Technology. 15, 102, 103, 105

IVR Interactive Voice Response. 5, 12, 14, 17, 57, 64

JAD Joint Application Development. 26

KEC Key Evaluation Checklist. 73

LL Living Lab. 75, 78, 100, 105
LLiSA Living Labs in Southern Africa. 105

M4D Mobile for Development. 17, 18
MDG Millennium Development Goal. 8, 94, 95
MIS Market Information System. 50–53, 55–57, 60, 63, 71
MOFA Ministry of Food and Agriculture. 40
MW4D Mobile Web for Social Development. 1, 2, 5

NGO Non-governmental Organisation. 27, 28, 31–38, 40–42, 44–46, 48, 53–55, 57–60, 65–67, 71, 76, 77, 79, 80, 83, 87, 88, 104
NTFP Non-timber Forest Product. 44

ORTM Office de Radiodiffusion-Télévision du Mali. 30, 32, 34, 43, 83

PSTN Public Switched Telephone Network. 51, 57, 58, 61, 63

RM RadioMarché. 9, 51–61, 64–66, 70, 72, 76, 78–86, 89, 92, 94, 95, 97, 100, 105
RNA Régéneration Naturelle Assistée. 33, 36, 38, 39

SDS Spoken Dialogue System. 11–20, 107
SIM Subscriber Identity Module. 65
SIP Session Initiation Protocol. 114, 115
SMS Short Message Service. 4, 5, 18, 33, 38, 47, 52, 88, 91, 107
SPIDER Swedish Program for ICT in Developing Regions. 4
SWEBOK Software Engineering Body of Knowledge. 21, 22

TTS Text-To-Speech. 5, 15, 16, 57, 58, 61, 62, 64, 65, 80, 84

UDS University for Development Studies. 37
URTEL Union des Radios et Télévisions Libres du Mali. 30
USSD Unstructured Supplementary Service Data. 4, 107

VOICES VOIce-based Community-centric Mobile Services for Social Development. 6, 21, 24, 26–28, 35, 37, 38, 40, 46, 47, 49, 52, 60, 61, 63, 65, 66, 72, 74–76, 79, 84–89
VUA Vrije Universiteit. 27, 36, 88
VUI Voice User Interface. 92

W4RA Web for Re-greening in Africa. 6, 27, 28, 49
WWW World Wide Web. 1–3, 37, 47, 51, 52, 65, 69, 95–97, 106

Chapter 1

Background to the Research

The concept of Information and Communication Technology for Development (ICT4D)[1] *has gained momentum among academics and development partnering bodies such as the World Bank for some years now. On one hand, the main reasoning behind this interest is a widely accepted notion that more and better information and communication furthers the development of a society or a group of people. On the other hand is the World Wide Web (WWW) which, since its invention in the early 90's, has proven to be a major medium for information dissemination and knowledge sharing. This thesis explores how this globally acclaimed technology (the Web) can be used with speech technologies coupled with the radio—a technology in widespread use around the world and especially popular in developing worlds—as well as emerging and ever increasingly popular technologies such as mobile telephony in innovative ways for the purposes of aiding development in both developing and underdeveloped countries. Special emphasis is laid on the need to achieve the aforementioned goal with what is available in a given context. This thought underlies this entire research and is further explored in this chapter.*

1.1 How to Harness the Web in the Developing World

The WWW is a major global platform for knowledge sharing and information exchange. From television through pocket personal digital assistants to publishing, its impact on every facet of life in this age, especially in the developed worlds, is unprecedented. However, the fact still remains that despite this success of the Web, over a billion others in the world cannot access the wealth of information available on the Web [Aart et al., 2011]. Currently, the Web is not accessible in many rural regions in the world such as in Africa. The Mobile Web for Social Development (MW4D) roadmap, for example, has shown that some important barriers still

[1] http://en.wikipedia.org/wiki/Information_and_communication_technologies_for_development

exist [Boyera, 2008]. Firstly, the Web lacks specific *relevant content* to people in underprivileged communities. The reason is that availability of accessible and locally relevant content can be an incentive for people to access and use the Web. For example, language-wise, there is very little content on the Web in Bambara,[2] predominantly spoken in Mali, or Dagbani[3] spoken in Ghana, even though the two languages, put together, are spoken by over five million people. Secondly, as the MW4D also identified, *access barriers* to the Web exist which include illiteracy, language barriers, and technical obstacles. That notwithstanding, the adoption and development of Information and Communication Technology (ICT) worldwide has not been even with most of the developing countries lagging behind the developed world. Many studies show great disparities that exist between countries with access to ICTs, the so-called *global digital divide*.[4] In the case of the WWW and Internet, for example, international submarine fibre optic cables have reached several African countries for the first time in 2009 and 2010 [BuddeComm, 2011; Cottrell, 2013]. Several other examples can be cited such as the results of an experiment conducted in which a distributed port scanner was built to scan all IPv4 addresses on the internet in Figure 1.1.

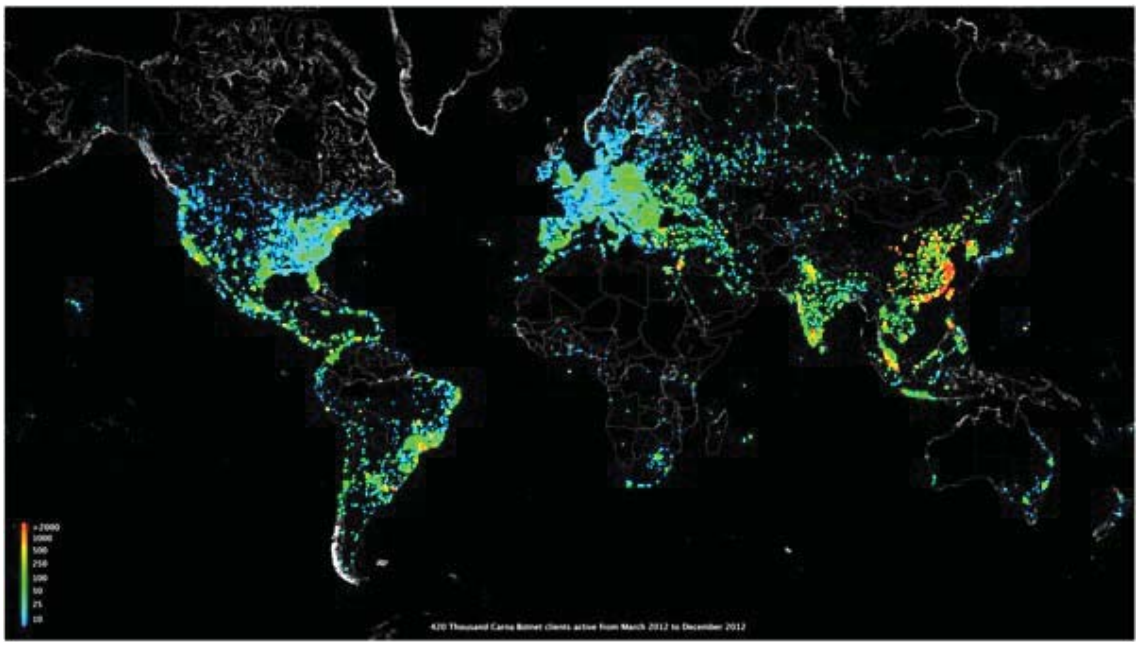


Figure 1.1: Internet map of the world in the year 2012. The bright areas show active connections to the internet. Africa is hardly visible in this picture. Source: http://internetcensus2012.bitbucket.org/paper.html

By the end of the year 2010, Internet user penetration in Africa reached 9.6%, far behind both the world average (30%) and the developing country average (21%) [ITU, 2010] and

[2] http://en.wikipedia.org/wiki/Bambara_language
[3] http://en.wikipedia.org/wiki/Dagbani_language
[4] http://en.wikipedia.org/wiki/Global_digital_divide

even less in rural areas. As at the year 2013 even, the Internet's contribution to Africa's GDP remained low, at 1.1 percent—just over half the levels seen in other emerging markets and well below the average of 3.7 percent in developed economies [Manyika et al., 2013]. Especially, the levels in sub-Saharan Africa regions are very low due to the lack of required telecommunication infrastructure and much needed electrical power for ICT infrastructure. Infrastructural needs like electricity which are essential for rolling out ICT projects are either non-existent or poorly maintained to be any useful in many parts of African communities.

However, when compared with Internet usage, mobile telephony has found substantial acceptance and usage levels in these regions which have struggled with Internet connectivity for decades. In 2010, when Internet user penetration level in Africa was under 10%, mobile telephony had become the primary mode of telecommunication as far back as year 2007 [UNCTAD, 2007]. Many studies conducted have attributed the rapid growth of use of mobile telephony in Africa to the widespread liberalisation of the communication market [see e.g. Aker and Mbiti, 2010; Boakye et al., 2010; Hellström and Tröften, 2010] across the continent. This claim is supported by empirical data which has shown that as far back as 2009, the continent showed the fastest rate of subscriber growth, introducing 96 million new mobile subscribers in a period of only twelve months [The Economist, 2009]. This development is interesting when contrasted with the observation by Aker and Mbiti [Aker and Mbiti, 2010] that in the year 1999 most African countries had no mobile phone coverage, and only Egypt, Morocco, Senegal and South Africa had coverage rates of over 40%. However, by 2008 over 65% of the African population had access to mobile phone coverage, with 93% in North Africa (Algeria, Egypt, Libya, Morocco and Tunisia) and 60% in sub-Saharan Africa. A notable factor which is thought to have contributed to this is the increase in market competition which eventually drove down prices and pushed providers to expand their operations in search of new markets. That resulted in the rapid extension of mobile networks, falling prices of services and mobile handsets, and innovative business models that reduced operators' capital and operating expenditure. This was complemented by huge investments in mobile network infrastructure and increased flexibility of prepaid mobile services.

Many success stories (e.g. studies in fishing villages in India [Jensen, 2007], in crop markets in Uganda [Muto and Yamano, 2009], or grain markets in Niger [Aker, 2008]) have demonstrated the abilities of mobile phone services to improve the livelihoods of people in underprivileged communities. Mobile telephony has come from a nice-to-have gadget for the upper-class in the late 1990s to "the single most transformative technology for development", according to development specialist Jeffrey Sachs (quoted the by Bloomberg Businessweek Magazine [Bloomberg Businessweek, 2007]). These developments have projected ICT services, especially mobile phone related ones, to have the potential to play a major role in furthering social and rural development in developing economies such as Africa [Akkermans et al., 2011; Boyera, 2008; UNCTAD, 2007].

The success stories, WWW, Internet and telecommunications infrastructure all together provide opportunities and make tools available for a number of development related initiatives in regions which need them. The situation has garnered interests from various development oriented stakeholders, international donor communities, the academic community and other interest groups and has culminated in the formations of umbrella of experts who advance the

cause. This umbrella is often referred to as a so-called ICT4D or ICTD. By definition, ICT4D refers to the use of ICTs in the fields of socio-economic development, international development and human rights. Often, however, the concept of ICT4D has been used to mean dealing with disadvantaged populations anywhere in the world, but it is more seen with applications in developing countries. It concerns with directly applying information technology approaches to poverty reduction efforts. ICTs can be applied directly, wherein its use directly benefits disadvantaged populations, or indirectly, wherein it can assist aid organisations or Non-governmental Organisations (NGOs) or governments or businesses in their efforts to improve socio-economic conditions. The reasoning behind this is simply that more and better information and communication furthers the development of a society [see e.g. Aker and Mbiti, 2010; Heeks, 2002, 2008; Toyama and Dias, 2008; Unwin, 2009].

Aside its reliance on technology however, the subject also requires an understanding of community development, poverty, agriculture, healthcare, and basic education of the environment within which they are employed. In the academic community this broad field is gradually being seen as an interdisciplinary research area with a growing number of workshops and publications [Heeks, 2008; Sutinen and Tedre, 2010]. Significant support from the academic community is also evidenced as done in the Swedish Program for ICT in Developing Regions (SPIDER) and informal community of technical and social science researchers which have risen out of conferences such as ICTD conferences.[5]

In the past many of the ICT4D-based mobile/web-related development programmes and initiatives have predominantly been services that have used mobile and web as mediums for information exchange [Boakye et al., 2010; Boyera, 2008]. These services have been based on one's ability to use the Short Message Service (SMS) and Unstructured Supplementary Service Data (USSD) functionality in mobile phones, or similar technologies that require some level of literacy or know-how for usage. Other disadvantages also include limited interactions with these services as well as the costs associated with the service itself. An example is the Esoko[6] platform, a market information platform that sends out agricultural information to phones using SMS. Another example is the co-partnered initiative by the Grameen Foundation and the South African based telecommunication solutions provider, MTN, to offer a variety of services offering agricultural, market or health information on mobile phones using SMS [Grameen Foundation, 2003]; similarly, a suite of "life services" (Nokia Life Tools) was made available on certain Nokia handsets, providing information relative to education, weather or market prices all through SMS technology [Nokia Corporation, 2008]. Many of these services have either gone out of use or have been discontinued.

This research therefore investigates other avenues for providing the services elaborated above, and especially, present a strong case for voice and radio as modes of information access and/or consumption to/from the Web where previous initiatives have failed. In addition, this research also proffers appropriate strategies for doing so.

[5] see e.g. http://www.ictd2010.org/
[6] more information on esoko here: http://www.esoko.com

1.2 Multi-modality, Access and the Web

The Web is essentially an information exchange medium and in areas where the Web is not available, it is the aim of this research to show that existing infrastructure such as available Global System for Mobile Communications (GSM) networks and community radio stations can be used in innovative ways to enable the sharing of knowledge and information in ways similar to how it is done on the Web. In the past, there have also been a number of initiatives which have attempted to use GSM networks to share knowledge by different organisations [e.g. Adam and Wood, 1999; Donner, 2007]. As has already been mentioned in Section 1.1, similar initiatives in the past have however depended on using SMS technologies for the purpose. Unfortunately, SMS is not usable for people with low-reading skills and with limited technical know-how. Many rural-dwelling Africans are most comfortable only with the voice-calling functionality of mobile phones. Moreover, most spoken languages around the world and especially those spoken in developing countries are not supported by the SMS technology on telephones. This need is what is pushing the urgency to focus on other available technologies and modalities and to investigate their possible use for building ICT-based services that are relevant and can be interacted with other than in SMS.

In areas where the Web has had and continues to have a somewhat gloomy outlook, other technologies have had, and are continuing to have, huge successes with information dissemination and access. For instance, in 2008 it was found that the radio, and especially the FM radio, was currently the number one medium of information flow for most rural dwellers [Myers, 2008]. According to Myers, the reasons for this are many including the spread of cheap transistors, the inability of television to compete due to high unit costs and lack of rural electrification, the opening-up of the airwaves in many countries, a thirst for alternatives to government-controlled media, and fresh investment by international donors, civil society, the private sector, glsplngo and governments.

In that sense alone speech- and voice-based technologies stand out as a clear preference for filling this need. Voice-based services come as the natural alternative given that speech is the natural use for most people with telephone devices. This preference is also largely because the technology and techniques for using them have matured over the years. Speech and voice technologies have seen lots of interests and investments from small to medium size private enthusiasts to big multinational companies who invest in its research in their quest to reach and/or attract as many new customers as possible with their businesses while increasing returns on investments. According to technology research and advisory firm Gartner, as at 2012, the outlook for this market is positive, "given the growth of Interactive Voice Response (IVR) technologies across organizations in the private and public sectors, and given the maturity of technologies being provided by vendors" [Lassman and Elliot, 2012]. The growth in this sector also translates into opportunities towards providing speech- or voice-based ICT services for low-literate and underprivileged communities around the world. Also since most of these technologies are open and standardized, their applications could potentially be in any part of the world.

As explained in the MW4D roadmap [Boyera, 2008], voice applications present a set of specific features particularly adapted to the targeted end-user profile. However, as of the time

of this research, only few experiences [see Agarwal et al., 2008; Patel et al., 2010, e.g. Voikiosk and Avaaj Otalo] on using speech technologies to provide social development services have been tested. This lack of experimentation can be explained by two main factors namely:

- A lack of a standardized free and open-source platform enabling the development of voice applications without advanced programming skills. Examples are proprietary setups like Avaaj Otalo and Voikiosk mentioned above.
- There is also a lack of speech technology elements such as Text-To-Speech (TTS) and speech recognition engines, specifically Automatic Speech Recognition (ASR), in local languages [see Plauché and Nallasamy, 2007], making the development of voice applications cumbersome due to the need of audio files managements.

Beyond the moral imperative that is associated with improving general well-being of humanity through development, there is also the need to safeguard local innovations which are mostly not written and therefore not available on the Web. As an attempt to solve these challenges, the VOIce-based Community-centric Mobile Services for Social Development (VOICES) project[7] was started. In particular, the project was started with the sole aim of filling the missing gaps listed above. Essentially, this thesis is based on this project. The project was an Europe-Africa partnership/collaboration co-funded under the EU-FP7 funding scheme. In the project, a voice-based market information service was deployed in Mali to serve a number of rural community farmers involved in the pilot. The project was arranged as part of the activities of Web for Re-greening in Africa (W4RA)[8]—a research body with its main objectives including, in a broader sense, initiating steps aimed at stopping worsening desertification in the Sahel, a so-called re-greening of the Sahel [Annor-Frempong et al., 2006; Reij et al., 2009; W4RA, 2010].

One of the biggest successes chalked by this project was concrete steps (and tools) that were undertaken (and built), with the aim of removing significant barriers such as illiteracy which impede access to technologies and/or knowledge as well as showing the potential for building other such services. One only has to acknowledge the substantial percentage of illiterate adults among most rural populations in the region in order to appreciate the severity of the situation. As a matter of fact, the CIA Factbook reports that as of July 2011, only 46.4% out of over two million inhabitants could read and write in Mali [CIA, 2012]. The use of local languages and dialects, like in many other sub-Saharan African countries, are widespread, many of which are not documented nor written but only learnt through oral traditions.

The project was started on three main thematic areas including

(i) delivering an open-source voice toolbox, and related speech modules for building voice-based mobile services.
(ii) demonstrating the power of this new type of applications on mobile.
(iii) helping to identify business models that ensure sustainability of such services.

The three themes above were a step toward exploiting voice applications for social development as well as opening the power of ICT to people who are outside the scope of currently deployed state-of-the-art technologies and services. As a scientific contribution to the field, I discuss these ideas in this thesis and further elaborate on their implementation.

[7] http://www.mvoices.eu, grant agreement no. FP7-ICT-2009-6
[8] http://www.w4ra.org

1.3 Field Setting of the Research

A series of activities and collaborations over the years under W4RA (see previous section) led to the discovery of a case on how local knowledge on rural farming techniques and agricultural activities in the Sahel[9] have led to the improvement of land fertility and higher crop yields. The Sahel is the belt of land that stretches across Africa on the southern edge of the Sahara. The region is characterized by low rainfall and frequent droughts. The crust of hard soil is, at times, almost impermeable, and harsh winds threaten to sweep away everything in their path. The region has always been a tough place to farm.

Figure 1.2: A farmer (right) in the Sahel in a conversation with an agricultural and land expert from an NGO. In the background are shrubs and trees beginning to appear and grow on the fields of these farmers after many years because of innovative local methods that have been employed by them on their lands for sometime. This picture was taken in January 2010 during a visit to the North of Burkina Faso, West Africa. Credit: Anna Bon.

Over the past three decades, however, hundreds of thousands of farmers in some parts of Mali, Burkina Faso and Niger, where the threat of the dessert is felt most have transformed large swaths of the region's arid landscape into productive agricultural land, improving food security for about 3 million people [see e.g. Reij et al., 2009]. Large tracts of land which were once unproductive are now home to abundant trees, crops, and livestock. Reij et al. argue that although rainfall has improved slightly from the mid-1990s relative to earlier decades, indications are that farmer management techniques are a stronger determinant of land and agro-forestry regeneration. The proof of this, he argues, is that in the difficult 1980s many inhabitants left the region in search of greener fields for their families and livestock culminating

[9] http://en.wikipedia.org/wiki/Sahel

in a significant drop in the populations in the region. And many who left did not return.

Reij et al. also cite an example in Ranawa village (in Burkina Faso) where the population at the time is known to have dropped by close to a half because of the drought. However, at the moment, the same village is an example of a community that has actively been *re-greening* its agricultural land area in the past two decades and it has demonstrably benefited from its own farming innovation (see Figure 1.2). The success of these re-greening activities lies in the rapid exchange and spread of local knowledge amongst large numbers of farmers. Knowledge about how to effectively and sustainably manage the lands, how to preserve trees and enhance soil fertility and how to improve crop yields and herds is very important for the people in these rural communities, whose livelihoods depend on agriculture and livestock.

Let's take Ranawa village as an example to illustrate the point. It is a community mostly of farmers farther away from the capital city and quite remote compared to other towns of Burkina Faso. However the village has up to 98% of the households with access to mobile phones and even more households which own AM/FM radio receivers at the time of this research. Apart from the usual communication needs that these phones satisfy, they are used for many other purposes including business (mostly farming) related information needs such as information on agricultural inputs and best farming/livestock-rearing practices, private and family matters, for checking and monitoring market prices in distant bigger towns and to negotiate with potential customers about prices of commodities and crops from farms. Also, the simple FM/AM radio is the de-facto medium from which much of their information is consumed and sometimes shared. The radio also serves as a mass communication channel for the radio stations in these communities who develop business models for radio programming and priced services for customers. Often much of this information is transmitted in the local languages of the communities within their radius.

1.4 This Thesis

Comparatively, the benefits of the mobile phone and the radio are worth the associated costs because they provide essential information for the people in rural communities across Africa (take the Ranawa village example elaborated in section above). Combining existing radio content, the Web and mobile telephony technologies in novel ways for voice-based access and other ICT-enabled services makes it possible to increase the speed of access to information and knowledge transmission/sharing between many other communities in a demand-driven way. Among the other purposes of this thesis already mentioned, it explores, in addition, the potential for ICT-related initiatives in helping to meet MDG[10] targets in information sharing and access in low-resource countries.

In that regard therefore, the following are the core issues of this research:

(a) The primary issue this thesis addresses is how one can support rural information and knowledge sharing with ICTs such as the Web, given the above-sketched adverse conditions and obstacles. A key point here is to start from what is actually there now, and how

[10] http://www.un.org/millenniumgoals/

to combine this, especially Web-mobile-radio-voice services, into systems that work under real-life field conditions.

(b) Furthermore, it is important that such information systems fit into the specific context they are supposed to work in. This does not just involve available technology and infrastructure but a range of social, economic and cultural contextual factors such as how a given technology is utilised in ways other than intended by the manufacturer in order to meet a local need or the usefulness of certain kinds of information to or among a group of people. Information systems should bring about tangible benefits and that makes it imperative that proponents of any solution must be able to identify what is valuable to people and what specific needs there are to be met. Further, the form in which the information is important, given the fact that issues of literacy potentially affect system design considerations.

(c) So, a second issue this thesis addresses is the contextualisation and systematic process whereby one gains a proper understanding of the context, by eliciting the various local context elements, analysing them and building them into prospective information systems that truly meet local needs and conditions in-the-field and on-the-ground.

Accordingly, the structure of this thesis is as follows:

Chapter 2 examines available literature on the subject of voice and speech technologies. This is because although the subject of speech and voice technology development is not and an entirely new concept in the developed worlds, the same cannot be said of its deployment and usage in developing and under-developed worlds. To date, beyond a few known ones, there's not much literature on the subject. And so the chapter attempts to give a general overview on the state of the art on speech and voice-based systems and their implementations in developing worlds.

Chapters 3 and *4* investigate the research questions raised by presenting use cases that were implemented in Mali; how the use cases were elicited and the systems that were built as answers to the research questions. The actual implementation of the project took place in the Ségou region of Mali but this was not without an initial phase of requirements and use case gathering activities by a team of researchers of diverse backgrounds from Europe.

Chapter 3 therefore gives a detailed account of all the activities that culminated in the final selection of implementable use cases under the project. In that chapter, more light is thrown on the mode of requirements gathering activities and the outcomes of them. In *Chapter 4*, the description of the actual system implemented is given. The chapter describes the use cases that led to the implementation of the *RadioMarché* service piloted in Mali, its design as well as how it was used by the locals. Another voice-based system, namely the *Tabale* service that was launched at later stages in the project is also described.

In *Chapter 5*, a framework based on currently available literature on evaluation studies is used to evaluate the project in the end. The final chapter of the thesis, *Chapter 6*, draws conclusions on the entire project and then makes useful generalizations on the subject of ICT4D.

To a very large extent, the research reported in this thesis has involved a significant amount of teamwork. Therefore, a specification of the personal role and contribution of the author to the work is called for. *Chapters 1, 2* and *6* are fully the work of the present author. What is reported in *Chapter 3* on requirements gathering was a collective effort of the project team.

In *Chapter 4*, the present author's major contribution has been building a web interface for generating, publishing voice audio communiqués for Web and telephone access in Mali. Also in the chapter, the author investigated other possible but cost-effective and sustainable alternatives for that technical set-up. And finally in *Chapter 5*, the author's contribution has been evaluating the *RadioMarché* tool and its impact using a project-wide accepted evaluation framework.

1.5 Publications

The thesis is based on a number of scientific publications within the period of the project. They include the following:

1. Nana Baah Gyan, Victor de Boer, Anna Bon, Chris van Aart, Hans Akkermans, Stéphane Boyera, Max Froumentin, Aman Grewal, and Mary Allen [2013]. "Voice-based Web Access in Rural Africa". In: ACM WebSci '13. Paris, France
2. Anna Bon, Victor de Boer, Nana Baah Gyan, Chris van Aart, Pieter De Leenheer, Wendelien Tuyp, Stéphane Boyera, Max Froumentin, Aman Grewal, Mary Allen, Amadou Tangara, and Hans Akkermans [2013]. "Use Case and Requirements Analysis in a Remote Rural Context in Mali." In: ed. by J. Doerr and A.L. Opdahl. LNCS 7830. REFSQ, pp. 331–346
3. Victor de Boer, Nana Baah Gyan, Anna Bon, Hans Akkermans, Wendelien Tuyp, and Chris van Aart [2013]. "A dialogue with linked data: Voice-based access to market data in the Sahel". Interoperability, Usability, Applicability. In: *Semantic Web* Semantic Web –. DOI: 10.3233/SW-130132
4. Anna Bon, Victor de Boer, Pieter De Leenheer, Chris van Aart, Nana Baah Gyan, Max Froumentin, Stéphane Boyera, and Mary Allen Hans Akkermans [2012]. "The Web of Radios - Introducing African Community Radio as an interface to the Web of Data". In: *First International Workshop on DownScaling the Semantic Web* Extended Semantic Web Conference
5. Victor de Boer, Pieter De Leenheer, Anna Bon, Nana Baah Gyan, Chris van Aart, Christophe Guéret, Wendelien Tuyp, Stephane Boyera, Mary Allen, and Hans Akkermans [2012]. "RadioMarché: Distributed Voice- and Web-Interfaced Market Information Systems under Rural Conditions". In: *Advanced Information Systems Engineering*. Ed. by Jolita Ralyté, Xavier Franch, Sjaak Brinkkemper, and Stanislaw Wrycza. Vol. 7328. Lecture Notes in Computer Science. Springer Berlin Heidelberg, pp. 518–532. DOI: 10.1007/978-3-642-31095-9_34
6. Chris van Aart, Anna Bon, Hans Akkermans, Victor de Boer, Stéphane Boyera, Wendelien Tuyp, and Nana Baah Gyan [2011]. "The Web of Voices: how to connect 4.5 billion internet-less people to the Web: Outrageous Ideas". In: *International Semantic Web Conference*
7. Hans Akkermans, Nana Baah Gyan, Anna Bon, Wendelien Tuyp, Aman Grewal, and Stéphane Boyera [2011]. "Is (Web) Science Ready for Empowerment?" In: *ACM Web Science Conference Proceedings*. Koblenz, Germany

Chapter 2

Voice Technologies and Spoken Dialogue Systems (SDS) in Developing Countries

Voice systems and speech technologies have been in existence for much longer than thought by domain experts although this has largely been in developed countries. In developing countries, and indeed much of Africa, the phenomenon is a relatively recent one. Their use can be attributed mostly to the increase in use of mobile telephony and the accompanying increase of infrastructure support for such systems. Other factors for the little use of voice systems in Africa include the fact that many countries on the continent are characterised by relatively small groups of multi-cultural, multi-lingual tribes and ethnic groups. And given the fact that the development of voice systems requires a significant amount of financial investments and technical expertise, its development has been limited to languages that are widely spoken, and reasonably so, for the numbers for its usage and return on investments for developing such systems. This particular reason has resulted in the development of voice systems for only the widely spoken/used languages in the world which are Western. This therefore means the unavailability of voice systems for use in developing countries in local dialects. However, when employed properly in a given context, voice systems have the greatest potential in reaching illiterate populations and therefore makes it important that such systems are further researched for less developed regions. This chapter takes a cursory look at this and also builds the foundation for subsequent chapters of this thesis.

2.1 Introduction

Surprising as it may sound, it is only in recent years that there has been a significant push towards the use of Spoken Dialogue Systems (SDSs) for information access in the developing

world[1] [see Sherwani et al., 2007, 2009; Tucker and Shalonova, 2004] compared to similar initiatives in the developed countries.

Illiteracy is still a major problem in many parts of the world. As at the year 2001, for example, UNESCO reported that were about one billion non-literate adults in the world.[2] The recent boom in mobile telephony access, especially in developing countries, provides opportunities for telephone-based (especially mobile cellular networks), information access to low-literate populations and offer an opportunity to "participate in the digital age" through means that they are comfortable with and are natural to them—that is, using voice systems and associated technologies such as IVR. It also affords technical experts and interested parties the launchpad for developing relevant and innovative services to reach some of these populations who are otherwise unreachable with the popular technologies of today.

To date, there have only been a few pockets of research activities which have aimed at exploring the feasibility of IVR interfaces for low-literate users [see e.g. Grover et al., 2009a; Patel et al., 2009; Plauché and Nallasamy, 2007; Plauché et al., 2006; Sherwani et al., 2009]. There have been a number of preliminary findings and practical lessons learnt but there still remain much to be done in terms of fully exploiting the possibilities of IVR interfaces in a context very different from the developed world [Barnard et al., 2008; Weber et al., 2008].

2.2 SDS in Developed Countries

SDSs are known to be used by millions of callers per day currently in developed countries. The history behind this dates back to the days of trials at Bell Laboratories in 1952 [Barnard et al., 2008]. According to Barnard et al., the development of voice systems and its evolution rarely followed the classical progression from scientific breakthrough to application in engineering technology. The authors also argue that back in the day in this field, it was much more common for numerous applications to be attempted in somewhat haphazard fashion with little reliance on rigorous scientific foundations.

Thus Barnard et al. posit that some of the application areas where SDSs had been expected to play a major role never materialized, whereas unexpected success for SDSs arose elsewhere. The authors also posit that, a review of the history of call-centres gives some indications of the processes that led to the some of the advanced systems currently in use today. They also argue that some of the earliest commercially successful applications of SDS were in answering telephone calls that would otherwise be handled by human operators, typically in call-centre environments and that factors which significantly aided this development include *Cost Savings, Branding techniques, and Efficiency*.

On cost savings, Barnard et al. also argue that at the time, SDSs were significantly less expensive to maintain than human operators and also able to achieve better automation rates than competing technologies such as those based on telephone key presses. For branding pur-

[1] "developing world" here refers to larger populations in e.g. India, most countries in sub-Saharan Africa, Brazil, etc. who are low-literate and technologically inexperienced, and it is important to note that these regions may have hubs of technological advancement with small sub-sets of highly literate populations.

[2] http://www-01.sil.org/literacy/LitFacts.htm

poses, they also posit that since spoken modality is a deeply mind-ingrained trait of humans and that spoken communication creates associations that can be employed to extend and enhance the brand of a company, the repeatability and control offered by an automated system are particularly attractive in an industry where burnout and turnover of personnel are significant factors. And lastly on efficiency, they argue that well-designed SDSs made it possible to exchange information in an efficient manner thereby cutting down on call durations, reducing toll costs and increasing customer satisfaction. All these factors aided the growth of the industry in its early stages.

In its early development also, SDS applications for call-centres in developed countries focused on tasks such as directory assistance [Lennig et al., 1995], stock quotes and travel information systems [Cohen et al., 2004], which required selections from long list of names of people, companies, or locations. Since little research was available on the best way to design such interfaces, much of the early development was based on a combination of intuitive insights and informal focus groups [Barnard et al., 2008]. During this process of informal development, several false starts and surprising failures were encountered. An example of this according to Barnard et al. was a much early enthusiasm about self-service applications that allowed customers in large industries to order and configure their paid services. There were also several trial systems that were developed and performed well in pilot tests.

And after many years of intensive development of applications that replaced much of the human-based services in industry, the technical, as well as the economic factors that determined the viability of SDS in call-centre applications became fairly clear in developed countries. This includes major progress in understanding of the technical factors that determine user acceptance followed from the development of reliable instruments for assessing user experiences [Hone and Graham, 2000] along with the systematic development and use of associated protocols for administering and assessing such instruments [Suhm, 2008]. Targets users were included in the design process and usability methods employed both during design and analysis [Cohen et al., 2004].

2.3 SDS for Developing Countries

2.3.1 Status

The lack of use of Spoken Dialogue Systems, or their delay, in the developing world, according to Heeks, has been attributed to a few factors [Heeks, 2002]. In the nutshell, the main factors have been attributed to the fact that the deployment of such systems faces a number of logistical, technical and financial hurdles. Even though the potential benefits are immense, this has remained so for quite some time despite the crucial role that relevant, up-to-date information plays in improving quality of life [Heeks, 2008]—a crucial need in developing countries. In addition, it is largely agreed on in the academic world that application domains such as education, agriculture, health care and government services all stand to benefit from the availability of widely accessible information sources that do not require widespread computer infrastructure or computer literacy [see e.g. Barnard et al., 2003, 2010b; Heeks, 2002, 2008; Patel et al., 2010; Plauché et al., 2006; Sherwani et al., 2007].

In developing SDS interfaces for use in the developing world, these interfaces tend to be the logical and natural means for implementing automated services or solutions [see Kumar et al., 2008, 2007; Plauché and Nallasamy, 2007; Plauché et al., 2006; Sherwani et al., 2007; Tucker and Shalonova, 2004]. The first reason is the pervasive use and the high and increasing penetration rates of mobile telephony in the developing world as has been discussed in the previous chapter, and secondly, the observation that the use of SDS-based interfaces requires minimal skills compared to the usability of other computer-based interfaces [Grover et al., 2009b] such as Graphic User Interfaces (GUIs). Also, telephone-based IVR services have less infrastructure costs in contrast to PC-based solutions and requires no maintenance from the user since the system can easily be centrally maintained at more geographically convenient locations [Brewer et al., 2006; Plauché and Nallasamy, 2007; Sherwani et al., 2007].

The scarcity of relevant, up-to-date information sources is one of the gravest deficiencies of the developing world, which therefore makes SDSs attractive as a medium through which this gap can be filled. But to achieve any result at all in this area, Barnard et al. argue that a careful analysis of the lessons learned in the developed world, along with an understanding of the salient differences in the developing world is essential in guiding the research community towards the performance of the appropriate trials and experiments that will accelerate speech systems to reach its potential in developing countries and to make speech a universal and accessible means for information dissemination in the developing world [Barnard et al., 2008]. It is this trajectory, it is argued, that similar initiatives in the use of SDS in developing worlds should follow in order to increase its use and viability.

2.3.2 Factors/Challenges/Practical Experiences

As the use of spoken dialogue systems has become increasingly widespread in developed countries, it is easy to forget the trial-and-error development that led to the rigorous design and evaluation methods used today. If a similar trajectory is required for a comparable impact of SDSs in the developing world, it is expected that many years of pilot deployments of such systems are necessary as speech technologists grapple with issues of feasibility, sustainability, user acceptance and general usability issues. This is largely due to the fact that scientific studies of SDS in the developed world assume a context that is different from that occurring in the developing world [Barnard et al., 2008].

Also, and more generally, beyond usability and creating simple, accessible user interfaces for low literacy users, other factors such as cultural and social contexts, establishing relationships with stakeholders and user communities and localizing as much content as possible play a vital role in the success of any ICT intervention in the developing world. An important example is the case of the use of speech feedback or input in kiosks as well as the use of personal mobile phones in public places. In many applications, this compromises user privacy since anybody within hearing distance can hear the user's input [Grover et al., 2009b]. And this is particularly important because as of the year 2009, for example, many of the current applications or services available via mobile phones in Africa focus on the health domain, e.g. AIDS/HIV outpatient care [Grover et al., 2009a].

It is nevertheless possible to identify similarities and differences between systems and users

in both the developed and developing world contexts. However, such information is not easy to come by. For instance, to this day, research on comparing input modalities for SDSs (mainly Dual Tone Multi Frequency (DTMF) and Automatic Speech Recognition (ASR)) is either hard to find or non-existent. That notwithstanding, a developed world review of applications can be applicable to developing worlds. One such study has been done by Lee and Lai comparing DTMF and ASR which shows that user preference and performance are found to depend on the nature of the task, the personality of the user and the capabilities of the speech-recognition system [Lee and Lai, 2005]. The type of task has a strong influence on a user's ability to complete a task effectively and efficiently and that speech input fares better for complex tasks and DTMF is more effective when tasks are simpler. Other studies have also shown that simply replacing DTMF with speech does not improve user performance or perception [Grover et al., 2009a]. On this basis alone, it would not be far-fetched to assume that DTMF is likely to be more acceptable in the developing world, where general numeracy is less common. Also, due to the resource dependent nature of natural language processing techniques, DTMF becomes much easier choice to develop than other forms of SDS. However, it is also recommended that a significant consideration regarding user training or familiarity with the system should be undertaken [Grover et al., 2009b]. Research has also found out that, generally, it is preferable to use more verbose, less efficient user interfaces to guide inexperienced users for whom time pressure is not a primary concern [see e.g. Barnard et al., 2003; Sherwani et al., 2007].

The role that context plays in the development of these systems cannot also be downplayed. An example is cited by Barnard et al. on the influence of culture on an e-governance SDS project in South Africa. In that example, the authors state that in South Africa alone, there are 11 distinct spoken languages with wide disparities within and between the various language groups in socio-economic standing and literacy. A history of the country also recorded a racially selective elite rule the country in a non-democratic fashion which fostered a deep mistrust in government. They then argue that compensating for these historical injustices required a particular attention to the needs of citizens who are functionally illiterate and that development of any of such SDS-based services should explicitly take into account the variable (if available) that will influence the user's interaction with the service [Barnard et al., 2003]. Similar situations exist in most African countries where ethnic and tribal differences oftentimes cherished and held in high esteem must necessarily be catered for in IT systems.

From the perspective of speech technologists, the most important challenges to address in order to make spoken interfaces a viable option for the access of information in developing countries include the following [Barnard et al., 2010b; Van Heerden et al., 2009]:

1. The design of spoken interfaces that are usable and friendly in diverse cultures, by users with limited or no computer literacy.
2. The development of speaker-independent ASR systems that function reliably in the local languages of the developing world.
3. The development of TTS systems that are easily understood in these same languages.
4. The codification of appropriate linguistic knowledge—especially phonological and phonetic information—which will often require original research for the languages of the developing world.
5. The collection and development of basic resources such as word lists, phone sets, pronun-

ciation dictionaries and corpora for resource-scarce languages.
6. The development of tools that support these activities and of platforms that make it possible to deploy them in both experimental and customer-facing applications.
7. The selection of application domains that are practically suitable in terms of factors such as economics, the availability of information and marketability.

In addition to the above mentioned technical challenges, others also posit that to make speech become a mode of interaction with technology and services a number of many more factors which also include but are not limited to cost, availability of training for the user, pay-off, complexity of the application, user needs and the quality of the design and development process [see e.g. Barnard et al., 2008]. These factors however, the authors argue, are applicable in all situations for systems developed for users in both the developed and developing worlds.

These significant challenges need to be addressed in order to make SDS mainstream and commonplace in developing countries and although significant progress has been made, a lot more need to be done through targeted, well-defined research to address these challenges.

2.3.3 Tools and Platforms

To build and support telephone-based information access with speech technology, an integrated platform that connects to the public telephone network is required. Several commercial platforms with such functionality exist but cost and licensing issues—which complicate the integration of new languages and capabilities—generally prevent their use in developing world [Barnard et al., 2010b]. There are open source solutions which are also gradually catching up and growing in popularity which can usually be used as the basis for the development of a telephone platform. An example is Digium Inc.'s Asterisk platform.[3]

One such platform which has developed after years of research which comprises ASR and TTS based on the integration of widely-used open source TTS Festival[4] and Asterisk [Barnard et al., 2010b]. This has tools for telephony functionality and speech-technology enhancements accessible though a Python programming interfaces as well as tools for control and monitoring. Other open source tools that support the creation of speech technologies in new languages include DictionaryMaker[5] (a toolkit that can be used for the efficient bootstrapping of pronunciation dictionaries), ASR-Builders[6] (tools used for training and experimenting with acoustic models for speech recognition) and Speect[7] (a modular toolkit for the development of TTS systems). Each of these tools assists with a particular aspect of language-technology development.

The author of this thesis together with other researchers have experimented with other set-ups. One of such is using the combinations of specific vendor-dependent software and hardware solutions which can be used together for development and testing purposes. An example of such a platform is using freely available voice browsing solutions such as Voxeo Inc.'s Prophecy

[3] http://www.asterisk.org/
[4] http://festvox.org/
[5] http://sourceforge.net/projects/dictionarymaker/
[6] http://asr-builder.sourceforge.net/
[7] http://speect.sourceforge.net/

platform[8] and hardware solutions that offer GSM gateways such as the 2N OfficeRoute gateway.[9] On a very small-scale project, this simple set-up can be used for developing simply IVRs for testing purposes only. The team is also looking into simple architectures that will provide the possibilities to be implemented on simple, low-powered hardware. Currently, experimentations are ongoing different hardware platforms such as the RaspberryPi[10] and Wandboard Quad 6[11] where these computing platforms are linked to simple mobile phones using USB or Bluetooth technology. Mesh and WIFI networking further allows for sharing knowledge locally and to aggregate levels with other nodes [see Schlobach et al., 2014].

Other solutions are software development environments that are provided by vendors in the field of voice technology development who allow the use of their platforms for development purposes only. Voxeo Inc. for example also provides the Evolution[12] platform which allows the hosting and development of applications for developers. Another example also is the open source Emerginov[13] platform provided and supported by France Telecom for developers especially from the developing countries to build, host and experiment with voice-based applications.

Thus, there are real hurdles to be overcome in order that SDSs become mainstream for everyday use in less developed countries. This research elaborates on some of the experiences attained through a field research in Mali and also employs available tools and platforms available today as well as on-the-spot techniques in delivering a voice-based service in Mali on a pilot. In the process, new insights are gained and documented. The research also discusses the methodology and particular tools used in overcoming some of the challenges mentioned above.

2.4 Leveraging SDSs for Development in Africa

Despite all the challenges and hurdles to development of SDSs, the potential for using mobile-based tools to aid development efforts in developing countries remains promising. Analysis of the Mobile for Development (M4D) landscape worldwide reveals a variety of stakeholders with increasing numbers of mobile-based projects, and donors such as the World Bank, infoDev and the Bill and Melinda Gates Foundation. It has been estimated that as of 2015 only 4.4% of the world's population live in the so-called "coverage gap" (which is made up of those areas that do not present a viable business proposition for the private sector and require subsidies), outside of mobile network coverage [Boakye et al., 2010]—the implication being that M4D technologies and initiatives have the potential to impact many of the world's poor.

It must be noted however that, to date, most cases of successful applications of M4D are found in Asia, where concepts have been proven, and more mature mobile markets are seeking new revenue streams. Boakye et al. cite the Philippines Department of Agriculture, for example, which has developed a service that gives farmers advice about fertiliser use via the mobile phone. Their study also points out that in Africa especially, there is growing evidence that governments

[8] http://voxeo.com/products/voxeo-prophecy/
[9] http://www.2n.cz/en/products/umts-gateways/officeroute/
[10] https://www.raspberrypi.org/
[11] http://www.wandboard.org/
[12] http://evolution.voxeo.com/
[13] http://www.emerginov.org

are interested in using mobiles as service providers, yet active projects in developing countries remain few. The authors also explain that the impetus for this has come mainly from mobile operators who have developed or intend to develop services with a development impact that also represent a return on investment—M4D that is revenue generating and saleable. In that sense then, operators are willing to contribute to development goals, but only by "doing business as usual". Common themes in business strategies of regional operators include network extension into rural areas, network upgrading (focused on urban areas), innovative applications, content, and services and, a focus on youth. However, up to this point, mobile operators have tended to support M4D through concessions such as free or subsidized SMS tariffs, which have been negotiated as part of Corporate Social Responsibility programmes. These are typically seen to be poorly resourced and integrated and not utilising the latest technology.

There are no hard assurances that systems that have worked successfully well in other places of the world would also work in new places in Africa. As has been discussed in the previous section, building such systems in new environments would sometimes have to be in a trial-and-error fashion and would require enough investigations into identifying what the real local needs are. Successful applications of these tools however would require thorough knowledge of environments within which these new services or applications would be deployed and used. Knowledge of the environment would include, arguably, a clear understanding of the channels through which information is disseminated in many parts of Africa and the usage culture of mobile telephony.

2.4.1 Channels of Access to Information in Africa

Successful attempts at leveraging SDSs for meaningful services especially in Africa must also take into consideration the channels available for information in many parts of the region and especially in the rural regions. Figure 2.1 gives an overview of the possible forms of access to information in East Africa and communication services as well as the various channels that can be potentially used for service models.

The methods of access are in the order of what channels are more pervasive from the top down to those that are less. Even though this was compiled for the East African region of Africa, this information generally holds true to most parts of rural sub-Saharan Africa as well. An important observation from the table is the fact that, FM radio remains the dominant channel through which much of local information is produced and consumed. This therefore brings to light the role that radio technology plays in the lives of many rural poor in Africa and how innovative strategies should be employed in order to impact many.

2.4.2 Mobile Telephony Usage Culture in Africa

Any attempt at implementing successful and meaningful voice-based services for use in sub-Saharan Africa must take into account the usage culture of mobile telephony in the region. There are significant differences in mobile phone usage and ownership models between the developing and developed countries. This is largely due to cultural, socio-economic and infrastructural disparities. Developed worlds tend to have a single ownership model, but in the developing

worlds, a multiple-user and a shared ownership model can be observed and has also been documented [see e.g. Patra et al., 2007].

Methods of access	Channels	Examples
Radio The most accessible and widely used form of communication across the region	Broadcasting Community Radio Feedback through mobile phone: SMS to radio Mobile phones equipped with an FM transmitter	Common ways to combine mobiles and radio: Channel for listeners to contribute news, views, stories and feedback Sending SMS to listeners on upcoming programmes, competitions or events Using SMS to transmit important information to be broadcast on radios during emergencies, for search and rescue, alerts and early warnings etc
Basic mobile phones Low-end mobile phones	Voice SMS Voice to text/text to voice Interactive voice response (IVR)	Voice conferencing 'Dial-up radio' Data collection and monitoring Logistics coordination
Mid-range mobile phones	Data transfer through GPRS Java (J2ME) enabled Mobile WAP Additional features such as camera, bluetooth	Mobile mapping Mobile community market Instant messaging
Smart mobile phones High end mobile phones (mobile phone as a computer)	Sensor Rich Application (All Purpose Tool) Global Position System (GPS) Social network features Mobile web Video and audio recording and sharing	Mobile sensing Community-based monitoring Social network applications
Indirect access For people who do not have direct access to mobile phones, computers or internet	Infopreneur (use of intermediary to access information) Village phone Village area networks	Shared access Shared handsets

Figure 2.1: The various channels for access to information in East Africa. Adapted from: http://www.cta.int/ (2009).

For example, in many parts of Africa, it is very common to see kiosks where people resell mobile minutes by allowing the population to come in and pay to use the phone service (charged per minute) even though this is increasingly being replaced as more and more have access to mobile phones. Not until recently, business models built around mobile telephony were such that entrepreneurs moved around from one place to the other with a mobile phone offering voice call services to customers. In many rural communities also, it is not uncommon to have households share the use and cost of maintenance of a mobile phone within a household. This shared use has implications for the design of SDSs services. In any such case of a system for example, the speech commands will have to deal with possible speech recognition issues from multiple users, noisy environments, and interruptions from the context of use. Other studies have also found that quite often, on-lookers are keen to participate as experienced in the Tamil

market user study in India [Plauché and Nallasamy, 2007; Plauché et al., 2006], and noise from the surroundings increase the chances for greater recognition errors with speech systems. In general, orally-dominated cultures favour DTMF-based SDS services since its recognition is not typically affected by a noisy background.

2.5 Chapter Conclusion

Spoken Dialogue Systems have had a longer history of use in developed countries than in developing countries. The success behind this history has largely been attributed to the need for large industries to reduce cost and maximise profits which resulted in a number of trial-and-error experiments to build the infrastructure for such systems. The same cannot be said for SDS in developing countries. In much of Africa for example, some countries are seeing the use of SDSs for the first time as a result of the boom in mobile telephony infrastructure on the continent. Indeed, there are quite a number of significant challenges that need to be overcome ranging from technological to cultural and socio-political challenges in order that SDS achieves widespread use on the continent.

To overcome these challenges, I argue that adequate, field-based, results-driven research such as this one is important. The motivation for this kind of research will necessarily have to be focused on solving local needs. As of this research, much of Africa has a huge gap with respect to information access and consumption and, in that regard, SDSs could help reduce this gap. The opportunities for this also continue to grow—SDS techniques and algorithms have improved, and mobile telephony usage continues to rise. Radio technology also continues to be a major source of information consumption and dissemination on the continent. All of that offer avenues for connecting more and more people to the information access and dissemination drive around the world.

Not much research exist on overcoming these challenges and this research adds to already existing literature on building SDSs for low-literate populations using locally available tools and platforms in innovative ways. As has been noted already, the success of such research is bound to take a trajectory similar to how its development began in developed countries—trial-and-error experiments and pilot projects which build on techniques, and especially so in Africa where conditions and expectations vary greatly from community to community. It is when many such experiences are created that SDS development and use become widespread in developing countries. The next chapters throw more light one such step in that direction.

Chapter 3

Requirements Gathering for Voice Services in West Africa

Software requirement gathering is an important step in any software project. It's a step in the software development cycle that enables both software developers and stakeholders to immerse themselves as much as possible in the environment for which the software would be built. The various processes involved in gathering requirements help software developers to also identify available challenges for which solutions are proffered and/or implemented. The VOICES project was kick-started by gathering requirements from the field in Mali. This chapter explains the processes that were employed under the project in the requirements gathering phase, the analyses of those requirements and the eventual selection of use cases for building and deploying a voice system for use in rural parts of Mali. The chapter also highlights significant differences in approach between the traditional requirements gathering strategies and, in our case, bottom-up, context-specific requirements gathering strategies largely necessitated by the prevailing conditions external to the project.

3.1 Software Requirements Gathering Overview

Software engineering has its early roots from the early 1940s where software writing evolved into a profession concerned with how best to maximize the quality of software and of how to create it. In recent times however, literature abounds on the subject with guidelines and check-lists such as the IEEE Guide, namely the Software Engineering Body of Knowledge (SWEBOK),[1] which essentially gives a summary of the state of the art on software engineering practises. The SWEBOK describes a software requirement as a property which must be exhibited by software developed or adapted to solve a particular problem. A requirement is generally defined as "a property that must be exhibited in order to solve some real-world problem" and a software

[1] available online at http://www.computer.org/portal/web/swebok/html/ch2

requirement is “a property which must be exhibited by software developed or adapted to solve a particular problem”. The problem may be to automate part of a task of someone who will use the software, to support the business processes of the organization that has commissioned the software, to correct shortcomings of existing software, to control a device, and many more. The functioning of users, business processes, and devices is typically complex, and therefore by extension, the requirements on particular software are typically a complex combination of requirements from different people at different levels of an organization and from the environment in which the software will operate.

According to SWEBOK, an essential property of all software requirements is that they be verifiable. It may be difficult or costly to verify certain software requirements more than others. For example, verification of the throughput requirement on the call centre may necessitate the development of simulation software. Both the software requirements and software quality personnel must ensure that the requirements can be verified within the available resource constraints. Requirements have other attributes in addition to the behavioural properties that they express. Common examples include a priority rating to enable trade-offs in the face of finite resources and a status value to enable project progress to be monitored. Typically, software requirements are uniquely identified so that they can be subjected to software configuration control and managed over the entire software life cycle.

Functional requirements describe the functions that the software is to execute; for example, formatting some text or modulating a signal. They are sometimes known as capabilities. Non-functional requirements are the ones that act to constrain the solution. As a result, non-functional requirements are sometimes known as *constraints* or *quality requirements*. They can be further classified according to whether they are performance requirements, maintainability requirements, safety requirements, reliability requirements, or one of many other types of software requirements. Figure 3.1 shows a map of the software requirement knowledge area. Requirements elicitation is concerned with where software requirements come from and how the software engineer can collect them. It is the first stage in building an understanding of the problem the software is required to solve. It is fundamentally a human activity, and is where the stakeholders are identified and relationships established between the development team and the customer. It is variously termed “requirements capture”, “requirements discovery”, and “requirements acquisition”.

One of the fundamental tenets of good software engineering is that there be good communication between software users and software engineers. Before development begins, requirements specialists may form the conduit for this communication. They must mediate between the domain of the software users (and other stakeholders) and the technical world of the software engineer. A number of techniques exist for requirements elicitation, the principal ones being:

- **Interviews**, a “traditional” means of eliciting requirements. It is important to understand the advantages and limitations of interviews and how they should be conducted.
- **Scenarios**, a valuable means for providing context to the elicitation of user requirements. They allow the software engineer to provide a framework for questions about user tasks by permitting “what if” and “how is this done” questions to be asked. The most common type of scenario is the use case.
- **Prototypes**, a valuable tool for clarifying unclear requirements. They can act in a similar

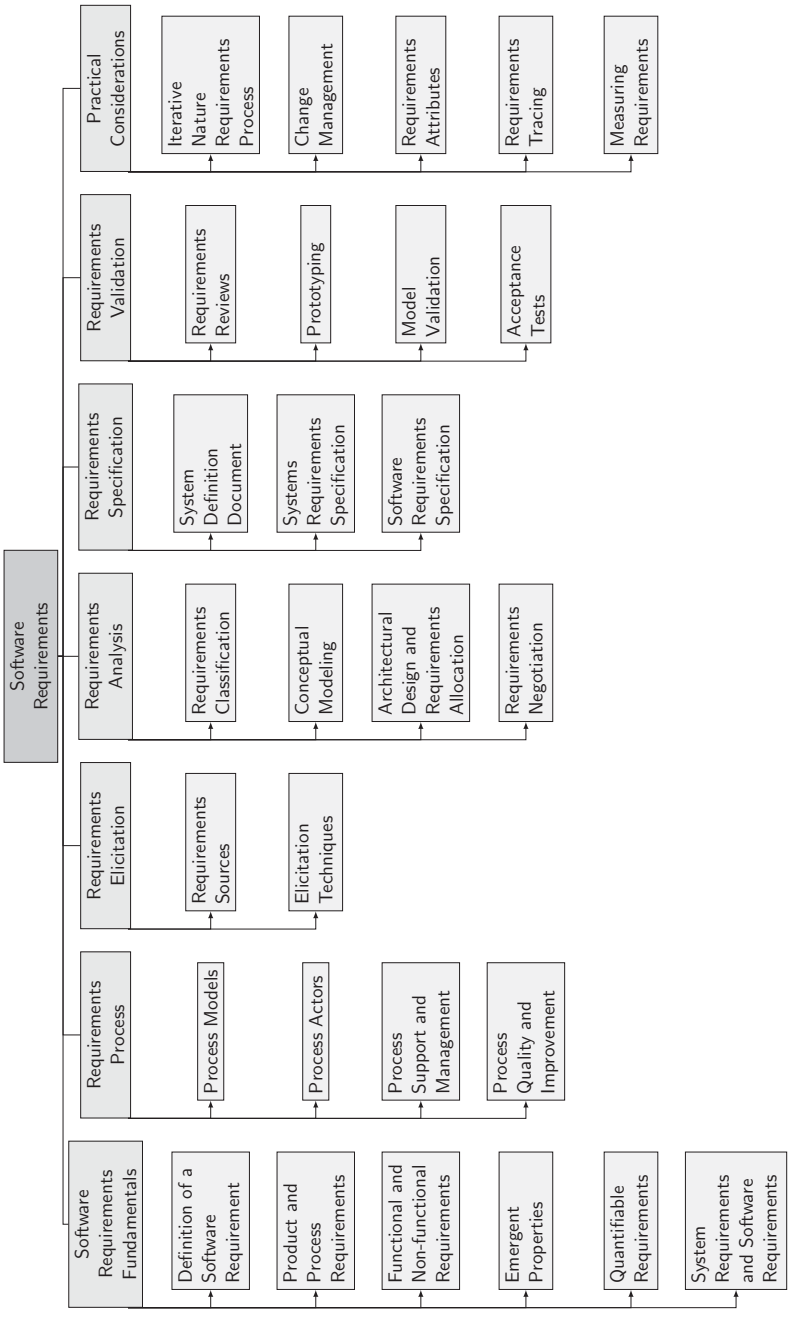


Figure 3.1: Software requirements knowledge area. Taken from SWEBOK.

way to scenarios by providing users with a context within which they can better understand what information they need to provide. Prototyping techniques come from a wide range from paper mock-ups of screen designs to beta-test versions of software products and a strong overlap of their use for requirements elicitation.

- **Facilitated meetings**. The purpose of these is to try to achieve a summative effect whereby a group of people can bring more insight into their software requirements than by working individually. They can brainstorm and refine ideas which may be difficult to bring to the surface using interviews. Another advantage is that conflicting requirements surface early on in a way that lets the stakeholders recognize where there is conflict. Meetings need to be handled carefully (hence the need for a facilitator) to prevent a situation from occurring where the critical abilities of the team are eroded by group loyalty, or the requirements reflecting the concerns of a few outspoken (and perhaps senior) people are favoured to the detriment of others.
- **Observation**. The importance of software context within the organizational environment has led to the adaptation of observational techniques for requirements elicitation. Software engineers learn about user tasks by immersing themselves in the environment and observing how users interact with their software and with each other.

However, as the experience in this project shows, there are situations where software engineers are expected to gather requirements from stakeholders who are not even aware of exactly what their technological needs and/or opportunities are. It can be argued that technology availability, its use and a user's general familiarity with it, to some extent, dictate what a software user might ask of a software engineer. In the absence of that a stakeholder might not be capable of providing useful feedback for a software development process. In that case the software engineer has to first find out what the possibilities are and then be able to demonstrate this to the user. A strategy such as live technology demonstrations, for example, then become a powerful tool for communicating with users. By carefully employing the techniques for requirements elicitation listed above, this hurdle can largely be overcome, as shown in sections below. A crucial aspect of this is building trust with stakeholders and creating such an environment that they can clearly discuss their ideas.

3.2 Approach to Requirements Gathering for VOICES

The requirements gathering phase for the VOICES project saw the team visiting a number of rural Malian communities (see Figure 3.2) to gather requirements. This was necessary per the project's proposal and purpose. It was also a step for the group to familiarise themselves with the environment within which the project was to take place. Much of the requirements were elicited through collaborative workshops and discussions with opinion leaders and local stakeholder groups. Another reason for this was also the attempt to bridge a glaring cultural and racial difference that existed during every workshop between the researchers, mostly Westerners, and their local African counterparts.

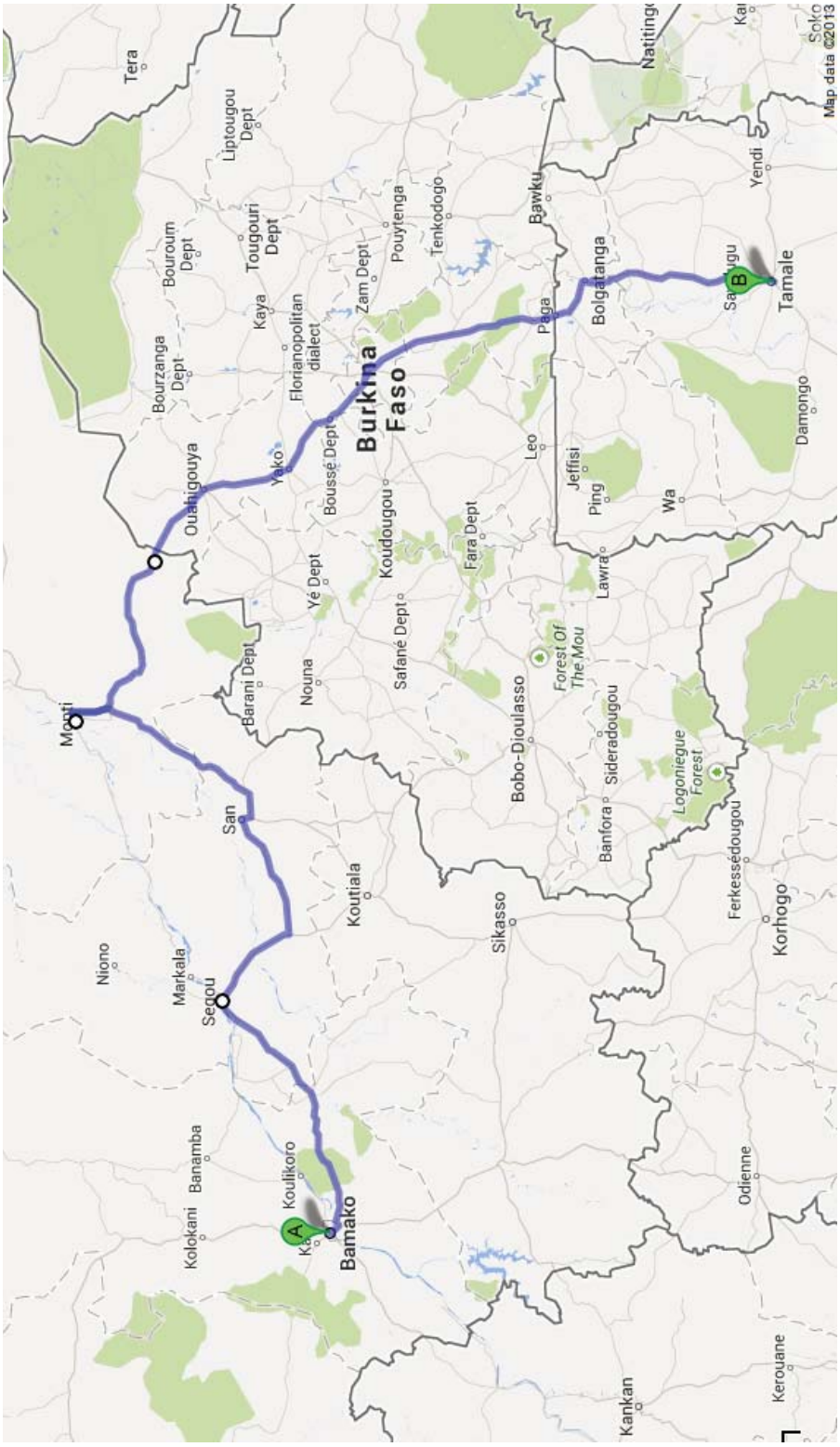


Figure 3.2: Itinerary starting in Bamako, Mali, through Burkina Faso and ending in Tamale, northern Ghana. Specifically this included Bamako – Ségou – Tominian – Bandiagara – Bankass – Ouahigouya – Gourcy – Ouagadougou – Tamale – Bolgatanga and many stop-overs and visits along the route. Altogether, the journey made over a 1000km. Created with Google Maps.

3.2.1 Collaborative and Agile Approaches

Requirements by collaboration explains how to plan and hold workshops to meet two essential needs: efficiently defining user requirements while building positive, productive working relationships [Gottesdiener, 2002, 2003; Leffingwell and Widrig, 1999]. With this approach, similar structured workshops, also referred to as Joint Application Development (JAD) sessions are organised with the aim of getting the requirements accurately through shared vision and clear communications between development and stakeholders. According to Gottesdiener, workshops can be used for many purposes for example, to outline the project's vision and scope, to create a release strategy or iteration plan, or to define requirements in varying levels of detail with the benefits of creating an efficient, controlled, and dynamic setting where you can quickly elicit, prioritize, and agree on a set of high-quality project requirements [Gottesdiener, 2003].

The team had travelled to Mali with a very limited set of use cases possible for the research. Through workshops and carefully designed discussion sessions, many more use cases for possible consideration came up. The format of the collaborations included workshops with invited participants (experts, interested parties, opinion leaders, etc) at different locations along our route from Bamako to Tamale. At other times we visited some selected farmers on their farmlands along with community heads/leaders and radio journalists. On those occasions, discussions centred around their efforts at preventing soil degradation and other re-greening inspired initiatives. This was because re-greening is, to a large extent, a central theme for the farmers in the Sahel (see Section 1.3 of Chapter 1), and central to this cause is farmer-to-farmer visits and knowledge sharing activities which represent an essential aspect of the re-greening knowledge sharing among the farmers. We sometimes also visited radio stations to know at first hand how they operated within communities (see Section 3.2.2). And this was because, in this region, at least for the time that we were there, radio communication was an important voice channel for information exchange. Prevailing factors such as the lack of appropriate infrastructure for other (modern) technologies in the region have made the radio a very dominant medium of information exchange. In these parts of the world, radio technologies act as a local hub for information sharing for entire villages and communities. There also, discussions revolved around their roles in the communities within which they operated and the strategies and business models they employed in playing their roles within communities.

The environment within which VOICES had to operate—both the physical, geographical surroundings with its attending infrastructure deficiencies, and the prevailing sociological and demographic conditions/factors within the communities we worked with—necessitated the need for adaptive planning, evolutionary software development, shorter delivery times, continuous improvement, as well as rapid and flexible response to change. Agile software development methods [Leffingwell and Behrens, 2009] had to be employed in order to achieve this. These methods stand in sharp contrast to the traditional waterfall model of software engineering where contact is only made during requirements gather and user testing phases. Time and budget constraints of the project would not have permitted such a strategy. For the VOICES project, scheduled visits from Amsterdam to the communities in Mali were part of the process, and with each visit an improved prototype of the system and more engagement sessions with stakeholders. This made sure that useful feedback from the community was fed into another

cycle of development to improve the design and incorporate new functionality that had been missed earlier.

3.2.2 VOICES "Road-show"/Field Research Approach

As has been previously mentioned, the requirement elicitation phase of the project started with a project team visit to the capital of Mali, Bamako. Specifically, this was from the 14th to the 26th of January in 2011 where a team of experts from the Vrije Universiteit (VUA) in Amsterdam, together with partners from the Web Foundation,[2] travelled to Mali with the aim of meeting local people for discussions sharing of ideas on the possibilities for voice-based services in the region. The primary objective of this road-show (see again Figure 3.2) was to demonstrate services envisioned under the broader aims of W4RA [Bon et al., 2013; VOICES, 2011]. In Bamako, our partner was Sahel Eco—a local NGO with over twenty years of working experience with farmers in the region (see Figure 3.3 below).

Figure 3.3: The NGO, Sahel Eco, has worked with many rural farmers within the Sahel region of Africa over the years on many different projects. This signpost in Tominian shows one of such projects. Credit: Anna Bon.

The key idea behind this road-show was that all the key learnings from the field would be pooled in to crystallize a set of services, which would then constitute the core of W4RA technology offering [W4RA, 2011]. The target audience for the road-show included VOICES African project partners, NGO partners in Mali (specifically Sahel Eco) as well as others in the

[2] http://www.webfoundation.org

subregion (namely Burkina Faso and Ghana), agricultural extension agents and ICT practitioners from the regions. Field research conducted during the period included focus group discussions related to the technology demonstration(s) with (agricultural) extension agents, farmers and ICT practitioners. Qualitative data and usability feedback that was collected at each demonstration site was then pooled in during subsequent brainstorming sessions to finalize the technology services offering for the project.

In the process, we gathered useful insights related to the work of farmers, extension agents, community radio stations, farmer cooperatives and NGOs, and how they generate and consume information with the available infrastructure. A number of interesting but previously missed use cases were gathered as well. For example we gathered that overall, the radio is the de-facto means of information across the Sahel and that people use it for a variety of purposes [VOICES, 2011]. These purposes, depending on the internal programming of the station, could range from broadcasting information related to lost or missing farm animals to more general *infotainment* purposes where the radio delivers a mix of general information for public consumption and entertainment. In each case of these programming however, there were defined business models in place to sustain these services whether the radio station was a privately owned enterprise or a government establishment.

Again, it was discovered that farmers, farmer representatives, extension agents, community workers, young and old all either had mobile phones or had access to one (or more) in some form. Access to a phone in this case is where the user of a telephone might not necessarily have the means to own a phone but occasionally uses the phone of others for private businesses. This is quite a common practice in some parts of rural Africa. In some cases, as we discovered in Bolgatanga in Ghana, organised women groups shared mobile phones with other women in the community who could not afford the total cost of ownership. Also, it came to light that within the region mobile phones have a variety of purposes for different groups and people. An example we found was with a milk seller in Tominian (in Mali) who called her distant clients. Another example is calls from community watchdogs in the field for help to arrest individuals seen flouting a community-wide re-greening rule against the cutting down of trees without a permission.

3.2.3 Technology Demonstrations

Each workshop organised at the various stop-overs followed a pattern; first, Sahel Eco representatives introduced the VOICES (and W4RA) projects to the workshop participants as well as the aims and objectives of the workshop; and then a technological *demo* by a member of the team that showed the possibilities of recording a voice message and retrieving it from the computer. One of these *demos* comprised of using a software that ran on a laptop connected by a wire cable to a microphone. It was necessary to make these systems look as simple as possible to the locals since many of them in almost all our meetings were seeing such demonstrations for the first time.

Another technical demonstration that followed was one which showed the possibility that voice message recorded from a mobile phone could be sent to and broadcast on radio from a computer. The ideas behind this *demo* was to give insights to locals on the integration of voice-

mobile and telephony-radio in an offline setting (i.e. doing this with no internet available). This second *demo* was achieved using simple radio transmitters connected to a computer running a software capable of delivering voice/audio recordings.

Figure 3.4: In order to elicit as much use cases and generate useful discussions and interactions with locals as possible, technology demonstrations formed a major part of the success of our road-show. This picture shows one of such cases in Gourcy in Burkina Faso where the author shows a demonstration of a prototype while some members of the team look on. Credit: Anna Bon.

After this demonstration, there was a presentation on farmer helpline initiatives in India. This was about a project in rural parts of India which have conditions similar to the regions we visited and where the exchange of knowledge among farmers was enabled and/or enhanced through an expert network and an operated knowledge base. At other times also (when internet connection was possible through data networks provided by available mobile telecom operator), a demonstration was presented on using Geographic Information System (GIS) tools such as OpenStreetMap in showing the possibilities of mapping out the villages of various farmers as well as mapping out other relevant spatial data for communities (see Figure 3.4). As has already been mentioned, these demonstrations were done in such ways to generate discussions with participants most of whom had little experience with and knowledge of these kinds of tools and technologies and services. At the end of the presentations a number of questions and contributions would come from the audience based on which discussions were generated and brainstorming sessions ensued. These discussions were often on business models for such systems, the availability of technological infrastructure, the role of local ICT developers and sometimes even government agencies in improving access and use of technology products and services.

3.3 Accounts of the VOICES Requirement Field Research

Below is a detailed, day-to-day account of what was done at each location of the field trip. Each account includes the activity, its location, the venue of the activity and the date on which this was done outside of Mali. The kick-starting workshop took place in Bamako. That and many more which followed in the two-week period are labelled and elaborated on hereafter.

3.3.1 Workshop at Grand Hotel Bamako, Mali, Saturday 15 January 2011

Participants: A total of 13 guests from several organisations attended this meeting: Radio representatives (Office de Radiodiffusion-Télévision du Mali (ORTM), Union des Radios et Télévisions Libres du Mali (URTEL), Radio Liberté), Association of farmer organisations (Association des Organisations Professionnelles Paysannes (AOPP), Comité Régional de Concertation des Ruraux (CRCR), Fédération Nationale des Femmes Rurales (FENAFER), Coordination nationale des organisations paysannes du Mali (CNOP)), ICT entrepreneurs (Rib_ml Informatique, Internet et Télécommunications).

Discussions: Discussions started after technical *demos* had been presented as has been pointed out in Section 3.2.3 above. The farmer organisation representatives (from the national level) saw a problem in making voice services sustainable, because they could not imagine a business model in which people in rural areas are prepared to pay for a voice-based service.

The ICT representatives (Rib_ml) did not show high motivation to participate in the co-development of voice-based and Web services for rural people. They were only involved in web hosting and data storage and their business portfolio did not include the development of innovative web services. A radio director explained the background of radio in Mali noting that the country has 13 spoken local languages out of which only 2 are written. As at 2011, Mali had 13 million inhabitants out of which only one million spoke French. This was significant to note as it only meant that local languages and voice communications are extremely important in order to reach a wide majority in the country. It was also clear that radio is an important medium to inform and reaches as many people as possible in the country.

3.3.2 Visit to Radio Ségou, Radio Premises, Ségou, Mali, Saturday 15 January 2011 (evening)

Participants: At the radio station's premises, the team met with Mr. Fousseyni Diarra, program maker at Radio Ségou (see Figure 3.5).

Background of Radio Ségou: This radio is part of the national radio broadcasting company ORTM, which also provides part of the funding for this radio. There are few computers at this radio station, but no internet connection. This radio has a coverage radius of 150km. The loyal listening base of this radio are young and old, men and women. Every household in the region owns a radio which can be powered by battery when there is no electricity which seems to be a frequent occurrence.

Figure 3.5: In the picture is a section of group that participated in the workshop held in Ségou. It includes radio journalists and presenters and NGO representatives. Credit: Anna Bon.

Discussion on possible use cases: Sahel Eco runs a project together with Radio Ségou on market information. Price information and names and phone numbers of sellers of shea butter and honey (two common products in this area) are collected verbally, in 20 villages in the environments of Ségou.

In this project, a person from Sahel Eco collects this info verbally, from the villagers going around by motorcycle. This information is collected on a monthly basis and stored in an Excel file on a computer owned by the NGO. The paper printout of this information is given to Radio Ségou which in turn regularly broadcasts this product/price information to the listening public. Three times a day a phone number is broadcast to encourage people to ring and provide more price info, themselves. This service is quite basic and inefficient because incoming voice messages are not recorded or stored digitally in any way. However, the information broadcast is highly appreciated by sellers and buyers of the products given the testimonies from the farmers themselves involved in this project. There was a clear need to to scale this information sharing system up to a more efficient level. In this regard a voice based service, as suggested, was welcomed by the representatives from Radio Ségou and Sahel Eco as such a system offered the potential to increase efficiency by enabling storing and retrieving voice content. Moreover, it was realised that a new system would enhance the quality of the radio programming, while reducing work and therefore costs for the radio as well. However, what was a clear challenge to this new system was a payment platform solution which was none existent in these parts of the region at the time.

Another interesting service delivered by Radio Ségou is the phone-in-and-leave-message or request for music. As simple as it was, a list of 40 songs is broadcast and people can select the

one they want to hear on the radio. People could phone on Sunday and talk live on the radio on a one-and-a-half-hour programme. Being a very popular programme among listeners, the number of incoming calls for music requests or requests to leave messages was much higher than the actual attended calls by the radio people. The problem was that the radio could only attend live calls during the program hour since they could not afford facilities that could record a phone message for later broadcast. The need for voice-based service in this scenario also became apparent. It was also mentioned that revenues for the station came from fixed contribution by the national radio organization ORTM. Others sources of funds are from NGOs (such as Sahel Eco) who pay the full price for announcements and non-commercial announcements (CFA1000 equivalent to about $2 at the time) by listeners.

3.3.3 Visit to Radio Moutian, Radio station's premises, Tominian, Mali, Sunday 16 January 2011

Background of Radio Moutian: This radio station was founded in 2008 when investments were provided by a European development agency for the purpose. At the station (see Figure 3.6) a member of our team was interviewed about our visit and about other general concepts such as the web.

Figure 3.6: Premises of Radio Moutian in Tominian, Mali.

The coverage spectrum of Radio Moutian, we were told, was broad enough that even some of their listeners were in neighbouring Burkina Faso. However, for licence (and other) reasons we could not know the real coverage area of the radio. We are also made to know that electricity use was a major problem for their operations and that the supply of the commodity was erratic. This had affected the operations of the station since it cost extra money to operate a standby

generator.

Discussion on use case: We got to know that the programs broadcast by this radio provided information about agriculture, education, health, civil and legal information (which are often provided by the NGOs) as well as entertainment programmes and on-air music. The radio, we were told, received an average of 200 calls a day from listeners who react on programs and leave messages for others. It was mentioned that non-commercial messages are broadcast for a fee of CFA500 (about $1) each whereas a short commercial announcement costs CFA2500 which represented the means of generating income for the station.

3.3.4 Visit to re-greening fields, farms of a select group of farmers, Tominian, Mali, Sunday 16 January 2011

Later that day after lunch, we visited the fields of Abdulah Tangara and Sounka Lobugou. These are farmers who partake in the natural farmer-managed Régéneration Naturelle Assistée (RNA) program and had done this since 2007, a program encouraged especially by Sahel Eco among farmers. Cash crops produced by the farmer include sesame, ground nuts, black eyed beans, sorghum and millet. It was mentioned that the re-greening activities of Mr. Abdulah won him a prestigious award in the past. This farmer owns a phone but for voice calls only as he does not, for example, know how to use the SMS functionality of the phone.

3.3.5 Visit to re-greening fields of farmer Moussa Sangara, Bandiagara, Mali, Monday 17 January 2011 (morning)

Background of the farmer: Moussa Sangara speaks the *Bambará* language[3] but not French, the official language of Mali. He also started applying re-greening techniques in this region 5 years ago as at 2011. During the time of our visit, 200 villages in that region were also applying RNA on their fields. There was a demonstrably clear reasons for the need of tree conservation by the farmers in the area during the visit. To this end, farmers who fell culprits to deforestation were subjected to social exclusion public shame. For such small communities and villages, this system had worked quiet well and had resulted in vast tracts of re-generated fields from which they feed their families and keep the village alive.

Here, unlike in other regions we visited later, farmers and nomadic herders go along well. The herder's cows and goats graze the fields and leave manure that fertilize the soil, and provide seeds. As long as the herder does not cut trees, it is fine to let his animals graze here. There is indeed documentary evidence to support this claim as has has been done by Allan Savory [Savory, 2013]. Mr. Sangara told us he also owns a phone which he uses mainly for voice calls. He also mentioned interesting programmes on the radio mainly about what he does on his farm makes him to listen to the radio every. The radio was his main source of information for new techniques and best farm practices that were provided by experts from the NGOs which includes Sahel Eco and other agricultural extension officers.

[3] *Bambará* is the widest spoken in Mali even though radio content is broadcast in many different local languages as well.

3.3.6 Visit to Radio Baguiré, Bandiagara, Mali Monday 17 January 2011 (morning)

Background on Radio Baguiré: Radio Baguiré was founded in the year 1994 in the Mopti region of Mali. At the premises, we talked with the radio programming manager Salif Aly Guindo. This radio works like a franchise company for ORTM. The radio station's success comes from small scale programming of local news which are in Dogon and Bamabará and very little of French. The radio has a radius of 150 km with a staff strength of 7 people. This radio is self supporting, thanks also to several NGOs who buy radio airtime. A solar power installation in the backyard provides energy for the radio.

Discussion on use cases: It was realised during round-table discussions that in this part of Mali the programs with the biggest impact delivered by the radio were those on agriculture and health. There are also weekly programs where people call in and leave messages which were also very popular. Themes on these call-ins are mostly on social interaction and agricultural topics. For example, farmers phone to the radio to inform about the actual amount of rainfall on their land. Radio collects this info by writing it down in a book as a form of documentation, and then broadcast it to others. And because rainfall in these regions are often low, such announcements on rainfall on radio alert others about possible rainfall in their regions which help them make proper plans and decisions for their farming/herding activities. People pay a flat fee (CFA500, about a dollar) to have their messages broadcast.

3.3.7 Workshop at Bandiagara, Hotel Togona, Bandiagara, Mali, Monday 17 January 2011 (afternoon)

Participants: There were 14 participants including representatives from community radio stations namely: Radio Ségou, Radio Moutian, ORTM Mopti, Radio Seno Bankass, Radio Baguiré, and seven farmers from nearby towns namely Bankass, Tominian, Soungalobougou, Gongon, and Yawakanda.

Discussion on use cases: After the demonstrations of what was technologically feasible with voice-based services, it was followed by thorough discussions with participants. From the discussions we learnt that there is enthusiasm amongst farmers and radio people for innovative voice services if it was accessible through mobile phone. Unlike the national farmer umbrella organizations in Bamako and other urban parts of Mali, these participants (farmers and radio people) could imagine useful application of voice services. An example they mentioned was voice services integrated with radio and voice directory services that can identify experts on certain subject (e.g. agriculture), voice messaging services, question and answer voice-based services and general market information of products and prices. Also, in this region, when it is time for vaccination of animal herds (an activity which engages many farmers), vaccination events could easily be organized using voice services, says herder participant Idrissu Sangué. Voice-based information about health (e.g. for pregnant women, how to treat malaria and others) is also useful. One participant mentions what could be named a "Voice Forum", a

voice based system where people can leave messages and react on each other's messages, on a certain topic, within a certain group or community. All these useful suggestions came from the farmers themselves some of whom had heard of these services only for the first time from us.

Thoughts on business model: Participants also gave their thoughts about the business cases necessary to pay for voice services. They believed people would be prepared to pay for a service that would save travel time, or will provide useful and relevant information (for e.g. prices of products from different market centres). It was mentioned that people liked to exchange information without having to travel around or not having to phone many others at different times and repeatedly telling them the same message. We shared in their opinions on this but the challenge at this point again was how to technically integrate a billing system with voice services we proposed to take care of the flow of money from information producers to consumers.

3.3.8 Field Trips in the Yatenga region, farm fields of farmer innovators, Yatenga, Burkina Faso, Wednesday 19 January 2011 (morning)

From Bandiagara in Mali we travelled towards Burkina Faso the next day. In Burkina Faso, we met with our partners there in re-greening initiatives, Adama Beleviré and Mathieu Ouedraogo (of Réseau Marp and NGO in the region), we visited farm fields near Gourcy of farmer innovators Ousseini Kindo and Yacouba Sawadogo (The latter is Mark Dodd's protagonist in the award-winning documentary "The man who stopped the desert" [W4RA, 2010]). Both farmers are well known farmer innovators in the region and around the world. They started more then 20 years ago their re-greening techniques and have now restored a broad area of land and converted it into agro-forest fields.

Discussion on use case: Both Yacouba Sawadogo and Ousseini Kindo said they received many calls per day for regular visits by farmers and farmer organizations who want to learn more about their re-greening techniques and innovative agricultural practices. These two farmers are really considered great experts on agriculture and especially on re-greening in the region. The fact that Yacouba and Ousseini do not read or write, and do not speak the Malian official language, French, supported the urgency of deploying voice based services use case to collect and store spoken knowledge in local language for a voice-based knowledge base as we had envisaged.

3.3.9 Visit to Radio La Voix du Paysan, Ouahigouya, Burkina Faso, Wednesday 19 January 2011 (morning)

After the field visit, we went on to the radio station "La Voix du Paysan" (i.e. the voice of the farmer) in Ouahigouya in Burkina Faso. At the radio the team was interviewed on a live broadcast about the VOICES project and the development of voice services.After we had be been shown around the facility we moved on to Gourcy.

3.3.10 Workshop at Gourcy, CARE International Offices, Burkina Faso, Wednesday 19 January 2011 (afternoon)

Participants: About 18 participants from farmer organisations (innovative farmers from the Yatenga region) and seed producers at national level in Burkina Faso came for this workshop.

Discussion on use cases: The Burkinabe Seed Producers is an association united in a large organization which is responsible for certification of seed products. They operate at four levels: national, regional, provincial and community levels. The process of seed certification was initiated and financed in 2009 by a project by the Food and Agriculture Organisation (FAO) of the UN, but has finally to become self-supporting, financed by the end-producers of seeds at community level. End producers pay a fee to have their seed products certified.

One problem that came up during discussions was that producers never provided information on the size of their seed stock. The whole process of collecting information of the seeds at community level was at the time done by hand on a manual, paper-based system. This information was collected by extension agents from the national seed producing organisations, who went to the villages. Here also, they suggested that this whole process could be facilitated by using phone and voice channels, especially if there would be a way to collect the certification data of the seeds by phone as well as making the payments through mobile phone.

Thoughts on business models: Here, the organization of innovative farmers was concerned about the costs of voice services. However, it was thought that if the payments that the seed producers made through seeds certification could be done through a mobile payment or anything of the sort, it would increase efficiency of the information collection and the entire certification processes. Despite the numerous questions on the feasibility and the business models for voice based services, the participants were sympathetic towards the idea of voice-based services.

3.3.11 Workshop at Ouagadougou, Hotel Ricardo, Burkina Faso, Thursday 20 January 2011 (morning)

Participants: Adama Belemviré, Mathieu Ouedraogo, from NGO Réseau Marp, Prof Oumarou Sié, Professor in ICT at Université de Ouagadougou, and Mr. Mousssa Ouedraogo, programming manager from the Ouahigouya Radio La voix du paysan who was the radio reporter who interviewed us the day before.

Background of Réseau Marp: Réseau Marp is an NGO in Burkina Faso with a similar mission as Sahel Eco has for Mali and that is to assist and promote RNA in the region. It is also one of the partners of Centre for International Cooperation (CIS) at VUA's re-greening expert, Chris Reij, who was also part of the team, in the African Re-greening efforts. The NGO does this in rural environments by facilitating knowledge exchange between farmers and especially with assistance of farmer innovators like Yacouba Sawadogo and Ousseini Kindo. In the long term, the goal of the NGO was explained to be to monitor the impact and scale of the actual re-greening activities, e.g. number of trees over a period of time.

Discussion on use cases: We discussed the similar subjects regarding voice-based services for farmers, radios and NGOs. Mr. Ouedraogo and Adama Beleviré from Réseau Marp showed enthusiasm for voice services in order to support information diffusion on re-greening activities, and collection of information from farmers. Their special interest was in the web-based GIS which had been described by a member of our team. In the demonstration, the possibility where any kind of information could be plotted on an OpenStreetMap site, be it visuals only (pictures, video) or with voice-recorded information, which could be very useful for farmers. The usefulness of such a tool was thought to be in the possibility to keep track of re-greening activities in the fields. Especially, NGOs organisations in this region, like Réseau Marp, are interested in mapping spatial data, and also in an interfaces that enable voice-based as well as with the World Wide Web. An idea was suggested by a participant for such a thing as a "voice-based social network", analogue to e.g. Facebook and other services analogous to social media tools.

Thoughts on business models: It came out that there are several options to make a voice-based system financially sustainable. One of them is making users pay a fee for each phone call, which we realised was a possibility if they benefited from the information they got from the service. The second option was finding sponsors to fund projects. Therefore, the possibility of applying for sponsoring of radio stations from telecommunication providers was discussed. In the end it was agreed that when radio stations start to collect and exchange voice content through a phone-based system, they will increase the network traffic and therefore the revenues for them as well. This implied that if radios stations could become voice content-providers, they could apply for sponsorship or support from the telecommunications providers, a common practice in the internet business. However, it was necessary to discuss this with the local telecommunications providers. This suggestion is what we demonstrated by the inclusion of France Telecom with interests in Mali as a partner in the VOICES.

3.3.12 Workshop in Tamale, Modern City Hotel, Tamale, Ghana, Saturday 22 January 2011

Participants: From Ouagadougou in Burkina Faso, the team headed to Tamale in Ghana. There we had our first workshop in Ghana with invited participants which included ICT developers, Staff members of the University for Development Studies (UDS) in Tamale, representative from the Ghanaian Ministry of Food and Agriculture, radio stations namely Radio Savannah , Simli radio, Ghana Broadcasting Company and a number of local NGOs: Trax, Groundwells, World Vision. Here, team introductions are made and then a short presentation is made by a leading professor from the university about development related initiative he and his research team are undertaking in Ghana. The university has a multi-disciplinary approach to (rural) development issues based on a so-called problem-based learning methodology. He mentioned that students of UDS are sent out to the fields every year of their study, to learn and get acquainted with the reality of rural areas and communities.

Discussion on use cases: The discussion focused first on the technical aspects of a voice based

system. ICT people wanted to know details, and were concerned with the technical aspects because ICT technical and organizational maintenance was considered a problem in Ghana. The NGOs at he meeting showed some reservation because they confessed they had heard about other ICT initiatives that had not been successful in the region and some parts of Africa (e.g. some projects in East-Africa), although they admitted that conditions were very different than in the VOICES project.

These NGOs present at the meeting were more concerned about the necessity of bringing information to the rural people they work with. Their interests in voice-based systems that we proposed was based on the prospects that these services promised in encouraging the exchange of local content by rural people themselves. For most of the NGOs at the meeting, voice-based services was new to them and found it to be a novel approach. The issue of literacy of farmers was also mentioned, and the possibility to use local languages in voice services was stressed by the participants. A presentation given by one of the NGOs present was about an ICT project on agriculture market products in Ghana named Esoko. There was pilot still running in Ghana and Liberia at the time of our meeting. The system described was mainly SMS-based. Farmers received mobile phones, financed by the project and they were asked to send information on their products by SMS. If farmers were illiterate, they could bring their children or neighbours, who knew how to operate the SMS functionality. The envisaged development impact of the ESOKO pilot, as was mentioned, was: (1) improvement in access to market information by the participating farmers and; (2) these farmers easily communicate among themselves.

They also mentioned a few of the challenges encountered such as (1) that information is not updated frequently by the farmers; (2) a limited number of farmers could participate in the project where only a selected group of farmers that had been trained and; (3) the system is difficult (not user-friendly) for less trained people. It also came out that the set up of this market information system is large-scale in terms of spatial coverage, so not all info is relevant for all participants. There are also many technical challenges with the system with very high downtimes. At the time of our visit much of the activities on the platform were sponsored and sustainability on the long run was not evident. Abukaari Fatawu from Simli Radio explained that the station had a program to train farmers on when to plant certain crops at which season. In Partnership with an NGO, they trained how to plant *neem* trees, and information on food preservation. People could call in and leave questions and answers during a programme. They also did collection of market information at some in time but one of the problems that they encountered was that market people sometimes did not want to share their info with the radio people with aim of maintaining their prices and reducing competition.

3.3.13 Field visits to villages/farms of locals, Bolgatanga, Ghana, Sunday 23 January 2011

World Vision, another NGO active in promoting farmer-managed RNA introduced us in two villages Yameriga and Tongo-Beo near Bolgatanga where the re-greening project had been implemented since 2008.

About Yameriga and Tongo-Beo: These villages were one of the few that was selected by

World Vision to actively support to implement RNA. They started re-greening activities in 2008. As a rule, trees were no longer removed from the fields and neither pruned nor burning of the fields. Also, because of the dry nature of the climate in the area stone lines had been made to improve contouring and avoid running rain water from washing away fertile soil. The village produced Shea butter mainly of good quality which was sold on local markets. At our arrival, we are welcomed by about 50 singing and dancing women, and next by a circle of about 150 villagers, men and women and the chief of the village. The dialogue was translated between English and the local language. Many people wore re-greening T-shirts from World Vision indicating their active participation in the project. After exchange of pleasantries with protocol we held an open forum discussion about mobile telephony, re-greening and knowledge sharing. Afterwards we made a tour around the surrounding fields with young Shea tree sprouts that were being protected.

Discussion on use cases: In these small villages of about 400 inhabitants, about 1 out of 10 villagers owned a mobile phone at the time (see Figure 3.7). The users explained that their phones were used for social interaction and for business purposes. Being mostly a farming population, outsiders very often need market information and therefore the phone come in very handy. We also discussed the possibilities of a payment service based on mobile telephony and the benefits such a system could have especially for women who want to save money. Next, we visited another re-greening village supported by World Vision.

Figure 3.7: This picture shows some of women from the group that welcomed us to their village for outdoor discussions. A woman proudly shows her phone to show she owns one. Credit: Anna Bon.

3.3.14 Workshop in Bolgatanga, EX-TEE Crystal Hotel, Bolgatanga, Ghana, Monday 24 January 2011

Participants: Representatives from Ministry of Food and Agriculture (MOFA) in Ghana, Single Mothers' Organisation of Farmers, Association of Church Development Projects (ACDEP) (also working on agriculture), Ghana Broadcasting Company (GBC) and other NGOs that work with mostly deprived rural communities in northern Ghana including World Vision.

Discussion and use cases: The MOFA representatives were more concerned about the information that will be exchanged than with the voice channel itself. This concern got a reaction from two farmer representatives stating that the government was not supporting information sharing by farmers at all. The business cases were questioned because most of the participants assumed that there has to be some input in terms of finance from government or from a development agency. However, a number of people also agreed that for projects to be sustainable, there had to be a way of self-financing these projects.

3.3.15 Team Debriefing Sessions

The next type of activity in the requirements gathering efforts during the road-show was in the form of group debriefing sessions after each workshop and visit to fields. Along our route many such sessions were held the purposes for which were mainly finalizing points and sharpening thoughts and ideas of the day. In the last periods of our travel, the group also had a major debriefing session to sum up all the ideas. This last session was held on Thursday, the 20th of January 2011 in Ouagadougou and the reason was also that other members of our team needed to travel out on other engagements. During this meeting a number of key points identified during the trip were brought up to be finally deliberated upon.

In summary, the key points agreed on key learnings from the technology demonstrations, analyses of the many use cases that had been collected on the trip and the way forward with them, an implementation plan for the systems we propose under the VOICES project [see the VOICES proposal, VOICES, 2010]) and our a planned partnerships with the radio stations in some of the communities we had visited on our way. These points are expanded on below:

1. **On technology demonstrations key learning**: It was decided that the key learnings together with use cases will lead to the technology pilot and service architecture and that the prototypes used in the demonstrations would be improved further as the real implementation. It was agreed that content creation and management would ride on top of technology that we decided to pilot-test since that had come up strongly from the various communities.
2. **On use cases**: The group had to decide on which of the use cases collected was desirable for implementation. This decision was necessary in the light of the time and resources available for the project. As of the time, the two broad categories of use cases that had been collected were:
   a) use cases on announcements and broadcasts by individuals from communities on the radio which were either free or at specified rates.

b) the other broad use cases were on all other radio programming which offered the ability to call in live during the time of radio broadcast using mobile phone.

At this meeting, specific use cases that had to be incorporated as pilot service(s) were yet to be decided on.

3. **On implementation**: On implementation, we deliberated on practical steps towards implementing the use cases to be decided on. This also was necessitated by the need to make sure the prevailing conditions at the time – logistics, infrastructure, stakeholder involvement, etc. – were all taken into account. This culminated in deciding on implementation tasks and the form they should take as well as finalizing responsibility action points among project partners. In the end, it was agreed that it was necessary to develop a baseline functionality which could be improved upon with time.
4. **On partnerships with radio stations in Mali**: In order to successfully deploy services with a partner radio, we agreed that it was also necessary that the radio had stable infrastructure for their operations since that meant better services for their clients, and most likely, huge listening base. Factors such as poor electricity supply easily crippled private ownerships of radio in the region.
5. **On service architecture**: For the service architecture, it was decided that the service offering should be related to farmer groups and NGOs as well as with cooperative groups for the purposes of making it more inclusive in access and in nature. Mali also was the preferred place for the initial pilot since we already had partners (Sahel Eco and others) there some of whom were part of the project. It was also decided that, if possible, existing local processes of information and knowledge sharing activities could be enhanced for a better chance of project success.
6. **On baseline functionality of system**: The baseline functionality of the proposed system after the road-show was thought to be the following:
   a) A robust but simple technology service for a known target group for whom the project was being undertaken.
   b) A system that easy to use and to manage.
   c) A functionality for the ability to allow remote install and maintenance.
   d) If possible, the proposed system should provide help desk services.
   e) The usage of the system should involve as many locals as possible who could also be trained in the process.
7. **On the role of ICT developers**: During the debriefing session, the role and importance of local ICT developers was also discussed. The discussion brought to the fore our struggle to identify local expertise who could be partnered with on the project. In Mali for example, there was only a handful developers who were usually also only in big cities. In the rural parts of the country they were mostly non-existent. In the end, it was decided that those found later could be engaged on contract basis only. On that score also, the need to identify and train local people in ICT as part of the project and especially those who could work on our tools and technology offering came up and was discussed. This was to be a step that would yield benefits later in the project when there was say, troubleshooting needs for a service or a system functionality.
8. **On infrastructure**: At the time, it was also important to decide on which telecommunica-

tion infrastructure to be used. Eventually, a project partner, France Telecom, was decided on. Their major responsibility was to build a platform on which all the services to be developed would run. They would also provide mobile telecommunication connectivity as well as access to useful APIs on their telecommunication infrastructure in Mali. This was possible because of their significant operations in the region through their subsidiary Orange Mali in Mali.

9. **On monitoring and evaluation (M&E) and their formats**: Lastly, at the debriefing session, it was also agreed that it was important to track pilot usage data. To this effect, it was agreed that M&E formats should be designed parallel to development and deployment phase.

3.4 Use Case Analyses for Voice-based Services

3.4.1 Method

The last debriefing session helped to crystallize the main ideas for possible use cases. Chief among the ideas to be used for this analysis was on what was to be the baseline functionality for the proposed system – the system had to be robust, easy to use, easy to manage by users and the possibilities for remote maintenance and support. The reason this was important was because it provided the headline basis for which the various use cases were to be analysed. Subsequently, the use cases were further sorted into groups after they had been properly identified. Some of the use case were on ideas obtained from discussions and brainstorming sessions during the various workshops described in different sections of the chapter. Other use cases were also on legacy running services which offered opportunities for further enhancements with technologies given available infrastructure. The initial groupings were based on which types of voice services would benefit from which type of users or consumers. The main beneficiaries were identified to be:

a) Radio Stations who worked in these communities.
b) Farmer organisations who worked with farmers in the communities.
c) NGOs who work in these regions.
d) All other services thought be useful but are not under any of the three above.

Under each user group, a number of use cases are derived. This is explained further in the sections below together with the types of services envisaged.

Use Cases for Radio Stations

For rural community radio stations, a number of services were seen to be viable because of their roles in these communities. Given the predominant use of voice mobile calls and radio in daily information dissemination activities, it was realised that voice related technologies could be used to enhance already running services. Enhancing such services would then help the radio stations to better relate with their numerous loyal listeners. On the other hand, many of these radio station only had the typical rural Mali settings of running such facilities (see Figure 3.8 for example) which means mostly analogue equipments and nothing state-of-the-art.

Figure 3.8: A typical set-up of rural radio stations along our route. Government-funded ones have slightly more facilities such as sound-proof studios and standby generators. Radio stations in these region have a huge listening base as a result of their programming and they play a central role in the information dissemination channel in the region. This is a photo of the studios of Radio Moutian I took in Tominian of Mali.

It was therefore thought that those stations could also benefit from the technologies we promoted and would eventually help them in their information dissemination, archiving and backup needs. Use cases for services for the radio stations included the following:

R1. An already running radio programming that allowed callers to phone in and record questions on a topic which are then later forwarded to experts for answers offline. Another form of this service was making a broadcast where an expert or the local people answer from a selection of the questions usually related to daily live and work activities. This was a service that was ran by Radio ORTM Ségou.

R2. A similar use case to this is a voice service where questions are broadcast and listeners phone in with answers either while the programme is still running or recorded to be broadcast later. Almost all the radio stations which had facilities to support this type of service had this running in one form or another.

R3. A use case of a voice service of questions and answers (Q&A) saved and sorted to build a knowledge data base which callers can access by mobile and voice in local languages also seemed viable. This was an idea that came up during one of our debriefing sessions.

R4. Another use case which was a particularly popular radio service was one where listeners phone in to radio stations and leave announcements. Some of the announcements were free of charge but others required payments. The only technological drawback of this was the need to include payment methods in order to make the service any meaningful. Almost all radio stations in the region did this as part of their programming.

R5. A use case on a service to allow access previously made broadcasts and/or announcements

via mobile phone; broadcast would be saved locally and retransmitted (this was thought to be appropriate for radio stations without internet access). This idea also came up during the team debriefing sessions.

R6. A use case of implementing a call-back service for farmers when a reply from an expert is available on a previously asked question.

All the envisioned add-on services above for the radio stations were only possible as far as the available hardware and the technological infrastructure at the time could support. Also, the use cases were ideas that came up from analysing the the modes of operation of the various radio stations.

Farmer Organisation Related Use Cases

Quite a number of farmer organisations met during the road-show and especially in Mali were usually formed by local farmers who shared a common interest. There were other also that had been formed out of initiatives of local or international NGOs who work with them sometimes offering them training sessions as well on farming related activities. The main reasons behind these groupings are generally because of the benefits that often characterise numerical advantage and authority. Some other reason is as a means of helping one another on their various farms often going in turns to every member's farm to help them when they need it.

During the analyses of the use cases, it was clear that a number of voice-based services could be of immense help to this group as well. Thus, use cases for this group were identified and they include the following:

FO1. First is a use case on a mobile/web service for calling together or contacting and organising members for meetings. This was to be in a form of a simple mobile-based service to be used by leaders to send out broadcast announcements to a list of participating members could be implemented. It was thought that this service would have such functionality as user profiles, meeting agenda, etc.

FO2. Another is a use case on member to member types of grouped voice messages similar to electronic "mailing list(s)" for emails. This was thought to be appropriate such cases as fire alerts on farms, wood cutting alerts, meeting announcements and general information to members of an association. For specialists in the field (e.g. pastoralists and agricultural extension officers who work with farmers) information about availability of grazing and water, obstructions to livestock corridors, border crossing, health alerts or disease outbreaks etc. would then be appropriate.

FO3. A use case on organising group purchases (e.g. for certified seeds such as sesame, Shea butter, honey) and making payments to individual producers who don't have bank accounts. Here, as has been stated in this chapter, the problem of a payment platform comes up if this use was to be implemented.

FO4. An NGO-supported market information system linking individual or grouped producers to buyers. From large scale productions ranging from milk cooperatives in Bankass in Mali, Tominian sesame producers and nation-wide Shea nut/butter and cotton producers to small-scale merchandise on Non-timber Forest Products (NTFPs) in general. This use case is run in different forms and scale from different regions across rural Mali and some

parts of Burkina Faso and Ghana. It was thought that they could be improved in several way especially with technologies for increased efficiency.

FO5. A use case on an advice help-line such as farmer to expert and farmer to farmer communications and advice services on matters on, say, technical and legal advice and best farming practices.

FO6. A use case on voice-based system on payments, savings and banking services for rural people. Here, it is important to note that many farmers we interacted with in the region are far from mainstream or rural credit and savings systems and do not have bank accounts at all.

Use Cases for Development Organisations

The third group of users around whom another set of use cases were built were local and foreign NGOs. All along our route during the road-show, there were visible signs of quite a number of both local and foreign development-oriented NGOs who work in these regions, most of them announcing their presence and work within a vicinity in the form of signposts and billboards. Most of the international partners have offices spread across the different regions in all the three countries visited. Their roles have largely been that of facilitating development projects and developing locally relevant programmes aimed at helping with development the local community. That role is anchored on the understanding that these interventions help with economic empowerment of locals (refer to Section 1.1 for more on this).

For this group also, the use cases included the following:

DO1. Use cases on services similar to those of farmer organisations where information could be sent to and from leaders and members of community and producer organisations. In this instance however, this could be used for announcing training seminars, visits and meetings. Also, sending out agricultural extension related messages, advice helpline notes with the service could be practical.

DO2. A use case on a voice-based service on recordings of important information and documents such as those on farmland best practices, technical advice, laws etc. translated in local languages, with the possibility to be shared with other development partners.

DO3. A monitoring and evaluation tool such as a map (GIS) for geo-locations and numbers of e.g. farmers involved in re-greening, honey producers together with functionality of profiles of these farmers. This could be extended to include carbon monitoring and verification services in collaboration with local research organisations (an example is what the Rural Economy Institute (IER) does) in Mali.

DO4. A use case on a voice-based service on anti-corruption or on local empowerment tools. This was suggested by a farmer in Mali during one of the workshops there.

3.4.2 Selection of Use Cases for VOICES

After categorizing the various uses, external factors made it imperative the list of use cases to be further reduced. For example, a quick and cursory look at the above enlisted use cases reveal those that are quite feasible and others that are practically not feasible given the timeline of the

project. As a result, the list of use cases was further trimmed down to a final list for the VOICES project.

This second selection was based on three main arguments namely; (i) the *difference in value* the project would make in the lives of people in the community which would be selected for the project after its implementation; (ii) the *value for money* in the context of the project and then; (iii) the *complexity of implementation* given the time frame of the project which was essentially a donor-funded one.

To this end, a set of criteria was developed and used for analysing the use cases further. This criteria was also used in then making comparisons for the already identified use cases. They were grouped into three as

a) **Criterion A:** the conditions that each of the use case should satisfy.
b) **Criterion B:** the technical requirements that should be satisfied.
c) **Criterion C:** the desirable functionality of implemented systems.

Each criterion was then further expanded to fit the context within which it was likely to satisfy the execution of the project. Those then became the parameters within which the grouped use cases were analysed.

Under *Criterion A*, it was necessary that each use case satisfies the following conditions:

- **Involvement of a radio station in the use case.** The reason this was important was because the radio is the most important medium of information exchange in the region. This also meant that that in order to reach the masses, the radio had to be necessarily involved for its "multiplier" capabilities.
- **Involvement of a local NGO as service provider.** For our purposes Sahel Eco (a partner in the VOICES project) became the local NGO of choice. The reasons for this were that firstly, with they being part of the project they could offer a much needed direction as far as local Malian content was concerned. Secondly, their experience in the region came in very useful since their long stay in the region had helped them to build trust among local people. Lastly, we noted that, in the case of Sahel Eco, they already had some projects running which could easily be adapted and further improved under the project.
- **Involvement of another NGO or farmer organization.** The final condition under this criterion was to ensure that either an NGO, preferably local, or a farmer organization was involved in some form in the project. This was taken care of with the involvement of Sahel Eco as they had been working with farmer organizations in Mali for years. The condition of this criterion was borne out of the necessity to expand our services and form new collaborations along the way of the project.

The second criterion, *Criterion B*, bordered on which technical requirements were important for each use case within the context of the project. This was important given the limited infrastructure that was available within the region of interest. Also, it was a hard requirement under the project in expanding technological innovations in the region. The requirements included the following:

- **That a web technology will be associated with the service**. We realised that though even though internet use was not pervasive in the rural areas, some had access to it. Those who had access were using the mobile telecommunications infrastructure available (through proprietary provider internet modem dongles) which allowed access to

the WWW. These modems however offered low bandwidths. By promoting the use of Web technologies even under low bandwidth conditions, the project aimed at improving acceptance and use of the Web within the regions.

- **The system to be built was to be hosted by a local or remote hosting service**. This need was informed by the fact that local partners did not have the means to host the service and/or hardware. Also, there was the lack of expertise and know-how on the services we proposed and therefore had to be helped to do this.
- **Internet connectivity would be required for some end-users of the services**. This meant that services had to be taking into account the low bandwidth situation in the region. This discussion also triggered ideas for systems that could work offline and automatically updated once connected to the internet.

A very important reason for this criterion also is that of the importance that the Web plays in information sharing and storage needs. It has be acknowledged also that in the urban regions of Mali, and particularly the Bamako the capital, Internet services are available (although much of it is characterised by low bandwidths).

Finally, for *Criterion C*, a random set of desirable functionality for the envisaged system was listed. This list was based on all the use cases that had been elicited although each functionality should satisfy both criteria A and B above. In summary, it was envisaged that the implemented system should or could have the following:

- An automated phone dialogue system with options.
- A voice-based user profiling service.
- An alert service either through a phone-call or SMS-alert.
- A group alert service either through a phone-call or SMS to alert a group of phone numbers.
- A voice-based service that allows the retrieval of information via phone.
- A phone-based payment service with the possibility of making an advance payment for a phone-call.
- A voice forum service with possibility of adding new information to an existing one.
- Language support: dialogue to ask for language, several languages.
- A database management support in order to digitize as much information as possible.
- A GIS tagging tool to allow user-provided voice-information capable of being plotted on a map.
- Content tagging tool with possibility to attach tags to certain info.

Subsequently, a short-list of sixteen (16) use cases was compiled from the various groups in Section 3.4 to be the use cases that held promise of implementation given the constraints and our resources [Bon et al., 2013]. This set was labelled under the m-agro pilot for the project and they are listed in the first column of Table 3.1.

3.4.3 Final List of Use Cases

In order to agree on which of the 16 use cases to work on under the VOICES project, stakeholders had to agree on which one suited the purpose. To this end, the MoSCoW method[4] was employed.

[4] https://en.wikipedia.org/wiki/MoSCoW_Method

Table 3.1: The use cases matrix using the MoSCoW method

	dialogue system	store user info	alert phone call	group alert	retrieve info	electronic paymnt	voice forum	languages	database mgt	GIS tagging	content tagging	user profile
1. m-Milk ordering & delivery service of Tominian – milk producers and NGO	*M*	*M*	*S*		*M*							
2. m-Tree protection alert service Sahel Eco – farmers and NGO	*M*	*M*		*M*	*M*	*S*	*S*					
3. m-Web Event organizer for herd vaccinations – farmer organisations	*M*	*M*		*M*	*M*	*S*		*C*				*S*
4. m-Farmer-expert directory service – farmer organisations	*M*				*M*			*C*	*M*			
5. NGO info-line on legal issues in many languages – Sahel Eco	*M*				*M*	*S*		*C*	*M*		*M*	*S*
6. Leave announcement/select a favourite song – Radio Ségou	*M*	*M*					*S*	*C*				
7. Shea butter & honey trading service – Radio & Sahel Eco	*M*	*M*			*M*			*C*				*S*
8. Access radio programs and announcements on phone – Radio	*M*				*M*			*C*	*M*			
9. Seed certification service – farmer organisations	*M*	*M*		*M*	*M*	*S*		*C*				
10. Radio questions & answers about agricultural issues – Radio	*M*	*M*			*M*			*C*	*M*		*M*	*S*
11. m-collective purchase organizing service	*M*	*M*		*M*	*M*	*S*	*S*					
12. m-GIS re-greening service – Sahel Eco	*M*	*M*			*M*				*M*	*M*		*S*
13. m-Farmer social network	*M*	*M*						*C*	*M*		*M*	*S*
14. mobile-web larger scale market system, – Farmer organisations	*M*	*M*	*C*	*M*	*M*	*S*	*C*	*C*	*M*	*C*	*M*	*S*
15. Sahel eco portal for re-greening and access to m-services	*M*	*M*		*M*	*M*	*S*		*C*				
16. m-event organizer for re-greening events	*M*	*M*		*M*	*M*	*S*		*C*				*S*

Legend: M = Must Have S = Should Have C = Could Have m = mobile

The method is a technique used in business analysis and software development to reach a common understanding with stakeholders on the importance they place on the delivery of each requirement. Eventually, the 16 use cases obtained were mapped in a MoSCoW matrix together with Criterion C in order to decide on which of the use cases to work on under the VOICES project.

Table 3.2: The final set of use cases under the VOICES Project

	dialogue system	store user info	alert phone call	group alert	retrieve info	electronic pymnt	voice forum	languages	database mgt	GIS tagging	content tagging	user profile
Shea butter & honey trading service by Sahel Eco and local radio stations & Sahel Eco.	M	M			M			C				S
Sahel eco portal for re-greening and access to m-services.	M	M		M	M	S		C				
A mobile event organizer for re-greening events and activities.	M	M		M	M	S		C				S

Legend: M = Must Have S = Should Have C = Could Have m = mobile

From the initial MoSCoW matrix (Table 3.1), the final set of workable use cases (see Table 3.2) for the VOICES project were solicited. Essentially, this final set of use cases were those that had most of the desirable functionality and also held promise for implementation given the time and resource constraints of the project. The final set comprised of:

1. The shea butter and honey trading service for Sahel Eco through the radio. This was selected because it had an advantage that it was already working in the field on a pilot. The pilot was also very well known to a number of stakeholders including radio people, extension agents, shea butter and honey producers in Mali with some already sharing information through the channel. For example, Radio Ségou and Sahel Eco already had collaborations on this in the pilot. Therefore it was easier to implement given the available infrastructure and also the potential it held for impact.
2. Sahel Eco portal for re-greening and access to mobile services. Sahel Eco needs a website to inform all stakeholders about re-greening activities. This website will have a social network facility where users can sign up and receive RSS updates, emails and alerts about new events. Find info in several languages about re-greening activities as well as other future relevant subjects.
3. An m-event organizer for re-greening. This was to be the first mobile-based service for re-greening in the region. This pilot is very similar, technically, to the use case on mobile event organizer for vaccination of herds. However, W4RA and Sahel Eco gave priority to

re-greening, since it held greater rural, social, environmental impact than the other.

3.5 Chapter Conclusion

Traditional requirements gathering processes are thorough and well-documented and are applicable to a variety of needs for software building. However, as this chapter has shown, certain instances require a careful attention to the rules and, perhaps, even sometimes, require significant adjustments to these rules before meaningful progress can be made in gathering necessary requirements. An example of such an instance is a situation in ICT4D where stakeholders, for whom a technology or software solution is to be provided, have no or very little ideas on what they might see useful and even want to use.

In those instances purposeful, meaningful and frequent technology demonstrations go a long way to shape conversations and direct the requirement elicitation process as this chapter has shown. Such instances also require significant adjustments and, even sometimes, on-the-spot improvising as well as such strategies as bottom-up, collaborative and agile forms of requirements elicitation while using the traditional processes of software requirements as a guide. Our contribution to the field is a systematic approach to requirements elicitation in ICT4D that shows how requirements can be built up in a collaborative and bottom-up agile fashion through field research. This we have been able to accomplish with people many of whom are far from today's technological advancements [Bon et al., 2013].

The next chapter of the thesis describes into detail how a voice system was implemented for one of the selected use cases above. Specifically, this is the first of the use cases enumerated above. In its implementation, a Market Information System (MIS) was built to complement some of the processes of an already existing platform for marketing farm products of farmers from specific communities and to make its running more efficient.

Chapter 4

Implementation of Voice Systems

In this chapter, two specific case studies of voice systems developed and then deployed for use in Mali are presented. This builds on what has already been discussed mainly in Chapters 2 and 3. The systems were designed and developed after the use case elicitation processes in Mali for use by a select group of farmers in the region. This chapter describes in detail the actual modelling and building of the systems first from their descriptions of the particular use cases, their design and then to the final implementation.

4.1 RadioMarché: A Voice-based Market Information System for Rural Farmers

In Chapter 3, a detailed description of how use cases were elicited was given. The eventual selection of three of these use cases has already been detailed in Section 3.2.2. This system (called RadioMarché (RM)) was built based on the first use case described in Section 3.4.3, and was to augment an already running "legacy" service. Essentially, what the new system did was digitizing and storing market information from rural farmers in Mali for further broadcast with an added innovation that this broadcast could also be accessed through Mali's Public Switched Telephone Network (PSTN). Specifically, my role was modelling and building a Web interface for the collation, creation of audio market information and its subsequent publishing for access by radio stations and the general public. RadioMarché literally means market on the radio [de Boer et al., 2012].

The mode of operation of the entire system was as follows: after digitizing raw market information as input, the system had a functionality that made the processed information available both on the WWW and on community radios station platforms for public consumption. A major advantage of this new MIS was the efficiency it brought to the manual alternative, replacing many of the inefficient processes with technology.

4.1.1 Use Case Informal Description

The RM pilot MIS platform deployed for use in the Tominian and Ségou regions of Mali was built to augment the operations of an already running market information broadcast service that had been set up by our VOICES Malian partner, Sahel Eco, in 2010. Figure 4.1 shows a pictorial description of this platform and how it worked.

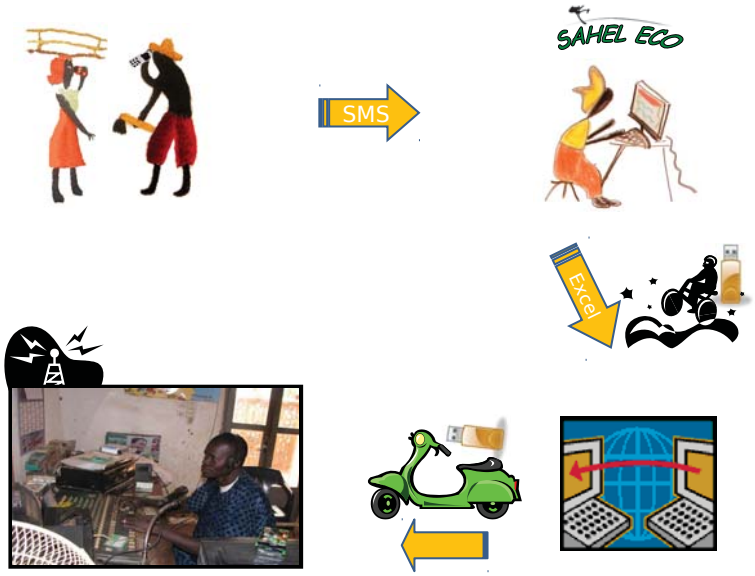


Figure 4.1: The original market information distribution infrastructure for rural farmers in the Tominian and Ségou regions of Mali. This diagram shows how information from the farm goes to the local radio station for broadcast to potential buyers. Credit: Sahel Eco & Anna Bon.

This service was focussed on the sale of shea nuts, honey, wild nuts and processed derivatives from local farmers. The service was used to distribute up-to-date farm and market information, specifically available products for sale, via community radios located in the regions of the farmers. In its actual operations of the service, a Sahel Eco staff receives offerings from the farmers or their representatives in the form of SMS message on their phone. The message contains information about a product offering specifically, its quantity, quality, price, and information about the seller—their phone number and where they can be found. This SMS information is entered manually by the staff into a spreadsheet for record keeping and creation of communiqués for the radio station. A communiqué is simply the list of selected farm products cultivated by farmers and are available for sale which is read out on radio.

Every week (when there is a new information available), a broadcast communiqué is drafted by the staff member and then sent, some via the Web through email, to four local radio stations (ORTM Ségou, Koutiala, ORTM Mopti, Radio Moutian) for broadcast to the general public. In some cases, it is physically delivered to these radio stations by a staff member. Out of the four radio stations they worked with within the regions, only ORTM Ségou has internet connection within their premises to access information on the WWW. The other stations, Koutiala, ORTM Mopti and Radio Moutian, only access that information by going to a nearby internet café and

printing out the received information.

4.1.2 Use Case Elaboration

In building the MIS platform to support the use case described in section above, a detailed analysis had to be performed. A use case analysis is done as a way of modelling the behaviour of a new system [Booch et al., 1999]. In analysing the original manual MIS, it was important to examine the exact role this new system would play. Figure 4.2 shows how this was done in the end. The RadioMarché platform was developed to directly interface between the NGO, Sahel Eco, and the community radio stations. With the new system in place, a major advantage it provided was short-circuiting a number of administrative and logistical steps in the information transfer chain.

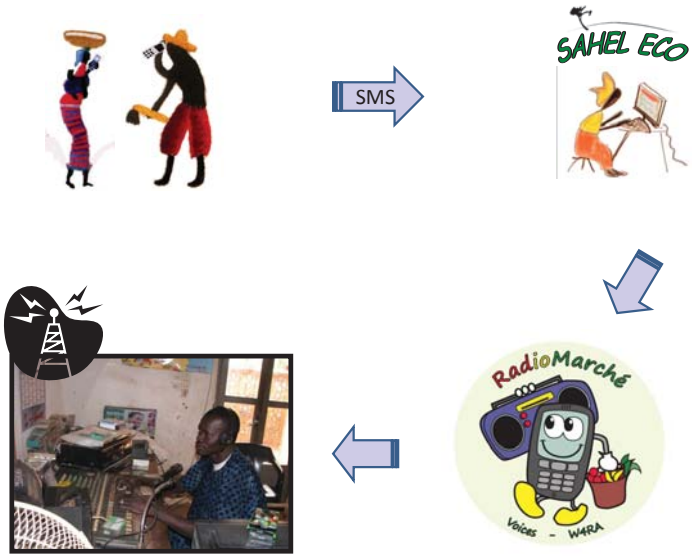


Figure 4.2: A pictorial representation of the role of RadioMarché in the Market Information System of Sahel Eco. Compared with the initial diagram, RadioMarché short-cuts some of the processes in the earlier implementation of the system and makes the new implementation more efficient, cost-effective, more reliable, among others.

Building the RM system required that a number of important decisions had to be taken into account. Chief among them was the need to model the behaviour the new system to mimic as closely as possible the old system. That was necessary in order not to disrupt the norm (or original processes) that much. For example, under the old system, staff of the NGO who received text messages on market data had to manually type in this information into an Excel file and further email this to the radio stations for download and subsequent broadcast on air. In the new design of the system however, all these activities were redesigned and replaced with their electronic equivalence where a Web form developed for the purpose automatically compiles this Excel format of the information and then forwards it to the radio stations with internet for access.

Right from the beginning, system ease-of-use was a primary consideration. This, it was thought, would help increase the chances of acceptance and subsequent adoption among stakeholders. An added innovation with the RadioMarché system was the addition of a new channel for access of the same information broadcast on the radios. For the radios without internet access, an automatically generated audio version of that information is made available for access through the mobile phone via the local telecom operator for broadcast.

Figure 4.3 models the implemented behaviour of all the activities involved in order to compile, create and disseminate new communiqué with the RM system. It models the activity of the NGO and that of the radio stations who had access to it. In the model, the activities for NGO staff includes entering new market, information, creating and publishing new communiqué. The activities for the radio stations on the other hand downloading (if with internet) or making a telephone call (via local GSM, if without internet) and broadcasting that information on air to listeners.

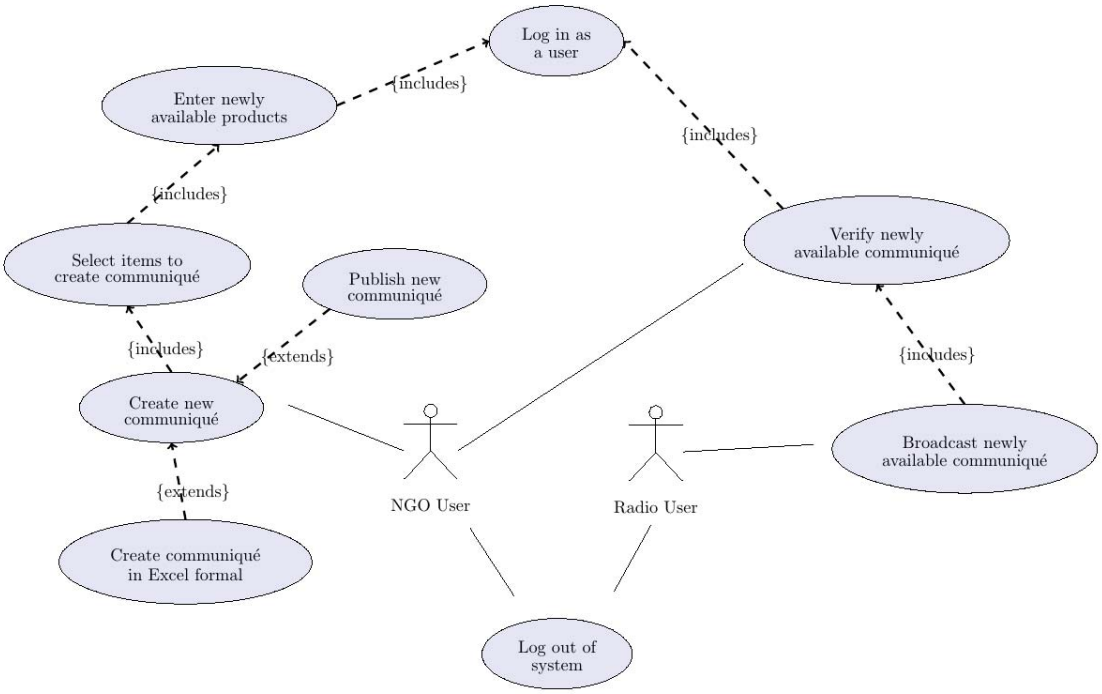


Figure 4.3: Use case diagram for the RadioMarché Market Information System.

The individual activities of creating and publishing communiqués represented the main innovation behind this new system. Creating a communiqué (Figure 4.3) essentially involved automatically generating an audio file representing the products from the farmers which are available for purchase for a given period of time (see Section 4.1.1 above). This audio file was generated automatically in the actual natural voice of the radio presenter known by the community. In the design and implementation phase of building the system, this was yet an important design decision. This was necessary in order that listeners identified with the voice as

much as possible and not tempted in any way to change the dial of their radio should they hear the voice. However, this also meant a drawback on scalability of the system. The other activity of publishing a communiqué involved enabling access to the communiqué via the local GSM network. The radio stations would then call the associated telephone number and then broadcast the audio live on air to the public. Table 4.1 describes the rest of the use case activities for the new system.

Table 4.1: The various activities of the RadioMarché system

User	Activity	Explanation
NGO Radio	Log in as a user	An account for each user of the new system for access to the system.
NGO	Enter newly available products	Use a Web form in the system to fill in information on new products available for sale.
NGO	Select item(s) to create a communiqué	Manually select enlisted products for a new communiqué.
NGO	Create new communiqué	Create a new audio file of a market information based on a selected number of available enlisted products.
NGO	Publish new communiqué	Push a newly created communiqué to the voice platform for access via the local GSM infrastructure.
NGO Radio	Generate a spreadsheet format of audio communiqué	This activity involves generating a version of any of the communiqué in the system in a spreadsheet format just as in the old way.
Radio	Broadcast newly available communiqué	Either download or call a given number to access the new communiqué for broadcast live on air.
NGO Radio	Log out of system	Close a session within the system environment.

4.2 RadioMarché System Design

This section of the thesis takes a look at the two main steps for the design and implementation of the RadioMarché system. These steps include;

1. the design considerations that had to be made and
2. the components that worked together to build the system.

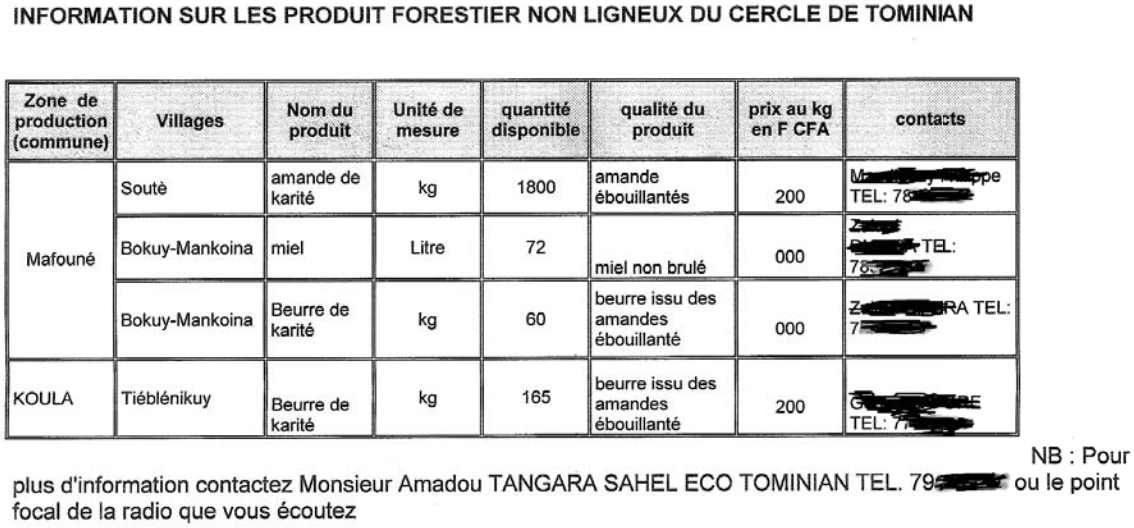
The above steps are discussed further below.

4.2.1 RadioMarché Design Considerations

The design of the RadioMarché MIS had to take a number of design decisions. These decisions were of varied nature but bordered mostly on front-end/interface design issues and on others as physical infrastructure and user support for the new system. The major decisions included:

- **Simplicity of Use**: By simplicity, it is to mean that because the RadioMarché system was the first of its kind in the region, it was important not to make use of the Web-based frontend overly complicated. Also, the target users of the system were a select group who had only basic knowledge on such systems although they had thorough knowledge on the entire operation of the original MIS. Since RadioMarché did not entirely replace the old system, it was important then not to burden them in any way with the use of the new system. This was largely overcome through following well established heuristics of user interface design specifically referring to:
  - Making navigation within the application as less confusing as possible. This was achieved by using clearly-labelled, easy-to-locate menu items on the interface avoiding sub-menus as much as possible.
  - Also related to navigation was the use of internationalisation and localisation techniques in Web application development. This simply means adapting computer software to different languages and regional differences for use with the system. The software therefore was adapted to fit the *lingua franca* of Mali (French) and their currency (FCFA).
  - Use of informative system feedback. This was achieved through the use of simple notification techniques to communicate as much information to the user as possible.
- **The Distance Challenge**: The issue of distance between developers and users was also a significant challenge. Since this innovation was being built from outside the borders of Mali, it was important that troubleshooting of technical problems was done in ways that would not deter users from its early use and adoption. To achieve this, as much priority as possible was given to instances of system failures while making sure the resolution of faults took as little time as possible in order to keep the system online. For the local implementation of RadioMarché in Mali, a direct remote link was set-up for access and debugging purposes.
- **The Issue of Low Bandwidth in the Region**: Internet connectivity was a major issue in the region with much of the connection going through foreign satellites-based access points. In addition, much of the internet in the region is only provided by telecommunications companies within the region though their infrastructure. To counter this, the Web form had to be as "thin" as it could be. This essentially meant little use of graphics and no use at all of videos and multimedia technologies. Another strategy employed to overcome the challenge of low bandwidth was using planned "offline and online" synchronisation techniques. How this was achieved was through the building of two separate systems—an online version on the Web and a local (offline) version configured on a local computer placed in the premises of Sahel Eco. Some time after the initial pilot, it was realised from the system logs that much of the system usage occurred on online version. The local version was then only used as a backup.
- **Ensuring Little Procedural Differences Between Old and New System**: RadioMarché was only intended to increase overall efficiency of the already existing system and not to create new procedures. For example, in the old system a spreadsheet of all communiqués was kept for reference (see a sample in Figure 4.4). In the new system, old this functionality had to be created where this spreadsheet was automatically created in this

particular format (including header images and address, etc) just as it appeared in the original system. All the communiqués generated within the new system was also digitally archived as in the old system.



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	[redacted] TEL: 78[redacted]
	Bokuy-Mankoina	miel	Litre	72	miel non brulé	000	[redacted] TEL: 78[redacted]
	Bokuy-Mankoina	Beurre de karité	kg	60	beurre issu des amandes ébouillanté	000	[redacted] TEL: 7[redacted]
KOULA	Tiéblénikuy	Beurre de karité	kg	165	beurre issu des amandes ébouillanté	200	[redacted] TEL: 7[redacted]

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

Figure 4.4: A sample communiqué data sheet. (For reasons of privacy names and contacts of persons involved are blackened out.)

4.3 Components of the RadioMarché System

This section discusses the components of the RadioMarché system. Table 4.2 gives an overview

Table 4.2: Summary of the different components of RadioMarché

Component	Function(s)
Web Interface	Register new users. Create new Communiqués. Publish communiqués. Archive old communiqués.
Voice Platform	Publish Communiqués. Provide IVR voice menus to callers. Allow voice access to generated communiqués.
TTS Engine	Responsible for the automatic generation of communiqués in French, Bambara and Bomu.
Emerginov Platform	Provides telephony interface and connections to local PSTN network.

of the various components that work together to make the voice-based MIS. The components include:

1. a Web form or interface for NGO users and user from some radio stations.

2. a voice platform which enables the telephone or voice interface.
3. a TTS engine that concatenates and encodes audio pieces to make meaningful audio files.
4. a platform that provides access to the PSTN telephony network.

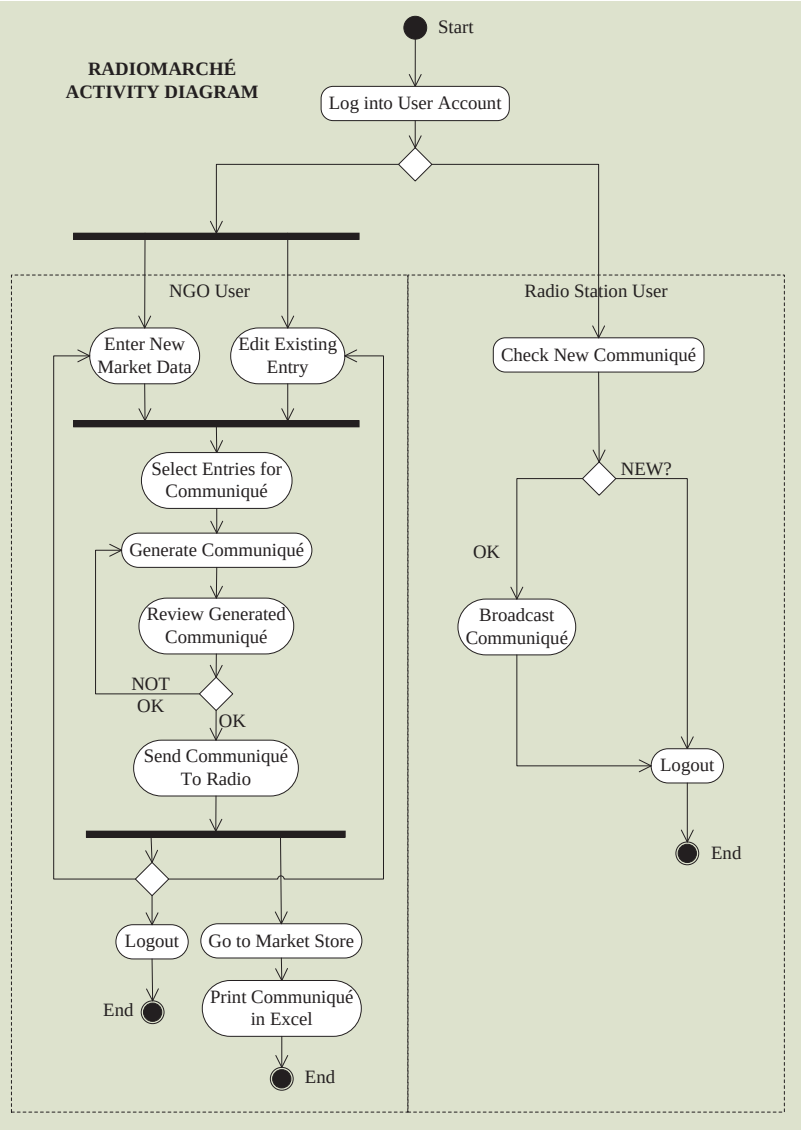


Figure 4.5: Activity diagram for the RadioMarché system.

The activity diagram for RM is shown in Figure 4.5. The figure shows two categories of users of the system. They include "NGO users" referring to users from the office staff of Sahel Eco who manage the system and "radio users" which refers to the radio stations who eventually broadcast communiqués. The figure shows the series of steps for both users. In the actual implementation of the system, all the steps for an NGO user involves using a designed Web

form for the purpose. For the radio user however, there is an added channel for use. The radio stations without internet access only have the option of using a voice interface to access the same information.

4.3.1 The Web Interface

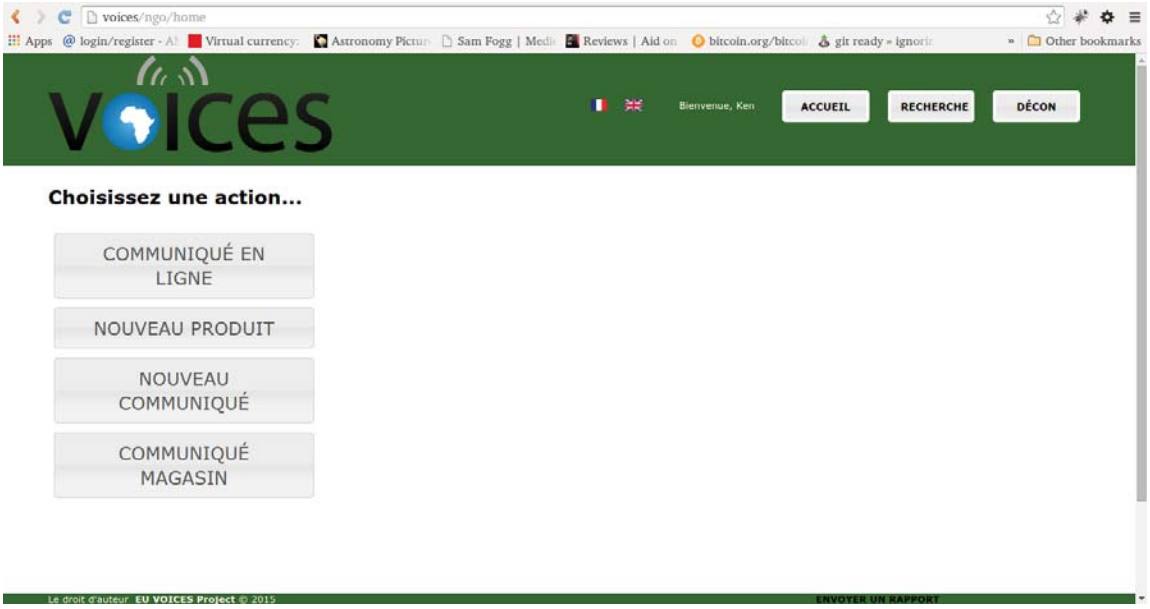


Figure 4.6: The RadioMarché Web interface for an NGO user. A user can add new products, create new commiqué(s) as well as access old ones.

Figure 4.6 shows the interface for an NGO user in RM. The web interface implements all the functionality mentioned in Section 4.1.2 does the following:

- Allows only registered users from the NGO to access the system.
- Provides an interface for users to fill in new market information.
- To allow users to create audio communiqué from entered data first in local Malian French, Bambara and Bomu languages in the voice of the radio speaker.
- Allows users to publish a generated communiqué on the voice platform for access and further broadcast by the radio stations.
- Provides the ability to generate Excel versions of the communiqué generated from the platform.

For the radio stations with internet access, a similar Web interface for a limited set of functions including:

- Listening to a new communiqué. This can be done within the web browser.
- Downloading a copy of the new communiqué.
- Automatically generating a copy of the spreadsheet for the the communiqué.

In order to gain access to the Web interface, every new user are required to be registered with the system. This step is essentially to make sure that only trusted users have access to the system. Apart from this security feature, all activities within the system are logged for traceability and

to aid troubleshooting efforts during system downtimes.

4.3.2 Communiqué Creation with the Web Interface

Discussions on the Web interface component of RM would not be complete without mentioning how it is used to compose new communiqué for broadcast. In the system, an NGO user is given the responsibility of filling in what products are available for sale from the farmers through the interface. The generation of communiqués from the interface consists of selecting a number of product entries. The staff decides on an appropriate communiqué number and then clicks a button that automatically generates an audio communiqué based on the selected entries. The communiqué number is only for internal tracing and tracking purposes. In Figure 4.4, a sample data sheet of a spreadsheet of a few products (Amande de karité (shea nuts), Miel (honey) and Beurre de karité (shea butter)) is shown with their quantities, prices and contact persons based for which a an audio communiqué can be created.

After the creation of a communiqué (an audio file in `.wav` format), the user can review the automatically generated audio and if satisfied, go on to publish it on the voice platform for access by radio users and can subsequently be broadcasted by radio stations to the listening public. At the initial stages of the pilot, only French communiqués were generated. Indigenous languages, Bambara and Bomu versions, were implemented later on after enough feedback had been received. All the communiqué published via the system are archived for later references.

4.3.3 The Voice Platform

All voice access to published communiqués on the RadioMarché MIS system are done through a dedicated voice platform. This component of the system was developed by the Web Foundation, a partner in the VOICES project. Technically, this component works by using VoiceXML[1] commands to build voice menus which guide callers through a set of choices. The two main functions of the voice platform are the following:

- It is responsible for providing an avenue where generated communiqué(s) can be published.
- It provides a voice interface to published communiqués for access via public telephone networks.

Once a communiqué has been published on the voice platform, it can be accessed by the general public through the telephone network if . For the pilot, only staff from the radio stations involved in the project were given the numbers to call the service. The Web interface of RadioMarché interfaces with the voice platform through a REST[2] protocol. In order to generate a communiqué from the Web form, selected entries (of farm products) for a new audio communiqué are automatically converted into a JSON[3] string and forwarded to the voice platform. The voice platform takes the generated JSON string as input and generates an audio file, stores it on the platform and then communicates back to the Web form. If the platform fails to generate the file some

[1] http://www.w3.org/Voice/
[2] http://en.wikipedia.org/wiki/Representational_state_transfer
[3] http://json.org

reason (e.g. due to some internal error) it reports accordingly to the user. On the other hand, if the creation was a success, the user is told about it on the Web interface and then this newly generated communiqué is marked for possible publishing for public access. Once published the communiqué can then be accessed through the local PSTN telephony infrastructure.

4.3.4 The Text-To-Speech (TTS) Engine

The TTS engine component of RadioMarché was built by partners of the VOICES project from the NorthWest University in South Africa. The method used is referred to as the slot-and-filler method [Barnard et al., 2010a; Barnard et al., 2010b].

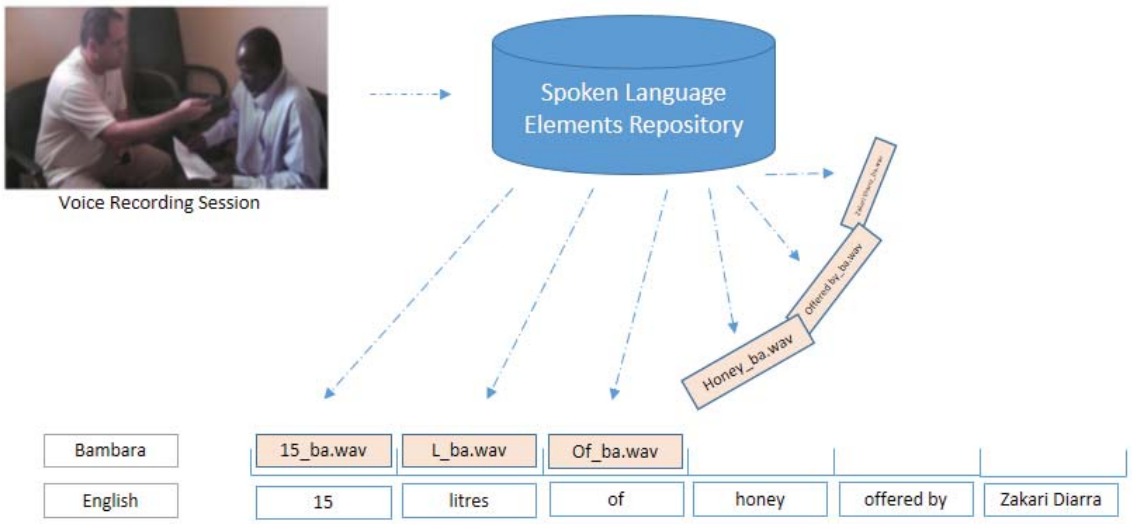


Figure 4.7: The slot-and-filler method for developed a TTS engine for low-resource languages as implemented in RadioMarché. Photo Credit: Victor de Boer.

Figure 4.7 shows the implementation of this method. The basic requirement for a slot-and-filler TTS component was the generation of a limited set of pre-defined messages with systematically varying content including dates, quantities, and people and place names. This was developed given a limited set of recordings minimally covering the required base messages, lists of names and number sets (such as data in Figure 4.4). For RadioMarché, a decision was made to build a limited domain unit-selection TTS systems based on word-sized acoustic unit inventories. In other words, the choice of available speech output was limited to only the products the farmers produced for sale and the only the voices of particular radio presenters in the pilot. This approach re-used existing software for managing audio data, synthesising messages and processing text input. In addition, tools for automatically segmenting speech and constructing the acoustic inventory from audio and transcriptions were used directly to minimise manual effort and thus construction time and costs.[4] As such existing software was customised

[4]This description of the TTS engine was made known to me in an email conversation with the developer.

to support word-sized units and the main task involved developing suitable text-processing modules for Malian French, Bambara and Bomu as described below.

The following text-processing modules and resources were developed for the three languages:

- Basic phoneme sets and letter to sound rules in order to use automatic speech segmentation software.
- Text normalisation routines to perform number and date expansions.

Speech recordings were done on the field in Mali in unprocessed form, requiring the following preparation before the process including utterance chunking, manual transcription corrections and verification and audio processing including noise reduction and removal of reverberations.

For integration into the larger RadioMarché system, the TTS engine had to be deployed on the Emerginov platform (described below). As the RadioMarché system generated messages in a JSON format, a conversion script was also required to convert this into plain text for querying the TTS.

4.3.5 The Emerginov Platform

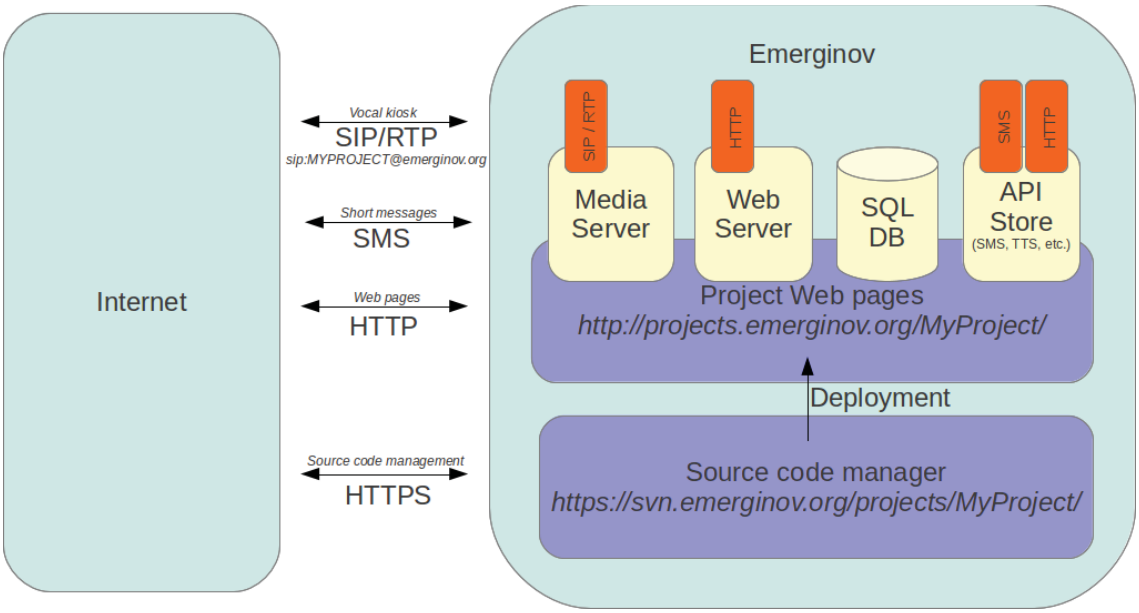


Figure 4.8: Architecture of the Emerginov Platform. Taken from emerginov.org

This is a platform built to host all the independently developed components of RadioMarché as one piece of software. It consists of a Linux-based system running Apache[5] and PHP.[6] The runtime systems were largely implemented in Python using Numpy and Scipy with one module written in Perl and was required to present a REST interface where a text query could be sent,

[5] http://httpd.apache.org/
[6] http://php.net

returning an audio file in RIFF[7] Wave format. The interface was written in PHP.

Figure 4.8 shows the architecture of the Emerginov platform.[8] The platform is an incubator of micro-services with one of it's aims being an initiative to encourage the developer community especially in Africa. It was developed and maintained by developers at France Telecom who were also partners in the VOICES project. Users of the Emerginov platform are provided with a toolbox, which includes tools such as a synthesized voices for voice applications.

Aside synthesised voices for the development of applications on the platform, Emerginov also provides such services as database back-end support, a code versioning system (`svn` in this case) and a Web server (Apache) which allows developed applications to be placed online. The innovative and perhaps most important service the platform also provides is software (and hardware) for connections to the telephone infrastructure PSTN network in Mali for the this project. With that it provided the ability to reach the applications developed on the platform using mobile telephones if only the application supports it.

4.3.6 Overall RadioMarché Architecture

Table 4.3 shows a of technologies behind the components of the RadioMarché MIS and the VOICES partners responsible for each component. Each component was developed and managed independently by the partners and provided interfaces through which the components interacted. The Emerginov platform hosted the other three components and also provided various tools and services for access to each component as well as maintaining them.

Table 4.3: Summary of technologies behind components of RadioMarché

Component	Technologies	Partner Responsible
Web Interface	HTML, PHP, CSS, JavaScript, JSON, SQL database	The VU team
Voice Platform	PHP, VXML, JSON,JavaScript, REST interface	The Web Foundation
TTS Engine	Perl, JSON, RIFF	NorthWest University
Emerginov Platform	Apache, PHP, Python, Perl, SQL database, SIP/RTP, VoiceGlue, HTTP, SMS, SVN	France Telecom

4.4 RadioMarché Implementation Versions

The RadioMarché system was implemented using two separate technical specifications (see Table 4.4). A major reason for this was as a way of overcoming the challenge of low bandwidth in the region as has been discussed in Section 4.2.1. By implementing two separate systems, users had the flexibility to use both depending on when local conditions permit. In one version, we used cloud-based services (on the Emerginov platform) to host the Web forms and databases. Voice access to the service was provided by Orange Mali, a local mobile telephone

[7] http://en.wikipedia.org/wiki/Resource_Interchange_File_Format
[8] http://www.emerginov.org

Table 4.4: The Different Installations of RadioMarché

Installation Version	Supporting Technologies	Partner Responsible
Local Platform	Apache, PHP, SQL database, Prophecy, SVN	The author
Emerginov Platform (Cloud)	Apache, PHP, Python, Perl, SQL database, SIP/RTP, VoiceGlue, HTTP, SMS, SVN	France Telecom

service provider in Mali (a subsidiary of France Telecom). They supplied local Malian telephone numbers used to access the service. The second version of the system is entirely local. This version has the Web form and database, voice platform and TTS engine running on a dedicated workstation located in a office of Sahel Eco in Bamako, Mali. The workstation is connection to the local internet of the Sahel Eco. Radio stations that have internet connection can access this network directly via the Web.

To provide telephony access to this second version of RadioMarché, a number of things had to be done differently for a standalone installation. Access to the IVR of the voice platform through the telephone network was enabled through a GSM gateway (OfficeRoute) connected to the workstation. The rendering of audio communiqués and IVR menus was achieved using a local installation of a voice browser software (the Prophecy VoiceXML browser by Voxeo[9]). Figure 4.9 shows the GSM gateway that was installed on location.

Figure 4.9: Implementation of the RadioMarché system in Mali. On the left, an audio recording and evaluation session needed for building the TTS engine is shown. The right part of the image shows the OfficeRoute GSM gateway which is part of the local standalone installation of the hardware setup.

The local version has the advantage that the system is accessible through the voice channel even in the absence of an internet connection. The fact that the system was completely locally installed also improved local ownership—local developers could be trained to manage the system

[9] http://voxeo.com/prophecy/

and even develop it further for the NGO and other interested parties. This second version also made the set-up less dependent on local Telecom provider which was a good thing because frequent fluctuations were avoided. The downside of such an installation, however, is the inherent deficiencies that some of the software on the workstation had. For example, the GSM gateway could only take four Subscriber Identity Module (SIM) cards (and hence only four calls) whereas the cloud version allowed more than 20 concurrent calls. The cloud version had the advantage that it was robust and scalable. In the end the local installation acted as a backup to the cloud version.

On a more general note however, one of the key contributions the RM system provides is demonstrating the possibility of a means through which locals without access to the internet could make content available with the help of simple mobile phones. The outcome of the pilot also reveals that given that data to be provided by community people are of some economic benefits, it's availability will be would be assured for as long as the benefits remain. This finding is mimicked by popular and widely used marketing platforms such as Amazon or eBay. Going back to the first research question of this thesis, this finding also gives indications of how possible innovative strategies could be harnessed to connect millions to the WWW.

4.4.1 Concluding Notes on RadioMarché

RadioMarché is a system built to replace an already existing system that has been running locally for rural farmers. RM only made it more efficient and productive. In building this new system however, a number of important design decisions had to be made from analysing the old system. This ranged from social issues such as illiteracy to more technical ones bordering on Human-Computer Interaction (HCI), simplicity of use and local bandwidth allocations. In the end a lot of these decisions led to a system which worked to the considerable satisfaction of local stakeholders removing barriers to information dissemination that existed in the old system and making its processes more efficient (more on this in the evaluation discussion in Section 5.1.2 of Chapter 5).

In building RM, not all manual processes in the old system were completely removed. For example, even with the new system the NGO continues to receive text messages which have to be manually processed for use with RadioMarché. This known limitation is already under investigation and being worked on. For example, with new designs which will allow farmers publish their products for sale on the platform using their phones without relying on the NGO to do this have been done by Dittoh [Dittoh, 2013]. Also, other innovative ideas such as ways of mapping out actual geographical locations where the data for RM emanate from in the region have been looked into.

Indeed, the rest of the sections from Section 4.5 of this chapter take a look at another voice-based system which have been developed also within the VOICES project to meet particular needs. This other system was developed in a similar fashion to how RM was developed and functions in ways that mimic a well-known Web system and service. That said, it must be noted that the difference between RM and major online e-commerce services is that this platform is limited to only a few number of products and also attached to a specific geographical region. This translates as shortfalls in functionality of the RM system in terms of TTS implementation

and hardware use as already explained. A system such as RM has been built to meet a specific need in a specific region of the world. Though on a relatively small scale, the idea behind this has worked quite well with the local participants such that it has, in some instances, created more demand for products than anticipated.

A number of other drawbacks with the new system are worth mentioning prominent among which is its lack of scalability. A major drawback is the limited number of products that RadioMarché uses. Since this pilot was restricted to a particular region, only the important farm products traded by farmers in the region were used which ended up being hard-coded into the core of the system. As a result, changing this number (and type) of products within the new system is not straightforward. Since audio communiqués are generated based on these products, there is a need to record new voices once a new products is added. The same can be about the situation where a new radio station is made part of the information dissemination channel. When distance is a real challenge, as in our case, then new strategies would be needed such as innovative ways of recording voices remotely for use with RadioMarché. We recognise these drawbacks and see them as incentives to improve the system.

There are issues also about sustainability of the new system and questions about who pays for the running of such a system. For a region such as the Sahel of Mali, sustainability models are definitely needed for such implementations. Even though these models are necessary in order that the services developed within the VOICES pilot continue to run beyond the project, this thesis does not deal with it. Chapter 5 of the thesis expands on this more.

4.5 Implementing a Related Use Case: A Messaging Voice Service for Rural Farmers

From this section on in the thesis, I discuss another voice-based system that was developed and deployed also in Mali as part of the VOICES project. The relevance of this section is to build on the foundation this thesis has already laid up to this point on the importance of the usefulness of voice-based Web services in different settings and contexts. This second system, *Tabale*[10], was built based on the third use case solicited during the field visit discussed in Chapter 3 of this thesis (see Table 3.2).

This other system (or service) was designed and developed by the core team that worked on RadioMarché, reusing the tools and methodologies that had been developed in that earlier pilot. The point this section seeks to drive home is the idea of how different voice services could be developed context-dependent and their applicability of such services given the context. To a large extent, however, the motivation for building this other service emanated from the level of success in terms of acceptance and use shown by the local communities for the RM system.

This second use case bordered on a voice-based service that was built as a support system to compliment the work of the NGO, Sahel Eco, with local farming communities. This service had automated built-in functionality to help reach communities of people through their mobile phones to help plan or hold an event or a meeting. This was accomplished by sending out short,

[10]"Tabale" is the king's drum in Bambara language which is used when there is an emergency or an important event or meeting.

language-specific, voicemail-enabled broadcast messages to the phones of a pre-selected list of participants for an upcoming event. The messages were such that receivers had the opportunity to respond to the messages.

The name, Tabale, of the service was chosen to reflect a similar activity that goes on within the communities where communal gatherings are commonplace and used often as platforms for various kinds of agenda. Using voice and Web technologies, this system was developed to enable sending out mass short voice messages to people. The Tabale service uses these technologies to solve a real need for an NGO in a region which has communities which are often distant apart but often has the need that they share ideas and interact with others from the region through workshops and training sessions.

Though quite simple in its operation, the major innovation of this service is the ability to deliver voice messages in native languages of the communities within which the service operated. After a while, when system logs showed a fair amount of usage, it confirmed the relevance of harnessing voice technologies for different context-dependent innovations to solve real problems.

4.5.1 Tabale Use Case Description

The NGO Sahel Eco whose focus of work is often on rural farming communities in Mali also often in their line of work, has need to offer training workshops, seminars and symposia for farmers and other interested groups in the region. For example, they sometimes facilitate farmer-to-farmer field visits which creates opportunities for some farmers to meet other farmers to brainstorm and share ideas on farming practices and on new ideas for working. Most of these farmers and interest groups are at distant villages and need to be contacted in order to schedule such meetings. However, this used to mean calling all potential participants manually by a telephone and asking them whether they would be ready to join such meetings or not and drawing a schedule based on this.

Aside being tedious and an error-prone procedure, calling participants individually also meant using considerable amount of time make sure participants were confirmed for a meeting or not. This is what prompted the need of a new voice-based system to meet this need for the NGO.

4.5.2 Tabale Analysis and Design

The Tabale system was built to fill this need for Sahel Eco to enable them better schedule and plan events in a more efficient way. Figure 4.10 illustrates the description of this use case. Through this system, a selected number of pre-registered farmers are notified through a voice message on their mobile phones giving details of a planned event to which they can respond and make known whether they could be available for the meeting or not. The system also provides a functionality where recipients of calls have the choice to call the service and retrieve the message asynchronously.

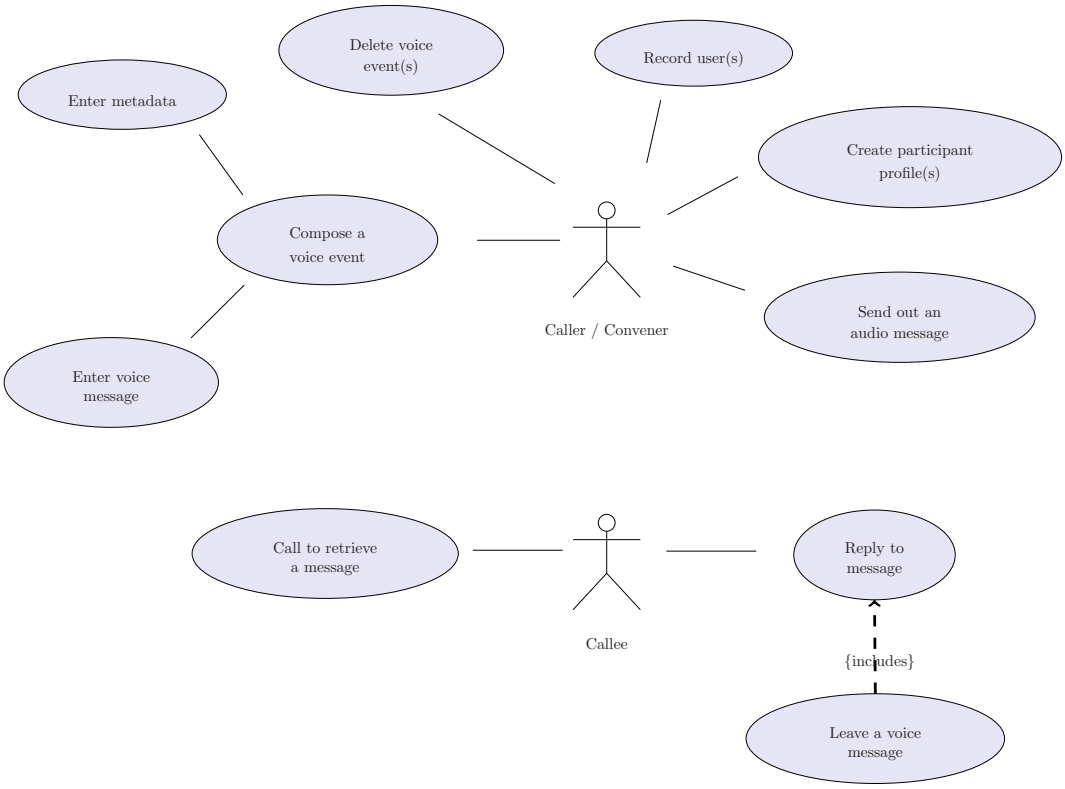


Figure 4.10: Tabale use case analysis.

Figure 4.11 shows the call flow design for Tabale. The figure shows an example voice message that has been created by a Webmaster at Sahel Eco. He/she creates this message using a Web interface designed for the purpose. Once a farmer picks a call from the system, a welcome message is played and then the actual meeting information is also delivered. In English an example message reads as follows:

> *There is a meeting about X organized by Y on Saturday 16 September 2012 in the village Cinzana-Gare, will you attend the meeting?*

This message has to be recorded in French, Bomu and Bambara and depending on the language preference of the participant, they get this message in their language of choice. The receiver of the call then has the option to indicate whether they would be able to attend the planned meeting or not. They do this by using key-presses on their phone to say either Yes, No or Not Sure. This information immediately registers on the Web interface from which the Webmaster can determine the list of participants for the scheduled meeting. This scenario is only for a single farmer and so depending on the number of farmers in the list the Webmaster selected during the registration, all potential participants for a meetings can be seen with a click of a button in the Web interface.

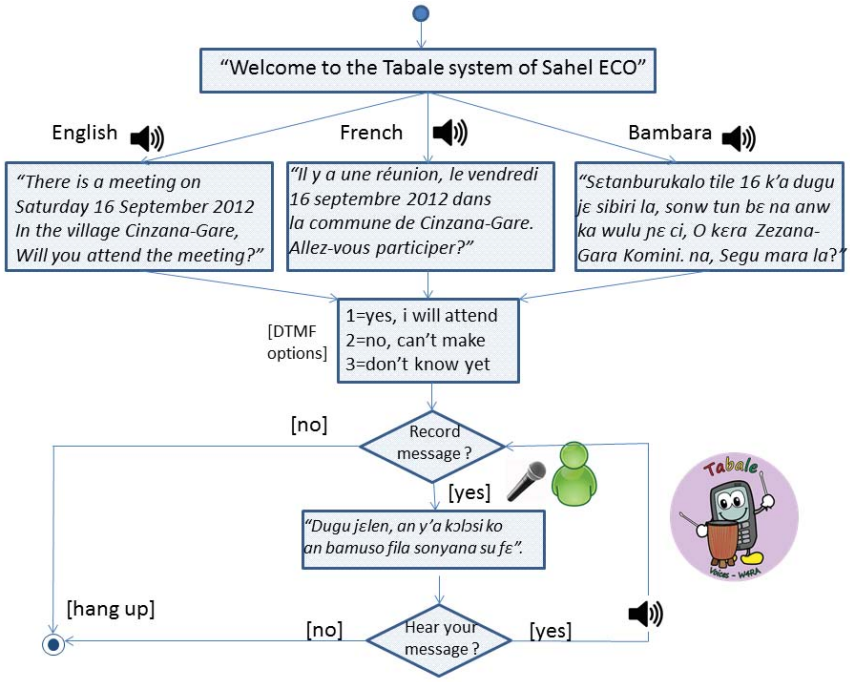


Figure 4.11: Tabale call flow design. This simplified version was used in training new users of the system. Credit: Max Froumentin (The Web Foundation).

The Tabale system was built to do a number of things. It allows a convener of an event to create profiles for participants which includes their names, their phone-numbers and language preferences. It also allows a convener to create or delete specific voice messages based on the profiles of potential participants. After an event has been created for a group of potential participants, the system automatically calls all these participants simultaneously and delivers the voice messages left by the convener; if there is no response on an initial call, the message is left in the particular participant's voice mail phone service for later retrieval. The message left by the convener is accessible by calling a number assigned to the service. And so when a recipient misses a call, they have an option to call a number and respond to the message. By default, French was used as the language of choice for calling participants. This can easily be changed by the convener if so desired.

4.5.3 Tabale Implementation

As has already been mentioned in Section 4.5 of this chapter, Tabale was built with similar technologies behind RadioMarché (see Table 4.5) and deployed for use in Mali. Technically speaking, the system can be operated from anywhere around the world since it is online on the WWW. However, only calls within Mali can be made to the system. Figure 4.12 shows the Web interface of the Tabale service.

Initial training sessions were organized for some selected staff from Sahel Eco who were taken through steps for running the service. The training also provided opportunities for feed-

Table 4.5: Summary of technologies behind components of the Tabale system

Component	Technologies	Partner Responsible
Web Interface	HTML, PHP, CSS, JavaScript, Flash	The Web Foundation and VU
Emerginov Platform	Apache, PHP, Python, Perl, SQL database, SIP/RTP, VoiceGlue, HTTP, SMS, SVN	France Telecom

back and further improvement of the system. A few suggestions on ways to improve the system which were mostly comments on usability and installation of third party software such as Flash technology.

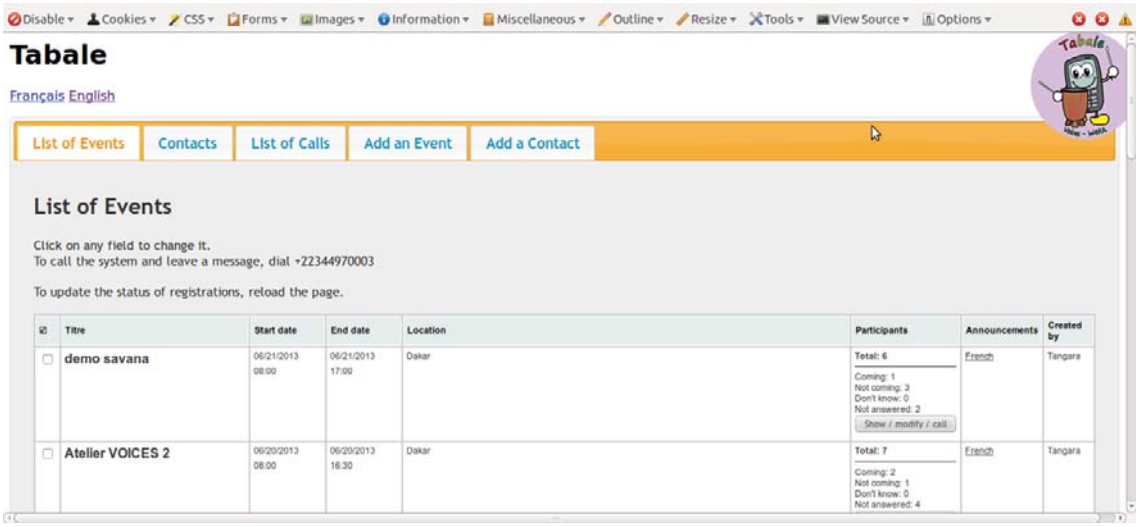


Figure 4.12: A Screeshot of the Tabale Web Interface.

Unlike RM, the Tabale system had only one version implemented and hosted on the Web. Plans to localize it, as was done with RM, were considered but could not be fulfilled. However, initial feedback (solicited through face-to-face meetings) showed considerable interest from locals and satisfaction with use.

4.5.4 Discussion on Tabale

Tabale is simple in its operation but solves an important local challenge of mass broadcast for a select group of people for a local organisation in Mali. This reinforces that argument this thesis raises about building solutions that relevant in a given context. In this instance, Tabale makes the benefits of the Web available to people who otherwise would have to use inefficient and costly means in order to organise a group meeting.

On the much wider front however, Tabale can be likened in some ways to a partial voice version of popular micro-blogging services such as Twitter on the Internet. It serves on a local scale but the same role. Once various instances of the service have been deployed at various

locations, it can provide a quick way of sending out pieces of voice information to different target groups of people on their mobile phones to which they can choose to respond or not. Its broadcast functionality makes it very handy to communicate to entire communities very quickly and in a language they can understand.

This "voice twitter" service has the added advantage of usage at the grassroots regardless of language and literacy as what most modern systems require for their usage. The use of simple mobile phones to deploy this service also shows the potential of the service to reach as many at the grassroots levels of Mali as possible when deployed for a purpose. At Sahel Eco for example, the benefits of such a system was immediately noticed by the NGO who suggested the other opportunities the service could provide including opportunities for governments to mass communicate critical information such as in cases of a natural disasters or for health related initiatives such as mass immunization exercises.

4.6 Chapter Conclusion

RadioMarché was built to improve an already existing manual Market Information System which had many barriers to effective dissemination of market-related information. The new service replaced some of the barriers with technology and improved overall efficiency. Tabale on the other hand was built to help a rural NGO better organise farmers and interest groups. It saved time (and sometimes money in the form of travel budgets and personnel assistance for simple tasks) in parts of the world where tools and gadgets for fast information sharing are not ubiquitous. Practically speaking though, the service can be deployed to meet any need for communicating within a specific interest group or community.

The two systems described above this chapter demonstrate the innovative use of voice and Web technologies to connect rural people to (or at least make available the benefits of the Web available to them) regardless of the underdeveloped infrastructure and other barriers such as illiteracy and unavailability of modern technologies in the region. By meeting local needs and building relevant applications, communities which would not have benefited in way from the Web were given reasons to create and share content using Web and voice technologies.

This chapter has also shown that indeed systems can be built to satisfy local requirements using available infrastructure that fit the situation or context. This, I believe, could be a template for other future ICT4D initiatives under similar circumstances. What needs to be emphasised here also is the bottom-up, collaborative nature which the implementation phase had to take. This took the form of a number of back-an-forth trips to and from Mali in an iterative system design fashion. That ensured that stakeholders were involved as much as possible throughout the development process.

Much of the tools and methodologies used in designing and building the systems have also been documented open-sourced to the general public for possible reuse by others (see e.g. Appendix). It is hoped that this will draw attention to interested parties who also might want to replicate this. Making use of available infrastructure coupled with a careful analysis of local conditions and context, Web and voice tools and technologies can be used to improve rural lives especially in the areas of indigenous knowledge and information sharing.

Chapter 5

Assessment of RadioMarché Field Pilot Results

This chapter evaluates and assesses the impact of RM on the local community within which it was deployed after its implementation. This assessment is done by developing a framework based on currently available literature on the subject and using that to measure the extent of real impact of RM in particular and VOICES in general. The need for this assessment is prompted by the desire to know the relevance of the entire project to the lives of the stakeholders in Mali. In summary, actual measurements of impact are mainly categorized into three main subject areas namely, process evaluation, outcome evaluation and future or upcoming perspectives. To narrow down to the actual field work, these three broad categories are broken down further into their various components which encompasses all that transpired under the project. Using these established evaluation strategies helps to paint a valid picture of what actually has happened since the pilot ended.

5.1 Evaluation Framework

5.1.1 Evaluation Methodology in a Nutshell

According to the branch of social science known as evaluation research [Davidson, 2004; Scriven, 2007], evaluation is the assessment of the merit (or quality), worth (or value) and/or significance (or importance) of something.

Evaluation methodology is to be placed among a wide range of social science research methodologies [Bryman, 2008; Trochim and Donnelly, 2008]. What makes it special is that social science research methods historically have a heavy emphasis (bias) on empirical data-based studies where the researcher is typically positioned as an outside (independent, neutral, even supposedly value-free) observer. In contrast, evaluation as a social-science research field inherently and necessarily makes value-based statements about its object of research. So, eval-

uation research does not and cannot limit itself to “the facts” (in contrast to empirical social science), but endeavours to interpret these facts into a framework of values - which gives rise to the follow-on research question what these values precisely are and why/how they are or can be explicitly justified.

Historically, evaluation research has its roots (already in the 1950’s and 1960’s) in big (US) government programs especially in public health and education, where the subsequent natural question emerged whether these programs (often seen as “treatments” or “interventions”, in very much the same way as a doctor or therapist treats a patient/disease with a medicine) were indeed effective and worth the money spent. Subsequently, the conceptualization and framing concerning how to do evaluations diffused to other sectors, including international development and cooperation [see e.g., CIDA, 2001; UNESCO, 2009] and also EuropeAid.

There is a body of literature on evaluation methodology and frameworks, but it is well possible to summarize most of it in what may be called the *consolidated conventional general framework for evaluation studies*, as it has emerged and been published in standardized evaluation check-lists (KEC, [see, especially Scriven, 2007]), associated text books [e.g. Davidson, 2004], and in scientific journals such as the American Journal of Evaluation.

In brief, the conventional evaluation framework and its check-lists can be conveniently summarized in terms of a two-dimensional space. First, it distinguishes a set of important different components of evaluation. Second, it recognizes a set of important typical generic evaluation *dimensions or criteria*. First, standard components of evaluation (typically called sub-evaluations) are:

- *Process evaluation*: this sub-evaluation is addressing the evaluation question what happened during the content construction, design, implementation and roll-out of the “intervention” or “program” and what lessons have been learnt from that. In other words, it addresses the direct outputs of the action.
- *Outcome evaluation*: in contrast, this sub-evaluation is not concerned with the direct outputs or deliverables of an action, but focuses instead on the (observable) effects in terms of outcomes or impacts on stakeholders. Note that these effects may be intended as a goal but also may be unintended, and the latter is also important to include in evaluative studies. In social science research methodology, this is commonly referred to as the issue of "internal validity" of research/knowledge claims or hypotheses.
- *Cost and comparison evaluation*: this sub-evaluation addresses the general question whether the observed effects have been achieved in a cost-effective (resource-economic) way and whether the same effects might have been achieved by alternative means (this also covers the so-called opportunity costs of the action).
- *Beyond-the-current-situation evaluation*: this sub-evaluation addresses the issues of generalizability, transferability, sustainability, exportability, etc. In social science research methodology, this is commonly referred to as the issue of “external validity” of research/knowledge claims or hypotheses.

Second, there is a long check-list of possible evaluative dimensions or criteria that are to be considered. The traditional evaluation research and methodology literature gives the following to consider as important candidates (check-list items):

- Has there been due recognition, analysis and inclusion of the (various) stakeholders’

needs - especially when they are currently unmet (“stakeholder needs assessment").

- What are the relevant evaluation criteria that follow from the specific professional domain? Namely, in many cases it is pretty clear what is “good” or “not-so-good” once a specific professional domain or focus has been singled out. Here for example it relates to ICT technology-based innovation.
- Soundness and consistency of “intervention/program logic”: actions taken have an (sometimes implicit) underlying rationale, usually of the reasoning pattern or type: if we undertake, say, a certain specific action, it will address (make a change in) certain specific needs or shortcomings, and that will help alleviate a specific performance problem or issue. This action rationale may itself be in need of evaluation.
- Fit to (local) context: the evaluation literature furthermore gives a (unassorted) long list of relevant criteria-to-be-considered here including:
  - Legal requirements;
  - Ethical requirements (e.g. privacy);
  - Attractiveness to target groups ("marketability");
  - Organizational, policy, and/or personal development goals;
  - Historical, traditional and/or cultural norms and values.

  In other words, actions must be properly embedded in the specific surrounding context or environment to be successful, and the various and diverse characteristics of this provide key evaluation elements of what counts as success.

The above are standardized check-list items that represent possible criteria of evaluation. The evaluation research literature points out that in each and every case, it is necessary to select the evaluative items and criteria and limit them to those that are actually most relevant and to specialize them to the case at hand. Thus, the conventional general framework for evaluation studies. The consolidation of the discussed evaluation framework dates back pretty much to the 1990’s. This is not to say that there is universal consensus: it has come under heavy critical fire from several angles. A number of more recent developments have taken place that attempt to correct a number of observed shortcomings and biases in the conventional approach to evaluation.

These newer developments in evaluation research [see e.g., Donaldson et al., 2010; Fetterman, 1997; Patton, 1997; Trochim and Donnelly, 2008] bear moreover a direct relevance to the evaluation of the VOICES field pilots:

Participatory evaluation (and empowerment evaluation) [see e.g., Baker and Bruner, 2010; CIDA, 2001; K. Calteaux et al, 2013; UNESCO, 2009; University of Kansas, 2013]. Traditionally, evaluation is considered to be an independent and outside activity (especially Scriven is an outspoken proponent of this view [see Donaldson et al., 2010]). More recently, much more emphasis has been placed on the desirability or even necessity that the relevant stakeholders themselves are to be in the driving seat as to the evaluation of the outcomes and perceived benefits of a program, intervention or action. This approach is labelled *participatory or collaborative evaluation*, and an ultimate consequence of this is the view that evaluation is to contribute to empowerment (especially Fetterman is an outspoken proponent of the latter [see Donaldson et al., 2010]). As a side remark it may be pointed out that this approach has an unnoted but very strong resemblance to the (much older) social science research methodology known as

action research [American Psychological Association, 1991].

Developmental evaluation [e.g., Gamble, 2008]. Traditionally, evaluation is very much seen as a one-shot activity. In the evaluation methodology literature jargon, formative evaluation is basically the same as mid-term review, and summative evaluation is end-of-project review [see Davidson, 2004; Scriven, 2007]. Another more recent development is that evaluation is to be not just outside criticism, but should be focused on conclusions that can be utilized by stakeholders in a (cyclical) learning or developmental way (especially Patton is an outspoken proponent of this approach [see Donaldson et al., 2010]).

Technological innovation evaluation [e.g., Rogers, 2010; Tuomi, 2002]. Evaluation research is a social-science field that is quite remote from technological innovation. Thus, experiences and theory concerning the phases and social factors that govern adoption and diffusion of innovations are not taken into account in the conventional frameworks for evaluation. Neither are recent approaches that aim to experiment with the introduction of innovations in a participatory and developmental (co-creation) way such as Living Lab [see e.g., K. Calteaux et al, 2013] that may be viewed as a form of action research specialized to technological innovation.

Table 5.1: Evaluation framework for VOICES

Name	Description	Elements
Process evaluation	Direct outputs of content construction, design, implementation and roll-out.	•Stakeholder needs assessment •Stakeholder involvement •Technological quality features •Fit to local context •Learning experiences and their inclusion
Outcome evaluation	Observable effects in terms of outcomes or impacts on stakeholders.	•Service use •Follow-on effects of service usage •Stakeholder interaction/feedback •Created awareness and other external effects •Comparative effectiveness
Future Perspectives	Perspectives beyond the end of the project.	•Generalizability •Transferability •Sustainability

Evidently, the evaluation framework used for the VOICES field pilots is not properly framed as conventional evaluation, as it is strongly influenced by the stakeholder-based participatory and developmental approach and by the Living-Lab-like (more on this later), field-experimental approach to (socio-) technological innovation.

5.1.2 Evaluation Framework for the VOICES Field Pilots

As has been pointed out extensively [especially in e.g. Davidson, 2004; Scriven, 2007], each specific case for any evaluation has needs of specialization to the domain and task at hand, as well as restriction to those evaluation check-list items that are most relevant to the case under consideration. This section of the thesis undertakes such a recommendation by developing the

following framework in Table 5.1. The table is used to evaluate the VOICES (the reader is to take note that, from here on, VOICES refers particularly to RadioMarché service) pilots based on actual happenings on the fields of Mali.

This framework is composed of three main sub-evaluation components which include process evaluation, outcome evaluation and evaluation that focusses on future perspectives. The major considerations for settling on these components was as a result of the need to evaluate the project in its totality. This to mean that an evaluation that starts right from the beginning of the project to its end. This was done in order to make sure all other successes and failures were duly accounted for as much as possible. This step also acknowledges that impacts made by the project were not only in the form of technical solutions but also in forms as economic and social impacts.

5.2 Process Evaluation

Process evaluation refers the assessment of the merit, worth or significance of everything that happens or applies before true outcomes emerge or can be observed [Scriven, 2007]. In the present case it covers the envisioning, content, design, implementation and deployment of the pilot, and focuses on the direct outputs delivered. The key evaluative question here is the *merit of the pilot services as an adoptable and potentially useful innovation*.

For the VOICES project, this central question is addressed by investigating the following aspects or dimensions:

a) The way stakeholders needs have been analysed and addressed ("needs assessment") as well as their involvement in the entire process.
b) The technological quality features of the pilot;
c) The appropriateness of the pilot in terms of its *embeddedness* or fit to the local context;
d) Learning experiences along the way and how they have been integrated into the development of the pilot.

The main highlights of this are discussed in subsections below:

5.2.1 Stakeholder Needs Assessment And Involvement

As already been mentioned in Chapter 3 (see Section 3.2.2), the VOICES team took a requirement gathering trip to Mali. The primary objective of the trip was to solicit the views of stakeholders on envisioned set of services for mobile related agro-initiatives. Table 5.2, gives an example on some of the main needs from some of the key stakeholders involved in the project. The main stakeholders included rural farmers who mostly own farmlands on a subsistence basis, foreign-funded local NGOs who work with rural farmers usually organising training sessions with them and stimulating knowledge exchange activities and the finally community rural radio stations. These radio stations have the all-important role of disseminating information with communities.

Table 5.2: A stakeholder needs assessment example for the RadioMarché market information system

Stakeholder	Role	Need
Farmer groups in the region such as Messrs A and B who own farms and work on them on a subsistence basis.	Farmer, honey producer and entrepreneur from Bokuy-Mankoina (in the Tominian region).	•Communicate stock information. •Negotiate price. •Advertise new products, such as honey.
Local NGO Sahel Eco and other NGOs groups in the region who work with mostly with indigenous farmers and farmer groups.	NGOs play an important role in the region through facilitating sessions and trainings and education needs.	•Stimulate local entrepreneurship. •Organize exchange of stock information. •Share agro-economic data and knowledge. •Stimulate sharing of indigenous knowledge and best practices.
Community radio stations in the region who act as the main channels for information dissemination.	General information dissemination and awareness creation initiatives.	•Tools and services to aid the broadcast of market and/or commercial information effectively.

Figure 5.1: A number of face-to-face meetings were organised during the implementation of the pilot as a way of soliciting as much stakeholder input as possible. This picture was taken during one such gatherings in Tominian in Mali. This picture was taken by the author..

Figure 5.1, for example, shows one of the many meetings held for stakeholder discussions. For developing, testing and deploying the RM system the Living Lab (LL) methodology was employed.

Essentially, LLs are experimentation and validation environments of ICT-based innovation activities. They are marked 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 cycles accelerating the innovation process [see e.g., Borjeson, 2009; Dlodlo et al., 2008; Schaffers et al., 2008]. Following this methodology therefore, the various stakeholders were contacted through stakeholder need-assessment workshops, requirements gathering and analysis discussions as well as end-user acceptance tests of system designs and implementation (as has been mentioned in Chapters 3 and 4).

5.2.2 Technological Quality Features

On technology features, this evaluation framework focusses on the what distinguishes the RM system from the lot. In that sense then, this particularly takes a look at the innovative use of web and voice technologies, telephone infrastructure and rural community radio settings become apparent. A major advantage offered by the system was the ability to digitize of market-related information and retrieve them when needed. This made archiving such information much easier and also easy to share. Another added advantage was the ability to use the telephony communications infrastructure, via local GSM network, in the region to access such information in ways that required relatively very little training and know-how. Since the information was delivered in voice, barriers to information access such as illiteracy and language was removed.

An aspect of this subject is the subtle but important purpose of providing a technological solution for a local need within the community as discussed below.

Filling a local need gap with technology

As has also been mentioned in Chapter 3, the idea for the system was conceived after a series of field trips and collaborations with local people. This was an important step because the people for whom the system was built had very little idea of technological solutions available at the time an how that could help them improve their businesses and/or communication needs. After a few technology demonstrations and discussions, the ideas for practically implementable use cases were suggested by the local stakeholders themselves.

The system provided a means through which locals without access to the internet could make content available with the help of simple mobile phones. The economically benefiting nature of the content provided by the locals ensured its (content data) availability for as long as the service is running. It mimics popular and widely used marketing platforms such as Amazon or eBay. The major differences are however that this platform is limited to a few number of products and attached to specific geographical regions. However, the idea behind this have worked quite well with the locals and in some instances created more demands for products than anticipated with it's associated new challenges that never came up for consideration.

Our intervention also gave the NGO an alternative to digitize all market relation information from rural farmers and a means to securely archive this also on the web. Hitherto, all such information was either found on a computer, which was vulnerable to breakdown, theft or computer malfunction. Another important improvement with RM is the control it gave the NGO over what an audio communiqué actually contained. This was because, according to them, they had had instances in the past where the radio people either gave out the wrong information on available products for sale and created inconveniences for people involved in the end.

5.2.3 Fit to local context

The framework for evaluating the VOICES project was also developed to take into account how the intervention fits into the context within which it was implemented. This is specifically the measurement of the effect that the RM system had within the community that hosted its implementation. To this end, a feedback reporting exercise was organised in Mali supervised by partners of the VOICES project in the country which was done after the system had ran for a while.

This feedback was in the form of a questionnaire taken around selected radio stations in the country as well as data on the sale of products from farmers. This was done in October and November of 2012 (see Appendix C.5). The feedback received was categorized into two parts namely feedback on usability (voice quality, web and phone interface) and the impact of the system (its usefulness and side effects) since its deployment.

Two other forms of how the intervention fits the context comes in the form of perceived usefulness of the system and its local effects on business and trade discussed further below.

Perceived usefulness of the RadioMarché system

On the whole, qualitatively, the analysis of feedback data indicated that the RM system improves the communication between the producers (i.e. farmers of honey and shea nuts and shea butter) and their customers and therefore improved their trade. The report from the radio stations also indicated that the communiqués broadcast on the radio are heard by many potential customers.

From an interview conducted with the farmers and the radio stations (who were part of the project), this translated into phone calls to them by potential buyers who were interested in their products after a four-month continuous broadcast. Many factors could be attributed to this increase including better and efficient processes as a result of the pilot as well the added innovation of using the GSM for access.

Effects of the RadioMarché pilot on local trade

As an example on the effects of RM on local trade within the region, it was also gathered from the feedback that the radio broadcasts for the communiqués created a demand of honey that could not be met by producers. This feedback was given by radio Mopti, radio Koutiala in the Tominian region. This then resulted in a pause in radio broadcasts of communiqués on honey until the time there was enough of the product available. That situation also prompted decisions

to create sales points for honey in the villages of Segou, Tominian to lessen the pressures of radio stations from buyers interested in buying the product.

From the questionnaires, it was also realised that although sometimes the demand for products could be met, lack of logistics prevented early supply. Facilities such as good transportation vehicles and storage facilities prevented meeting demands of buyers. On the whole, as has been pointed out already, this is largely due to the fact that the value chain behind the system even before the operation of RM is not yet well organized. The service has therefore provided new business ideas for the NGO involved such as setting up a selling point and organizing producers in a better way to maximize profits and to help make the system sustainable.

5.2.4 Learning experiences and their inclusion

The RadioMarché system provided a unique experience to witness at first hand the impact such tools can have on the lives of farmers in rural African communities. Also, the pilot provided a unique opportunity for useful feedback on how such systems could be built in future pilots. For instance, in developing and implementing the RM system it was important that the system worked as closely as possible as in the old way. In others words, all new processes that needed to be developed had to fit the context within which it was being implemented and not only because it could be useful.

In achieving such goals however, we learnt for example that non-scalable methods had to be employed (see e.g. Section 4.4.1 of Chapter 4). Many of the non-scalable challenges became hard requirement for the implementation of the RM system.

Also, as part of a working visit to Mali in November 2012, two native speakers of Bambara and Bomu languages were interviewed on what they thought about the then newly developed and implemented TTS engine. The questionnaire only sought to know the quality of the tool and how close it was to a real instance of a natural speaker. Some of the feedback from them included the fact that the initial design had no pauses between the words and that the intonation did not seem natural. When asked to rate the system, the Bambara TTS it was rated a 3 on the scale of 1 (for very good) to 5 (for very bad) whereas for Bomu, it was rated 2 by the native speakers. This already indicated a some level of success. The feedback was relayed to partners in North-West University, South Africa, who worked on it in the next implemented version of the system.

5.3 Outcome Evaluation

This sub-evaluation addresses the observable effects (outcomes or impacts) that the pilot deployment has had on target groups and downstream stakeholders. Note that this may include intended as well as unintended effects. To assess the pilot outcomes, the following aspects or dimensions are considered below:

1. Service use.
2. Follow-on effects of service usage.
3. Stakeholder interaction/feedback.

4. Created awareness and other external effects.

5.3.1 Service Use

In trying to understand the extend of use of the RM service, a number of farmers were asked of their opinions in a survey on the usefulness of the service to improve communication and trade (refer to Appendix C.5).

Figure 5.2: Bottled honey, processed néré (almond) seeds and shea butter (in blue and black containers) for sale by women cooperatives farmer groups in Tominian. Credit: Anna Bon.

On service use issues bothering on usability of the system were at some point also evaluated. A number of suggestions for possible modifications to the initial systems were given. That included the following:

- On service satisfaction, one of the complaints was as follows: "customers call us to say that their product orders were not answered with satisfaction": the immediate solution for this was creating a point collection delivery in Tominian was proposed by producers;
- Another bothered on the quality of the phones being used with a comment as: "We need a phone with a better quality of sound to listen better." This issue had to be dealt with by the users themselves since the pilot had not included the distribution of phones for use. However, this was not thought to be a problem which could derail the project;
- Other concerns were on the implementation of possible new functionality suggested by our users: "We need to be able to upload the generated sound (audio files) from the platform web, to place it on the air as." This genuine concern was implemented in the next version of RadioMarché that was later deployed.

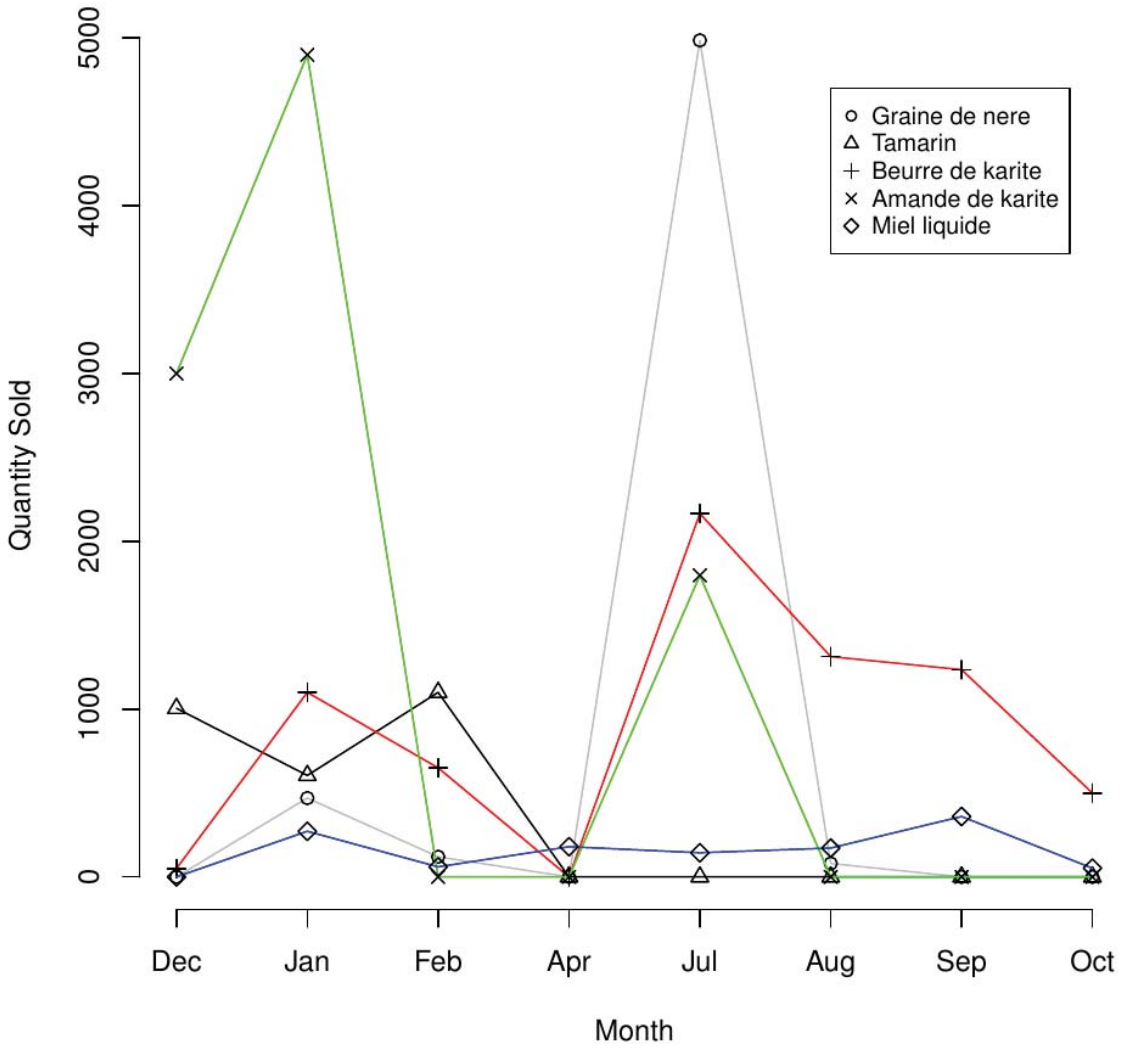


Figure 5.3: Sale trends on the RadioMarché system between December 2011 and November 2012.

On the possible side effects of the system within the community, Figure 5.2 shows some of the packaged products that were sold using RM.

Figure 5.3 on the other hand shows the sale trend of the products within the period of December 2011 to November 2012 from the logs of RM. The logs showed that the month April recorded the lowest of activity in terms of sale for all the products (except Miel), whereas months March, May, June and November recorded no sale at all. The quantity fluctuations were as a result of the availability of products on the market from the farmers.

Also, from the system logs it was established that in total, 23 market information communiqués were published between the period on the RM system (Table 5.3 shows the total of each product. Appendix C.4 shows the complete data). Overall, the results showed a steady increase in use of the system and fluctuations in prices. However, other factors developed over the period

Table 5.3: Summary of RadioMarché Logs for Period December 2011 – November 2012

Product	Total Quantity Sold (kg or l)	Total Price (CFA)
Tamarin	2710	4750
Beurre de karite	7014	28066
Amande de karite	9697	2425
Miel liquide	1340	41230
Graine de nere	5650	5525

that also affected its operations. These factors includes the following:

1. Local Malian phone numbers that were essential to the use of the system were not available within the period of November 2011 to April 2012. This was due to an initial miscommunication with the Malian telecom operator. As a result the system was not tested November 2011 by radio journalists in two stations. Also, the local line that should have been accessible through the Emerginov platform gave no response to the phone calls. This flaw was only discovered when the team visited Mali in November 2011, and held meetings with the radio journalists.
2. A coup d'état occurred in Mali on March 2012, in which the then president of Mali was removed from power by dissident soldiers. The political unrest that followed this event took much of the attention of the local partners. Electricity outages became more and more frequent which affected productivity in the country; also, the state radio (of which a partner radio station ORTM Ségou is part) was occupied by the rebels, and travelling was unsafe during a period of several weeks.
3. There were periods where as a result of errors discovered, the system had to be taken offline for them to be corrected.
4. There were periods of complete non-production since fruits and nuts were out of season in Mali.
5. Initial adoption of the system was slow as it was launched at the time when users thought it was safe to use the old system alongside the new one. There was no testing phase before launch of system since we had limited time.

Although these factors impacted negatively on the operations of the pilot, they were not significant enough to derail the project entirely. However, but for these factors also, service usage could have been significantly more than recorded. Some important lessons can also be drawn from these drawbacks such as adequate preparations and familiarisation with environment are key to deploying successful ICT4D projects.

5.3.2 Benefits effects of service usage

As has been already mentioned in previous sections of the chapter, the feedback gathered indicated that the radio broadcasts of RM communiqués created a demand of honey that could not be met by the producers. An important outcome of this then were steps that the supervising NGO had to take to streamline the activities of the farmers involved. This includes new ideas to designate sales points for products that are in demand and hence allow the farmers

themselves to manage demand. Another effect was on new ideas and business models that developed as a result. A typical example is the case of one of the privately owned rural radio stations in Sigodolo that designed new business models around their already existing platform for information collection and dissemination.

Also, as part of the evaluation of the the VOICES project, audio and video records in the form of interviews were made of the testimonies of the farmers involved in the pilot. This was done to document real impact that had been achieved as a result of the project. Below is a statement from one of the many village participants in the pilot.[1] Zakary Diarra farmer, honey producer and entrepreneur from Bokuy-Mankoina, (in the Tominian region of Mali):

> "I now sell 200 litres of honey. With RadioMarché, after the broadcast on the radio I was able to sell all of my honey. I am able to pay schooling for his children and also able to buy a cart and donkey"

Another farmer, Naomi Dembele, had this to say:

> "Thanks to this system we, the women who produce shea butter, are known throughout the country, and whenever there is a demand of shea nuts people will come to me. I am proud that I am known across the country."

The above quotes is an indication of some level of real impact the service had on the lives of rural farmers involved in the project. Similar stories have come from other participants and radio businesses.

The benefits of the system also came in forms such as revealing deficits in the original product supply chain which had not been previously anticipated. For example, farmers found that many buyers or customers were not satisfied with the response to their orders in terms of quantity. Especially with honey and néré which had more demand that could be supplied in sufficient quantities to satisfy customers. Also, cooperatives came to know or realise not to have the financial and technical capacity to produce honey and néré in large quantities due to factors such as the fickleness of customers, difficulties of access and poor telephone networks. Other benefits translated to new ideas such as new customers such as those in hotels, and local supermarkets although this demanded new and proper packaging and branding. shea nuts into finished products like shea butter.

5.3.3 Created awareness and other external effects

An important achievement accomplished under the project is the development of methods for the development of TTS engines for low-resourced languages particularly such as Bambara and Bomu in Mali. The methodologies behind this are currently being documented together with the procedures which could be extended to other languages of anywhere in the world. This then creates the avenue to develop voice-based services for the millions of rural dwellers in Africa and other regions of the world.

[1] A video interview of this is available online at http://vimeo.com/68218759

In many ways also, the project has helped to broaden the awareness of the possibilities for voice-based service for use by low-literate rural dwellers. Even though these types of services have been in use for decades in developed worlds, not so much of its development and possible use has been done in terms of research in less developed worlds. Another factor is the number of the local dialects that are spoken in regions across Africa which makes it quite difficult to develop such services. The project therefore extends the little work which has been done in the past and seeks to promote research in that regard.

5.4 Assessment of Future Perspectives

The two components of our framework, process and outcome evaluations already discussed in this chapter both refer to observable results (outputs and outcomes, respectively) obtainable within the course and duration of the action. In contrast, this section provides an evaluation of the perspectives beyond the end of the VOICES project. Although also this assessment is as much as possible evidence-based, presented data will necessarily be more indicative rather than fully conclusive. For the present pilot, the future perspective assessment is addressed by investigating the following aspects or dimensions:

a) **Sustainability**: the likelihood that developed services will be further adopted and maintained by stakeholders on a continuous basis, beyond their current initial development (project RTD stage).

b) **Transferability**: this discusses the capabilities made available to transfer required knowledge regarding voice-based service development, maintenance, and use to various stakeholders and interested third parties.

c) **Generalizability**: this refers to the possibility to expand the piloted technologies to other use cases, services, domains, and countries.

5.4.1 Sustainability

On sustainability, VOICES has undertaken some studies on the possibilities of moving the project beyond the pilot. For RM in particular there have been various attempts to sustain the project beyond the pilot. To this end, a number of business models have been discussed and the possible ways to achieve this. However, finding or developing a single, concrete model on sustainability has been difficult because of a number of reasons. The difficulty is as a result of the many factors that, although are needed to ensure sustainability becomes a reality, are however *external* to the project itself. One such difficulty is the poorly developed infrastructural needs within the communities where the project was piloted. These needs as the local supply value chain, storage facilities for farm produce, and others such as capacity of farmers are underdeveloped. This creates a situation where stakeholders cannot meet demands for orders in real, practical terms and quantities. And this also essentially means not earning enough to cater for the running of the platform beyond the pilot. However, the ideas and tools developed in the project can be sustained. And this means propagating them in ways that others can use which has translated into forming collaborations abroad to ensure adoption and use.

For the operation of the RM system itself a number of important steps were taken with sustainability in mind. One such steps was the use of hardware that was easily reconfigurable and robust enough for the environment (see Section 4.4). The implementation of the offline RM platform was done with the sole aim of making sure the system could be continued even when project partners had pulled out and also promoting local ownership. To press that further, VOICES has organized a number of important community-building activities which included, amongst other initiatives, the delivery and roll-out of a mobile training lab that offers education for local partners and entrepreneurs in developing mobile ICT and Web services. This also involved a community of enthusiasts who want to further deploy voice technologies in their own environment. VOICES has also proved the fitness of its results and its adaptability to the African context by local pilots and associated community building which culminated in health services pilots in Senegal, and on agricultural and re-greening knowledge sharing initiatives in the Sahel countries.

5.4.2 Transferability

Transferability refers to efforts put in place to make tools and knowledge acquired within the project available to others for possible implementation or use. Various steps were taken to ensure transferability of under the project. Right from the beginning of the project, conscious steps were taken in the form of the kind of tools for building the services. RadioMarché was built with freely available tools and technologies with free and open licences for use. In addition, the RM source code together has also been made available on GitHub (see Appendices A and B for more on this) by the author to the public with instructions for its installation and use.

Along the same lines, other the tools, services and methodologies developed under the VOICES project have been made available to the open source community. The Emerginov software platform currently has been bundled as an Ubuntu package and the first version released onto the Linux (Ubuntu to be specific) software repository by its developers at France Telecom. Though still missing a few components at the time writing this thesis, the basic installable modules of the platform have been bundled and released whiles other modules are being worked on.

Also, as has already been mentioned, partners in the project from the Northwest University in South Africa have developed a methodology (see more on this in Section 4.3.4) for modelling and developing simple text-to-speech engines for local African languages. This methodology, referred to as the slot-and-filler method, aims to provide clear steps and procedures that could be used to build inexpensive but useful text-to-speech engines for voice systems. By these procedures, many languages could be supported and used in voice systems.

At the time of writing this thesis, plans to offer training sessions to local Malian ICT entrepreneurs and small businesses who have interests had been initiated. A number of follow-up trips have already been undertaken to Mali in this regard (see Figure 5.4). This training would offer opportunities for them and spur ideas for setting up all kinds of services around such technologies. This will eventually offer close collaborations between developers in the region and developers from different parts of the world in order to advance the agenda of building voice services for use by many rural poor increasing access to the Web in the process. Apart from Mali, there have been collaboration efforts in neighbouring countries of Mali with potential partners

who wish to use the tools and ideas from VOICES. In Ghana for example, the University of Development Studies has taken up other initiatives to better serve their immediate communities a result of one such collaboration with the VOICES team. There have been similar efforts in Burkina Faso and Niger.

Figure 5.4: One of the many follow-up visits to Mali where stakeholders had to be trained on the use of RadioMarché. This happened on the premises of the national broadcaster ORTM in Ségou in 2012.

5.4.3 Generalizability

The long term effects of this pilot under VOICES can be expected from the extensive community-building activities undertaken during the pilot. This entails long-lasting contacts with NGOs, rural radio stations and farmer organizations, local and global entrepreneurs, ICT and web developers and donor organizations, as to create community of practices that may further the results of the project in this environment on the shorter and longer run.

To ensure the local adoption and exploitation of the tools and methods beyond the project, business models have been designed for its results in co-creation with local partners and communities. These business models may help local entrepreneurs to create local ecosystems and deploy the results of the project in a sustainable way.

At a local level in Mali, the project has made a step in providing local farmers access to new markets for their products, offering them new opportunities and increased income. VOICES also provided new tools to Sahel Eco to increase its impact and ease its action in the field through the use of ICT tools. The current services will soon be scaled up to other similar organizations in Mali, Burkina Faso and Ghana. There are plans to train staff members of Sahel Eco and their local partners on how to deploy and support mobile technologies in Mali so that they will be able to support further extensions of the current services.

At a global level, a set of tools and methodologies have been developed and given to the open source community to help them develop and deploy sustainable voice-based services. Also many

presentations have been made at international conferences and through scientific publications to spread this ideas and create opportunities for sharing ideas. As a result of the awareness that have been created, it is expected that more and more initiatives that currently only use SMS will start to consider voice-based services as a more appropriate alternative. The solutions and tools of VOICES therefore are essential in that regard and unique. There are no other similar options that exist today, and in that regard the VOICES project has lowered the barriers to building such services. The press coverage received by the project from major journals (such as the New Scientist Magazine[2] and SciDev[3] and others), as well as awards received and spin-off ideas from the project [see e.g. Gueret et al., 2014; Schlobach et al., 2014] and patronage from the international media group, Al Jazeera,[4] with a spin-off project demonstrate the impact of the project in the domain.

The ideas from VOICES have spurred other ideas on the possibilities of similar tools in neighbouring countries such as Ghana. Newer ideas include those without the need of NGOs as agents as has been considered by Dittoh [Dittoh, 2013]. Partnerships have also been built in Mali, Burkina Faso, Niger and Ghana with other organisations who wish to deploy similar services through initiatives and intervention. Also in Ghana, this has resulted in closer collaboration between researchers from the University of Development Studies in Tamale and VUA in Amsterdam aimed at promoting research of mutual interest and fostering the development and growth of ICT4D initiatives among Ghana rural folk.

5.5 Final Conclusions on Evaluation

The methodology used in evaluating the VOICES project as has been described in this chapter can be applied to any ICT4D project. We have shown that by carefully analysing aspects of any ICT4D initiative, it can be evaluated using the conventional evaluation techniques as a useful guide. This will require some deviations from the conventional, often straight-jacket, evaluation benchmarks which often do not satisfy or meet the evaluation needs of such projects. The chapter has also shown how to extend the participatory/agile approach to ICT4D and how it can also be fruitfully extended to the evaluation phase of innovative ICT4D. It is also argued that evaluation should be integrated into requirements gathering, implementation and roll-out phases of an ICT4D project and not be an outside after-the-fact activity.

In concluding the discussions on evaluation, the results of the pilot in Mali can be summed up as follows:

- **Demonstrated the potential of increased Web access**: Through the project, a case has been made for the adoption and implementation of voice-based services and systems as a way of basic rights needs of individuals in access to information. VOICES has demonstrated that relevant systems can be built independent of overly expensive infrastructure but that

[2] reference for this publication can be found here: http://www.newscientist.com/article/mg21829145.900-voicebased-web-access-helps-illiterate-get-online.html#.UffGwyGf234

[3] and here: http://www.scidev.net/global/icts/news/voice-tech-helps-africa-get-online.html

[4] http://www.aljazeera.com/indepth/features/2012/12/201212713152520185.html

which is available within a given context. This idea can further be broadened to include the quest to expand access to information and expanding the reach of the Web.

- **Further integration of Local Community Radios and ICT**: Among its features and functionality, the toolbox and methodologies developed in the project has facilitated the bridge with local community radios. In addition, innovation through the use of local GSM channels also opens up a well of opportunities for the building other use cases previously not possible for the radio stations and thereby increasing access and efficiency.
- **Better Support of Languages**: The VOICES project has delivered tool support and a methodology for under-researched and under-resourced languages to aid building of voice-based services. The tools and methodologies will go a long way to facilitate the creation of local content in African languages through voice-based services.

That said, it is also important to emphasise that a number of challenges still do persist and need further research. One such challenge is that in the parts of Mali where the pilot was undertaken, many of the volunteers who were involved in the project were mostly subsistent, small-scale farmers who dealt in relatively small quantities of commodities for sale to the general public. The technical solutions offered by RadioMarché at some point generated a lot of positive interest which could not be satisfied because not all the value chain has been properly developed and capable of meeting higher demands in those places. In that sense then, the system became a nuisance and publishing of communiqués had to stop at some point during the pilot. This brings to light some other aspect of dealing with farmers on that scale.

Apart from this challenge, the evaluation also revealed some more real technical challenges that prevail in the environment and need further research. Particularly, apart from the persistent lack of supply of an amenity like electricity, much of the operations of the RadioMarché service relied on service providers who, in our case, were willing to work with us. The huge initial cost for investing in other alternatives are formidable coupled with other legal requirements that might come up working in countries such as Mali. However, given the huge potential of voice-based services in these regions, all that dovetails into the willingness to take business risks and finding the right technical people to implement tools and solutions.

Finally, the chapter has also highlighted some important mistakes to avoid in future ICT4D projects.

Chapter 6

Generalizability and Contextualisations

This concluding chapter takes a second look at the issues that have been raised so far, namely, the global digital divide problem and the implications it has for vast populations especially in the developing worlds. Also discussed is the attempt my research has made to address this problem in a specific context in rural Mali. In the previous chapters, I have taken a look at the definitions of this problem and specifically described instances where two such attempts have been made to bridge the divide using the Web and other freely available technologies in innovative ways. In the instances described, the attempts were to help rural farmers with technological tools to reach out to a wider market of buyers and also to aid their line work within their environment and context. The chapter builds on this and then further discusses future research possibilities along this path, specifically in the area of building workable and usable voice interfaces for use by less literate populations. Finally, concepts of generalizability and accuracy in the context of this research are discussed and explored further—what these concepts mean for this research itself and also for the wider research community. The chapter then concludes on the wider implications of a research as this on general ICT4D issues, ICT and economic development in rural Africa, and the strategies and/or methodologies for successful ICT4D research and education in Africa.

6.1 Recap of The Major Issues

Africa and other developing regions in the world lag behind the rest of the world in terms of demographics on ICT usage. For example, analogue telephones, computers, broadband internet connections and many other recent digital gadgets are missing from the average home in many African countries. What one is likely to find though is a radio set for receiving information on the airwaves. Radio has its roots in colonial history with a link to the largely oral and the aural in the cultural practices across the continent. Radio has even been called "Africa's medium" [Gunner et al., 2011].

It must also be pointed out, however, that despite the many years of neglect of technological

infrastructure development in Africa, some inroads have been made in relatively recent times with regard to the use of modern technologies, especially with ICT. Worthy to note among these is the rise in the use of mobile telephony and the accompanying improvement in infrastructure for such services. Many African governments have diversified their economies and opened them up as well to allow participation from private sector stakeholders in the mobile communications industry, and thereby, promoting strong but healthy competition within the industry resulting in improved services to consumers.

The impact of this participation from private stakeholders in the mobile telephony industry has been registered in the form of huge patronage from citizens, some of whom are using telephone services for the first time in their lives. In a little over a decade, the continent has become the world's second most connected region by mobile subscriptions, has witnessed the fastest growth in mobile subscribers in the world and, according to a 2014 CNN special report, was on track to hit one billion mobile subscriptions in 2015 [Jidenma, 2014]. The exciting part of this development is that it opens up avenues and opportunities to reach previously difficult-to-reach communities through these devices and technologies with innovative services. In order to do that though, a major barrier needs to be overcome.

This barrier is adult illiteracy which is widespread on the continent. According to a UNESCO report, Africa is the only continent where more than half of parents are not able to help their children with homework due to illiteracy, and that 38% of African adults (some 153 million) are illiterate.[1] The effect of this on building mobile-based services is significant in that it indirectly dictates what these services should be—their type and also issues on modality, format and access among others. Here, it is interesting to note that the vast numbers of the type of mobile telephones pushing the numbers on usage through the roof are feature phones and not smartphones.[2] This is by no means a coincidence because smartphones require a certain level of know-how and education for navigation of the device whereas feature phones require far less these restrictions. Since the time that mobile-based services first appeared on the scene as possible useful alternatives, there have been various attempts at research on building these services using SMS. The results, although notable, have been all but astounding with a significant number them going out of use and failing to make any impact at all as intended. This can largely be attributed to the problem of illiteracy as already mentioned since SMS usage inherently requires that users are literate.

My research has demonstrated alternative solutions through which ICT4D can be made meaningful to rural communities using Web, mobile, speech and radio technologies. These technologies have been used to meet specific needs in communities where such services were needed. Along the same vein the approach to implementing such services has also been provided. Specifically, the research has shown the need for bottom-up, needs-oriented, collaborative agile approach as an essential component for successful implementations of these kinds of projects. This approach, the research has shown, builds trust among all stakeholders and eventually feeds in requirements gathering, system development and deployment phases of an ICT4D project.

[1] http://www.unesco.org/new/en/dakar/education/literacy/
[2] see e.g. http://www.itnewsafrica.com/2012/08/africas-top-selling-mobile-handsets/

6.2 Future Research (VUI Guidelines)

My research has demonstrated that voice-based services do indeed work in even rural conditions. An important outcome of this is also that adequate training for would-be users could be all there is to do in order that users who are not computer literate can use such services. However, it is still not well-understood whether such a training is in itself enough for any type of Voice User Interface (VUI)-based mobile service. The research has shown rather that in building voice-based services, it is also important to understand, in the context of ICT4D, the real (human) needs and challenges within the environment where such services would be implemented. This understanding then is key to building tools and services that are usable by these communities.

A major challenge in building VUIs is finding out whether a designed interface is easy to use or otherwise.[3] Research over the years has shown a number of guidelines available for designing easy-to-use VUIs. These guidelines allow for the development of usable, consistent applications. Some guidelines enumerate general principles, whereas others give specific details regarding interface design [Souza and Bevan, 1990]. In general, VUI guidelines can be presented as patterns which provide a *lingua franca* that can be understood easily. Patterns are a valuable source of information and they promote reuse. Patterns cannot, however, serve as a single source of design knowledge i.e. they must be complemented by traditional sources of information [Cohen et al., 2004; Schnelle et al., 2005]. The guidelines include, but not limited to, the following:

1. Linearity, i.e. the sequence or steps taken through the interface must be straightforward [Sherwani et al., 2007, 2009].
2. Limited choices, i.e. the number of options at each node in the design must not be more than three [Cohen et al., 2004; Sherwani et al., 2007, 2009].
3. The prompts must be precise [Abbott, 2002; Sherwani et al., 2007, 2009]. This essentially means each prompt must be:
   - Brief
   - Non-descriptive i.e. to-the-point.
   - Straight-forward i.e. prompts that are easy to understand.
4. Touch-tone interfaces i.e. DTMF operated VUIs are generally easier to use than alternatives such as speech interfaces [Abbott, 2002; Cohen et al., 2004; Patel et al., 2009].

From the above guidelines for instance, one can easily design a contrasting "difficult-to-use" VUI simply by ignoring much of its dictates. For instance, a design that largely incorporates speech operations easily becomes a difficult-to-use design since speech interfaces are much more difficult to work with. However, in a rural African context this is still a grey area of research. It would be interesting to know in a future research what this actually entails and what specifically needs to be done in order to achieve a usable VUI by all.

Future research is thus recommended as a lesson learnt from building RadioMarché which did not particularly consider all the above guidelines in detail. The guidelines were implemented in bits and pieces. It would be of interest to find out exactly what each of these guidelines entail

[3] Some ideas here have come from the work of two Masters students Onur [Akgun, 2015] and Serdar [Parlak, 2015].

and the extend to which their proper definitions in similar projects would have on eventual implementations—a finding this research did not achieve.

6.3 Generalizing Research Findings

I now turn the focus to generalizing the findings of this research to the burgeoning field of ICT4D research. Especially, the notion of *generalizability* has roots derived from quantitative methods [Burrell and Toyama, 2009]. It draws on formalized procedures of data calculation, using random sampling from a given population. Through statistical modelling, whatever patterns are found in a given sample are assumed likely to be true of the population as a whole. According to Burrell and Toyama, generalizability, however, does not only apply to statistically significant results, but also case studies of small populations that identify new phenomena, causal processes, counterexamples, or additional evidence for existing hypotheses. Apart from those based on statistical theories, generalizability can also be derived from other disciplines. Kennedy [Kennedy, 1979], for instance, argues that ethnographers, for example, employ methods which dwell on abstractions, models, framework and theory constructed on empirical data often starting with a single case study. And that what differentiates this form of generalizability from quantitative statistical evidence is the strength of researcher's arguments and layering of case studies which allows movement from the specific instances to an application of the model in other settings.

Also, for any research finding, the *accuracy* of the research and its generalizability go hand in hand. As rightly noted by Burrell and Toyama, any attempt to generalize a research finding should also take into account the importance of accuracy. This is because with generalizability comes the spectre of over-generalizing. Looked at from another perspective, accuracy is an aspect of *confidence*—a much wider term used to determine, on a general note, whether a phenomenon under study is adequately described or captured in its reporting with some degree of precision. Therefore, results from statistical random sampling, for example are accurate only generalizable to the larger population from which the sampling takes place and even then, this is only the case for a truly representative sample. In that sense, the authors rightly note that there is no guarantee that a result that necessarily holds true for the Indian population, no matter how large a sample on which it is based or how statistically significant will apply to a population in, say, East Africa. In the same vein, a single case study is rarely enough to make assertions about what is taking place in other regions.

In some research fields, and especially in ICT4D research, some academics [see e.g., exchanges between the authors in Burrell and Toyama, 2009; Unwin, 2009, as well] argue that generalizability is as essential as the research itself. This is because when such studies make no attempt to consider how findings might apply outside the specific, directly examined case, they are of limited use to the research community. In most rural African communities, there is not much coordinated research available on most of the issues that prevail within these communities [see e.g., Annor-Frempong et al., 2006; Barnard et al., 2010a; Barnard et al., 2008; Boyera, 2008; Heeks, 2002; Krishna and Walsham, 2005] due to many reasons. Some of the reasons for this lack of coordination of adequate research includes mainly that much of the

research done in Africa on rural poor are donor funded and are only undertaken when first of all, there are funds available. Secondly, even in cases where funds are available for research, they are often granted for those types of research that fit into the needs of the donors. This in the end augments an already bad situation where not very much is known research-wise about the socio-economic and technological lifestyles of much of rural Africa. Given such a situation, generalizability plays an essential role in promoting development related needs in the parts of the world and therefore makes this chapter an important conclusion.

The sections below (Sections 6.4 to 6.7) therefore attempt to generalize the findings from the field pilot on RM and Tabale in Mali particularly to the immediate regions around the Mali, namely Burkina Faso and northern Ghana. This is possible given the similarities in the types of economic activities, environmental and climatic conditions that prevail in most parts of these environments. Essentially, the RM innovation is only a system and the tools and technologies behind it should be able to aid any process when suitably adapted in any of these regions.

6.3.1 "D" is for Economic Development

Yet an important concept which needs further elaboration in the context of this research is the concept of *development*. In many ways this research lays claims to the fact that ICT can, and should, be promoted for use in development efforts in deprived regions in the world. Currently, the different ways of understanding or defining development is an ongoing debate in the global development research community. The source of disagreements have mainly been based on the uncertainty that surrounds which aspects of life are and are not important part of global development efforts.

However, a brief look at the history of *development aid* suggests that the concepts of development spans decades of international activities across different regions. According to Toyama and Dias [Toyama and Dias, 2008], the roots of this can be traced to the years of post-World War II when the United Nations, the International Monetary Fund and the World Bank were all formed to aid reconstruction efforts and to strengthen trade partners, particularly, of the United States. Colonies of Europe which also later gained independence along the years set ambitious plans for economic growth. Coupled with the advent of the Cold War, the United States and the Soviet Union each started seeking support from the these newly formed countries in the form of offering development aid. Toyama and Dias posit that these events laid the foundations for activities on a global scale that were intended to help poorer countries grow out of poverty—what have come to be known as development. There have also been attempts to define the baseline for what development means in the past. Some studies have mainly been solely focussed on measuring the Gross Domestic Product (GDP) of a country and its link to alterations in the industry. Other studies have been on the growing gap between the rich and poor, a phenomenon which has drawn a greater attention to the particular needs of the poorest segments of society [Basu, 2000; Burrell and Toyama, 2009]

In recent times, attempts have to been made to broaden this baseline for defining development. One such attempt has been the setting up of Millennium Development Goals (MDGs) which formulate specific sectors where developing countries need to improve. The belief is that significant improvement in certain sectors of an economy such as in health and education

sectors of a country would have verifiable causal effects in the lives of the general citizenry of the country. Thus a healthy, educated individual can be expected to earn more than a sick, poorly educated person as rightly posited by Burrell and Toyama. However, an important observation is the subtle friction that exists between the different ideologies. As also rightly noted by Burrell and Toyama, an example is the absence of entertainment in the MDGs. Even though significant research shows entertainment as a major driver for technology adoption, it is not included for the intended beneficiaries of aid who frequently seek it.

For this research, the "D" in ICT4D stands for development especially for the marginalised with particular emphasis on those in West African countries. This definition of the concept of development is also one that solely depends on the economic development aspect of a population within the region. It is important to mention this since different perspectives exist. For example, even though there seems to be a general agreement that ICT tools have indeed been used to make fundamental differences in the lives of the world's poorest and marginalised, other contrary perspectives also exist. One such contrary perspective often argued is that the evidence available is not conclusive especially when one focuses on relative definitions of what poverty is. However, this research has shown empirically that ICTs have indeed been used to contribute positively to development when it is defined exclusively as economic growth as also suggested by Unwin [Unwin, 2009, p. 360].

For this research, this development is defined within the context of economic development through efficient mechanisms enabled by ICTs. Fundamentally, and as has been shown in preceding chapters (especially Chapters 4 and 5), RadioMarché only enhanced a system that already existed but was inefficient in some of its operations. It aided an already existing local activity for reaching a wider market of buyers for rural farmers. The results obtained from the short pilot were tangible and real. Evidence of this had come from testimonies from some of the farmers who acknowledged increase in sales and economic activities during the time the research was in progress. Other evidence was from logs files programmed as part of the system itself. That said however, it is appropriate to say that the application of ICT4D could also be done in ways which do not necessarily translate in economic benefits. A mobile phone call to relatives in the aftermath of a disaster provides benefits which cannot be easily quantified or measured economically.

6.4 The Role of the Web, Voice Technologies in ICT4D

In order to understand how the World Wide Web has transformed society and continues to do so, it is important to recognize the three characteristics of information in general. These are namely that (i) information is produced (ii) it needs to be stored and lastly (iii) it is consumed [Unwin, 2009, p. 54]. This characterisation is important in order to understand the role of information in ICT4D initiatives and how multi-modal access to information is crucial.

On how information is produced, Unwin argues that the process of information production is embedded within societies in which it takes place, and therefore reflects their gendered, ethnic, political and social structures. He makes a comparison with how that has been done in the past and how the Web has transformed this. He argues that the traditional worth or value

of a type of information has depended on who produced the particular information thereby making information from elites in societies being of more value than that from less socially or politically important. The evidence of this, he continues, could be seen in the market place, for example, where information is largely valued in terms of utility in the sense that it is closely linked with supply and demand and in which case information for which there is little demand is thus considered to be of low value, whereas people have been willing to pay large amounts for information that is deemed to be important. In that sense then, the advent of the Web has, among other things, enabled the transformation of traditional structures of power in the production of information. For this reason, Blogs (short for Web Logs) are popular these days and information is only a click of the button away.

Unwin further argues that the WWW has enabled the dissemination of vast amounts of information on a scale never before witnessed in history and this can been seen in how information is stored. Traditional library systems, record offices and filing cabinets have all been gradually replaced with online services for reasons ranging from competitive advantage to economic feasibility. Also, traditional storage formats of information such as paper are gradually being replaced with magnetic disks and tapes, optical storage media etc. Particularly, magnetic storage enables the Web to play a significant role in the form of database back-ends that store much of the information available the Web. This ease of storage of information due to the increase in the use of magnetic storage makes search engines popular in that access to stored information has been made easier and convenient. At the click of a button, the screen of a computer can be filled with rich sources of valuable information never before seen in history. Importantly, he however notes that this phenomenon is not a global one. In societies where oral tradition is very much practised for example, indigenous traditions and customs are passed from generations through art and word of mouth. Even though this can also be transformed and stored in some form, it is not trivial. In the end, Unwin notes that as more and more information is stored and access digitally, those who for whatever reason are unable to access it are becoming increasingly marginalised.

The last important characteristic of information is that it is consumed. With this characterisation, a handicap of the Web as it largely is at the moment is revealed. Much of the access to the Web has mainly been for textual information. Even though there's increasingly significant support for audiovisuals for all types of users, textual information is by the far the common form in which information is consumed on the Web. This reason underlies the urgent need for multi-modal access to the vast wealth of information on the Web. It is also the reason this research investigated related technologies such as the mobile telephony and the radio in places like rural Mali where the internet could take years before becoming commonplace. Voice access to the internet as a mode has the advantage that it is a natural form of communication to almost all persons and especially for the rural poor, sometimes the only form that they are capable of. Multi-modal access to information including those on the Web therefore is very relevant in today's world primarily because there is enough technology to implement this as has been shown by this research.

On the other hand, the way to achieve multi-modal access to the Web is not straightforward. Over the years, and especially with ICT4D research, information has often been analysed under the lens that that all activities related to ICT4D initiatives should necessarily be concerned with

access to information with some economic benefits for the poor. This idea runs contrary to opinions that, indeed, the marginalised often also have a much varied interests for information just like all others in society [Unwin, 2009, p. 43]. And so in the implementation of ICT4D programmes, as Unwin rightly argues, it is therefore essential to ensure that sufficient attention is paid to the provision of appropriate training in the acquisition of information and the mechanisms through which communication takes place.

6.4.1 Technical Opportunities and Challenges for ICT4D

In relation to global WWW access, the believe that solving infrastructure deficiency for internet connection would automatically translate to its widespread usage in deprived region cannot be supported by facts. On the contrary, enough evidence abounds in sub-Saharan Africa to suggest that laying fibre optics alone would not solve the challenge. As has been pointed out already, mass illiteracy rates and relevant content on the Web are some examples of the barriers to the access. This research has shown, mostly through experience, that a level of literacy or know-how is necessary for content creation and/or access on/to the Web. Myers [Myers, 2008, p. 24] also cites an instance where the need for an internet connection never showed up as an urgent need in quick poll asking for what 'one' piece of equipment owners of four radio stations in Sierra Leone would wish for. Instead, according to Myers, they wished for generators to power their devices and vehicles to ply long routes.

Any quest for development agenda of using ICT should therefore be tailored in line with already existing infrastructure and locally readily available technologies. Innovation plays a vital role in all this since new ways would have to be devised sometimes to aid problem solving which may even consist in the use of unconventional methodologies to be employed when the need arises. Also, much involvement of local expertise and methods in projects would help a lot with this.

On available local technologies, a few of them readily come to mind. Myers [Myers, 2008] and Bon [Bon et al., 2013], for example, have shown that the impact of the radio and mobile telephony can be felt in many parts of Africa. The available technologies present opportunities for novel applications in ICT4D for improving economic well-being of rural poor in developing regions where possible.

6.4.2 How are RadioMarché and Tabale Related to the Web?

My research is used to further highlight the opportunities available for the use of already available technologies in many parts of rural Africa to achieve economic ends. To do that, the Web and its usage in the developed world is used as a yardstick for how this research is an innovation. On the face of it, RadioMarché and Tabale do not look like anything close to the usage and functioning of mainstream WWW and internet for rural people. However, a closer examination reveals some similarities, particularly Web-like functionality, that are worthy of mention.

In summary the two systems described in Chapter 4 (see Table 6.1) provide the ability for local stakeholders to access Web information via speech using simple mobile phones [Gyan et al., 2013]. Although we do not provide universal browser-like access, we argue that by focussing on

Table 6.1: Summary of systems deployed.

System	Description	Interface(s)	Impact	Web-like feature
RadioMarché	A market audio information distribution platform that uses the radio stations as the medium information broadcast.	A web interface for the NGO. + A voice interface for the radio and the public.	**Merits**: Improved marketing of farm products. **Demerits**: Fixing only a part of a chain of challenges.	e-Marketing on eBay or Amazon.
Tabale	A audio message broadcast platform that sends pre-recorded audio messages to telephones and to which receivers of messages can respond.	A web interface for the NGO + an voice interface for callees.	**Merits**: Broadcast simple, language-independent, short audio messages easily to phones. **Demerits**: Designed for a specific set of languages.	Message broadcast such service such as Twitter.

specific use cases, we promote local uptake and usage. Starting from specific use cases allows us to optimize user interaction and ensures that the systems are actually used since they address real needs and problems. Although they do not provide a universal access through the web (as a generic web browser would), we have investigated, through the use cases, the feasibility of a voice interface for user tasks that are analogous to user tasks prevalent on the (Social) Web:

- RadioMarché provides access to a market place, where people can trade goods. This is analogous to marketplace web sites such as Ebay.com and Amazon and more.
- Tabale allows users to invite people to events, who in turn can confirm or not their presence and leave a message. This is a functionality that can also be found in Facebook, or event organisation sites such as eventseer.com. Beyond event creation, it can also be used to disseminate short messages to many people at a time, a service that micro-blogging sites such as Twitter offer on the Web.

The RadioMarché, and Tabale Web/mobile services exemplify the approach of making the most of existing technologies to empower people and local communities. Rather than relying on future technologies, or targeting a small part of the population (those connected in 3G and/or possessing high-end handsets), we connect the 2G world. (It is noteworthy that indeed the existing infrastructure in sub-Saharan Africa is mostly 2G and the migration to 3G (let alone 4G) will not be undertaken soon on a large scale across the continent at the time of this research.) In the long term, the different projects described thus aim at empowering grassroots organizations and local developers to favour the emergence of digital, mobile-centric ecosystems, through 2G-based open source technologies.

Such an attempt at building the Web and associated services on now locally available infrastructure and technologies aims at reducing the barriers to their adoption in the communities.

Training sessions that were organised at some points during deployment were only designed to help them use the specific service that had been built. Generally, the approach here has been that the widespread familiarity with usage of mobile phones should be enough for the adoption of such services. This is to be contrasted with pretty common strategies where entirely new gadgets and devices are introduced, presupposing a certain interest for technology or people who are technologically savvy.

Non-functional requirements play a major role in identifying what needs are to be satisfied among news users. This is especially so when developers of such systems have very little knowledge of the communities within which they will operate. In many of such instances, such projects have been shown to always fail [Heeks, 2002]. However, this can be partly overcome by setting the right environments for local user participation and possible co-creation. By involving as many potential local users as possible right from the beginning of such projects, a lot of context-based factors that have the potential of derailing such projects can be taken care of.

In summary, with the Internet very far from many of these rural regions in the foreseeable future, there is the need to rethink and flexibly recombine technologies and do things generally differently in order to attain the goal of increasing the reach of the Web, benefits of information exchange and knowledge sharing. Using bottom-up and partnering/co-creation approaches focused on localized and contextualized use cases is one way to do so.

6.5 Context for Implementing ICT4D

This chapter cannot be complete without elaborating on the role of context in ICT4D research. Context plays an important role for any research and especially so for a field such as ICT4D. For that reason, before any attempt is made on generalizability context must also be discussed. Much of the development efforts that dominated the early 1960s in many parts of Africa, as Unwin rightly puts it, were fundamentally different in focus and intent [Unwin, 2009, p. 40].

These were largely top-down modernisation models which culminated in the transfer of information and scientific knowledge primarily from “developed” to “less developed” countries. This approach was predicated on an assumption that some information, often derived from European or North American science, is more significant for the development process than other, more traditional kinds of knowledge. By and large, factoring context into these interventions were either ignored or were not considered at all. The results of this was the notable failure of most these interventions and systems [Chaudhuri, 2012; Heeks, 2002; Tedre et al., 2009]. This also resulted in abandoned technical systems that had no locally knowledgeable technicians to operate them once the foreign technicians who operated them left.

As the years went by, new approaches that factored in contexts were developed. For example, a new approach surfaced in the 1980s which was participatory in nature and which took into consideration local knowledge and know-how. In contrast to top-down approaches, community-based and participatory approaches to development have focused much more on a bottom-up and shared experience of information [Unwin, 2009, p. 42]. This new approach attempts to address challenges of communities from within grassroots level, involving stakeholders and often including them in decision making. Also, methodologies such as Action Research and

relatively recent ones such as *Living Lab* have proven to be very useful in requirement gathering endeavours that promote as much local involvement as possible. Chapter 3 of this thesis has shown how Living Lab was particularly partly employed in gathering requirements for the RadioMarché system. According to Akkermans et al. [Akkermans et al., 2011], these approaches and methodologies stand a much better chance to properly deal with issues relating to validity of information and to capture a broader notion of validity-in-the-field as research outcome, as well as the inclusive dialectical design nature of the research process that is to lead to socially robust and actionable knowledge.

6.5.1 Adapting Living Labs to Rural Contexts for ICT4D

The Living Lab methodology is largely a Western (mostly European) idea and necessitates some form of repackaging when its implementation or use is for research in a developing country context. This need for its use at all is rooted in reports of failed systems mostly thought not to have considered contexts within which they are implemented (see for example a UNICEF report by Boakye et al. [Boakye et al., 2010]). It is argued in this research that for rural ICT4D research much of the these, mostly non-functional, requirements can be solicited through this methodology.

Schaffers et al. [Schaffers et al., 2008] agree that developing a successful strategy for preparing, developing and implementing LL as innovation environments in rural areas requires taking into account local situation characteristics. In this research for example, the main initial challenge was the physical distance between developers of the technologies/innovation and potential end-users of the implemented system. As a result, it was important that developers understood the environment within which the new system would be operated. How that was achieved was through several stakeholder meetings with various communities in Mali. Also relevant is the fact that, again in our case, even though the technologies behind our idea are not entirely novel, the applications to the context was entirely a novel concept with very literature on experiences and steps to take. Hence the need for adaptations to LL. Developing any innovation inherently takes an iterative approach. And ideas usually mature with time. Using pilots in our context for instance served that purpose. The role that LL played in all that is, among other things, streamlining the process and helping to crystallize how to elicit requirements in the particular environment.

6.6 ICT4D and Computer Science Education in West Africa

Attempts will be made here to generalize some of my findings to the areas of computer science education as a discipline in tertiary institutions particularly in West Africa. As has already been mentioned in Subsection 6.3.1, the disciplinary relevance of ICT4D can be broadly interpreted as the topics at the intersection of ICT and social development related matters. Efforts to define the term ICT can mean differently depending on what technologies are involved. In this context however, it is defined to agree with what Toyama and Dias [Toyama and Dias, 2008] put succinctly as that

> Taken literally, ICTs can include everything from the printing press to Africa's talking drums, but in the context of Information and Communication Technology Development (ICTD), "ICT" has the connotation of modern electronic technology, and central roles are played by the PC, the mobile phone, and the internet.

The emphasis on the roles of modern electronic technology such as PC, mobile phones and internet is as a result of the commoditization and mainstreaming of these technologies. As has also been explained earlier, the concept of "Development" in ICT4D on the other hand cannot be easily defined as there is somewhat more disagreement about what constitutes development [Unwin, 2009]. This disagreement mainly stems from the fact that its definition is highly subjective. What would constitute as development for a region or a group of people can easily be a source of debate.

With this definition and understanding in mind, it would then be appropriate to posit that in order that ICT4D projects become relevant and have impact in local communities, the important role that computer science education plays cannot be overemphasized. This role can be looked at from two perspectives. Knowing these perspectives is important because of the differences in culture, economy and infrastructure that are known to separate the developed from the developing worlds. The first of these perspectives is that of *locals* who live and get their education within the communities which benefit from these projects and the second is the perspective of *outsiders* who, most of the time, are from the developed worlds and become part of the these projects as specialists and experts, inclusive of even those not necessarily from developed worlds but have specialized skills and knowledge to work in other parts of the world. The impacts of these perspectives can be explained once we acknowledge that computer science education in the developed world is backed by a fairly traceable history. The current curricula of its education has been designed in the early 20th century on the backdrop of new developments and demands at the time. Africa on the other hand does not have this benefit of history for the type of education being offered on the subject to students. Africa has her own unique history of computations which should be (or already should have been) incorporated in the modes their education structure.

Also, unlike the industrialized worlds, a great number of prevailing social conditions cannot be easily taken for granted in West Africa. Issues such as post-colonial governance, tribal traditions, extreme poverty and differences affect pedagogical approaches in schools and therefore should be taken into account in order that the right kind of education is given to students. In most African countries, the different kinds of views of ethics, debate and modes of working as well as linguistic backgrounds create such diversity which would not permit a "fit-for-all" pedagogy [Tedre et al., 2009]. On the other hand, taking the perspective from a developed world, it is usually not straightforward for most "Westerners" to imagine the actual situations. Especially for those who have very little travel experiences to the continent, their idea of economy, infrastructure, etc. are usually not so much what they expect in most parts of Africa. For these also who may have needs in ICT4D training it is therefore necessary that a different kind of approach is applied.

6.6.1 Implications for Education in Africa

Not much data is available on the first use of computers in Africa but the first computer in the whole of central Africa, for example, is known to have been installed in 1960.[4] Many other regions in Africa are likely to have dates similar or dates not so far from this. Compared with the days of computing of Charles Babbage, Alan Turing and others in the West this is very much recent. (It must be said however, that in Ghana[5] for example there were home-made devices that worked in the fashion of computers even though the theoretical framework around these tools were not known until recently. An example is a quite popular local device/gaming tool called *oware* in the local Ghanaian parlance which is a two-bit calculating machine [CNN, 2013] often played as a pastime by many.)

Much of the computer science education in many schools in sub-Saharan Africa has largely been based on standardized curricula such as that from ACM/IEEE (e.g. [Sutinen and Tedre, 2010; Tedre et al., 2009]) or something similar which has been developed with expertise mostly from outside the continent. Often these curricula have proven not to be adequate for developing countries. As an example, a brief look at the standard ACM/IEEE curricula reveals that they do not even mention environmental and climate issues. In fact, it does not prepare students to work in rough environments at all. Unlike in the developed countries, not all installations in developing countries are built in laboratories and sanitary environments; the environments are often hostile and all aspects of climate conditions can be beyond the specifications of equipments to be used to aid teaching and learning. Though not an entirely bad idea, the problem with that approach is that they have proven, over decades of use and implementations to be inadequate for many developing countries. The evidence of this is the far less contributions to the field (discipline) from the region compared with the rest of the world.

In a paper on setting up Information Technology (IT) education in an university in Tanzania, Tedre et al. [Tedre et al., 2009] offer some indications on how this education in this area of study could be streamlined to better address the needs of the country. Much of what they agree on, to a large extent, apply also for a country such as Ghana. Most sub-Saharan countries can also identify with much of the problems that Tedre et al. enumerate largely because of the similarities and history they share in post-colonial Africa. To sum it up, computer science education in most of sub-Saharan Africa have largely been imported, theoretically oriented curricula which fail to meet expectations of most of these countries. Within the context of good ICT education in developing countries, and especially Africa, issues that can easily be taken for granted in developed worlds become significantly important. These include, but not limited to, inadequate electrical infrastructure which cause hardware to malfunction, wear out and breaks; a hostile natural environment which causes problems with equipments parts and eventually destroy them; quirks of local manufacturing and procurement which complicate acquisitions; counterfeit products, non-existent customer care and lack of warranty that make purchases of equipments and spare parts risky; excessively complex customs and shipping procedures that make foreign acquisitions difficult; widespread problems with corruption that make accounting tricky; and lack of qualified staff and specialists to operate imported tools and equipments.

[4] http://www.ifip.org/36years/m16zw.html
[5] where I come from.

This makes it imperative that, in addition to the theoretical knowledge of computer science education in tertiary institutions and universities, there should be the offering of opportunities for carefully tailored *practical* skills to help students identify challenges around them and applying these skills to solve them. Practical in this sense refers to courses that emphasize lab work, practical sessions, hands-on projects and skills development. For reasons of mostly of ICT infrastructure shortages in sub-Saharan Africa and a lack of an extensive network of experts who can be called to take care of problems in technical, specialized fields, computer science education in Africa must have a broad and specialised reach.

Tedre et al. [Tedre et al., 2009] also cite six principles which underline IT education in Tanzania but can also be relevant for other sub-Saharan countries. These include an education which is *context-sensitive*, which has an underpinning idea that each society, climate, environment, economy, and culture pose some unique challenges for IT professionals thus making its education context-sensitive. The next is *problem orientation* which refers to the typical constructivist approach of problem-based and project-based learning where students work on real-world problems and reflect on them. The third principle is *practicality* which is that the many challenges that permeate every facet of any African society would require practical oriented approach to their solutions. Fourth is *interdisciplinarity* where it has become all very necessary that many fields collaborate to work on their collective problems and challenges. For ICT4D purposes, this point is even more important. The fifth principle is *international recognition* for the studies that are conducted which could be done through international conferences and seminars and publications and then lastly is the kind of education that gives a *basis on research* for ICT education in universities in sub-Saharan Africa. On that score therefore, ICT4D presents many ideas and incentives on which when the right pedagogical choices are applied in universities could be a lot beneficial first for the universities teaching computer sciences and secondly for most communities of sub-Saharan African countries.

6.7 ICT4D Education Beyond Africa

On the whole ICT4D research has not attracted the interest of the mainstream of computer science research. Part of this reason is because the field is a relatively new one.[6] According to Sutinen and Tedre [Sutinen and Tedre, 2010], two main reasons account for this. On one hand the subject of development in many tertiary institutions has been considered to belong to the area of social sciences, and that in most schools, it is often included under, for instance, human geography in certain curricula or something close. On the other hand, it seems to be the case, also suggested by Sutinen and Tedre, that using ICT for development does not appear from the first sight to be computationally challenging enough to attract the attention of computer scientists.

The general tendency among computer science researchers from developed countries, and especially those with very little experience in development-related efforts in developing coun-

[6] As an example, take a look at an interview with Ken Banks who is noted to be the first to have used a mobile device for a development-related project: https://bestict4d.wordpress.com/2013/06/02/10-tips-for-successful-ict4d-interventions-an-interview-with-ict4d-pioneer-ken-banks/

tries, is to conclude on such matters that "if it works here with us, it must work there too". And so a technology or process that works in developed countries is often assumed to be able to work in other regions with results that have shown that it is not the case. That notion has been proven to be unworkable, as this research has shown for example, and has indeed also been shown severally in the past by other research that there is more to laying fibre optic lines for internet access in, say, rural Mali.

Such reason and understanding is why ICT4D education should be made taught in schools outside Africa. Two aspects of this comes to mind. First of all, the need for such a curriculum and research in schools outside Africa and, secondly, how it has to be done. The need for ICT4D-related education in curricula around the world would go a long way to aid development efforts around the world. As has already been mentioned, much of the aid that go to developing countries is from the developed worlds who work through NGOs. Similar conclusions can also be said about much of the modern technologies in use in most parts of the developing worlds. In much of Africa, apart from a few distinct instances, there's little record of use of local technologies for much of the challenges that confront the continent. The technological industry and economy that is behind much of the new tools and devices in the developed worlds are also absent in much of Africa.

Teaching the subject outside Africa would therefore give a broader perspective to students on issues relating to development and the role ICT can play in all that. That perspective would hopefully also feed into ideas for new tools or modifications to existing ones that might come up later for implementation. For example, it is quite possible that not many students in computer science classes in Western schools are aware of the erratic nature of electricity supplies that characterises much of sub-Saharan African power supply or the dust particles that fill the much parts of the air even in some urban areas which has the potential of shortening the usage span of complex electronic devices or making them non-functional. When students are armed with such knowledge in the lecture rooms, it will eventually guide much of the research initiatives and processes.

Some electronic and High-tech industry leaders have taken notice of this and have long started off in making specialised products for different parts of the world. The electronics giant Samsung[7] for example, through extensive research on the African continent has began developing branded "Built for Africa" products that take into consideration the prevailing conditions on the continent in their operations. Similar initiatives have also been started by makers of mobile devices and electronic gadgets with the aim of attracting consumers in Africa.[8] Teaching of ICT4D concepts will therefore enable students in developed worlds to be in better positions to address some of these needs with a broader perspective when in future positions to do so.

With its short history, however, ICT4D research has grown to be diverse and multidisciplinary. And so how to go about inculcating this understanding in students largely depends on what the needs of a particular institution are and how the teaching of the subject relates in the school's overall aspirations and aims. Much of this, however, would essentially entail opportunities for

[7] see for example this: http://www.samsung.com/africa_en/africancitizenship/africasub3.html

[8] see also how Huawei, the Chinese technology giant accesses the situation here: http://www.huawei.com/en/sustainability/digital-divide

field visits to some deprived regions and/or creating learning environments that help students to study and think within that context.

6.8 Conclusion

RadioMarché and Tabale were, from the evaluation results, a success because there was a clear need for such a tool given the available infrastructure within the region. Often-times, in most deprived regions, there is a gap between what implementable solutions there are using available technologies and the infrastructure available to support them. RM proves that with enough innovation and a better understanding of needs of people, these gaps could be closed. However, knowing how to spark off innovations to such systems requires a thorough understanding of the conditions that prevail in such situations.

The Living Lab methodology provides useful strategies which can be used to gather as much non-functional requirements needed for these types of ICT4D projects. Though not yet a proven methodology in the field of requirement engineering research, its use is increasingly popular. Research institutes such as European Network of Living Labs (ENoLL) in Europe and Living Labs in Southern Africa (LLiSA) in South Africa promote it as a requirement gathering method for building IT systems. The methodology creates avenues for co-creating and co-developing systems with as much user-involvement as possible. Though being a largely European idea, it's application proves useful in other settings such as in our case in Mali where it was important to establish trust and relationship between implementers of the project and the stakeholders involved.

Much of the usage of mobile services among Africa's deprived rural areas are with low-level devices such as 2G phones. It is expected that in the coming years, most of these would be replaced as the markets open up to more and more competition. Similar conclusions can also be made about internet connectivity and use of the Web. Once governments create the necessary policies and environments for these kinds of technologies, it is expected that many more will switch from slow and low-latency satellite-based internet connections to a much more faster fibre-optic connections. In the meanwhile however, ICT4D services that would work are those that take into consideration the available infrastructure and their support and factors such as patterns of usage of these kinds of tools.

This research has investigated the possible connection that exists between voice technologies, the Web and how they could be used for rural development. With so much information available on the Web, this idea of using voice-based services for access of information on the Web proves to useful and could be the only lifeline for generations which would otherwise be cut off from such technology. Voice is a natural form of communication for most people and so building speech systems as was done in this research is relevant and worthy of more research. In other words, access to the Web should not only be browser/visual-based but other ways such as has been shown in this research.

This fundamental idea should inform the development of academic curricula both in developing regions, especially in sub-Saharan Africa, and the developed worlds. ICT4D curricula must be aimed at equipping students with the prerequisite skills and set of knowledge to help

them identify societal challenges and be able of think of solutions with available infrastructure and emerging technologies.

English Summary

Information dissemination in its right format and context, especially in rural Africa, is crucial sometimes even for the survival of market value chains and whole communities. However, many proffered and popular solutions are, oft-times, outside the reach of many rural dwellers in Africa. For example, the World Wide Web (WWW) is a major global platform for knowledge sharing and information exchange. From television through pocket personal digital assistants to publishing, its impact on every facet of life in this age, especially in the developed worlds, is unprecedented. However, the fact still remains that despite this success of the Web, over a billion others in the world cannot access the wealth of information available on the Web [Aart et al., 2011]. This inaccessibility is mainly due to some important barriers that still exist [Boyera, 2008; BuddeComm, 2011; Cottrell, 2013] namely that,

1. The Web lacks specific *relevant content* to people in underprivileged communities. The reason is that availability of accessible and locally relevant content can be an incentive for people to access and use the Web. For example, language-wise, there is very little content on the Web in Bambara, predominantly spoken in Mali, or Dagbani spoken in Ghana, even though the two languages, put together, are spoken by over five million people.
2. *Access barriers* to the Web exist which include illiteracy, language barriers, and other major technical obstacles.
3. The development and adoption of ICT worldwide has not been even with most of the developing countries lagging behind the developed world. Many studies show great disparities that exist between countries with access to ICTs, the so-called *global digital divide*. For example, in the case of the WWW and Internet international submarine fibre optic cables have reached several African countries for the first time in 2009 and 2010.

That notwithstanding, Africa's mobile telephony infrastructure and subscriber base is one of the fastest growing in the world [Aker and Mbiti, 2010; Boakye et al., 2010; Hellström and Tröften, 2010]. A recent report by *Afrobarometer*, in fact, suggests that "more Africans have access to cell phone service than piped water" [Mitullah et al., 2016]. Radio technology is yet another technology that has taken a firm foothold in everyday life in much of sub-Saharan Africa. Radio has been referred to as the number one medium for information flow in rural Africa [Myers, 2008]. With this success comes opportunities to reach many with relevant information and aid information dissemination and knowledge sharing efforts in innovative ways.

In the context of this research, I describe one such initiative in which indigenous knowledge on soil reclamation are shared on a farmer-to-farmer basis in re-greening efforts in parts of the Sahel threatened by desertification. In the past, there have already been many attempts

at information dissemination for other such services in health, market information broadcast services among others. Those attempts, however, have mostly concentrated efforts on using SMS and USSD technologies offered by mobile service providers. Unfortunately, inherent deficiencies in these technologies have prevented such efforts from achieving substantial results and much needed impact. All such efforts are what have culminated in a broader area of research brought under the umbrella of ICT4D. With this background, my research primarily investigates new modalities for reaching out to the technologically underprivileged using speech technologies together with Web technologies to fill an information dissemination gap under a selected use case with rural farmers in Mali.

Chapter 2 investigates the history of speech systems (broadly referred to as Spoken Dialogue Systems) and what their applications have mainly been in developing countries. In the chapter also, the challenges and past experiences are discussed as well as the tools, platforms and how they can be leveraged for building such systems.

In Chapter 3, I describe strategies that can be useful when soliciting for requirements for any software project in rural Africa. In particular, I share practical experiences in Mali and some of the useful insights that led to eliciting and compiling use cases for this research. I also argue in the chapter that, essentially, traditional requirements gathering processes should be conditioned, when necessary, to suit the environment within which they are employed for adequate results. I share experiences on frequent technology demonstrations, on-the-spot improvising methods, bottom-up and collaborative strategies and show that they go a long way to direct conversations and aid requirement elicitation processes in a rural setting.

In Chapter 4, I describe the actual systems that are built from the use cases. That involves building a market information system (*RadioMarché*) and a messaging system (*Tabale*) for farmers using the technologies I describe in Chapter 2. The two systems were the actual implementations for two selected use cases from stakeholders in Mali. In both of these systems voice or speech technologies are employed in innovative ways to help solve local challenges and meet real needs. The main argument of the chapter is building systems that satisfy local requirements using available local infrastructure.

Chapter 5 describes a general purpose evaluation framework for evaluating any ICT4D project. I demonstrate how to extend the participatory/agile approach of software engineering to ICT4D and how to evaluate such projects as well. The evaluation includes analysis of data from system logs and compiled answers to designed user-satisfaction questionnaires which were collated as part of the results of the research. I also argue in the chapter that evaluation should be integrated into requirements gathering, implementation and roll-out phases of an ICT4D project and not be an outside, after-the-fact activity.

The final chapter of the thesis, Chapter 6, is where I generalize the findings of this research. In particular, I explain a bit the concept of development as regards this research and the role that the Web, speech/voice technologies play in information dissemination and knowledge sharing. I also explain further the part that context plays in this type of research and then discuss a strategy that has proven useful for contextualisation. I then examine the implications this research has on broader subjects such as curriculum and tertiary education in Africa.

Nederlandse Samenvatting

WWW, het World Wide Web, staat universeel bekend als het wereldwijde platform voor kennisdeling en informatieverspreiding.

Maar als we dit iets precieser bekijken: het is wel groot, zelfs hoogstwaarschijnlijk het grootste sociotechnische netwerk ooit, maar het is nog niet *echt* wereldwijd.

Immers, momenteel hebben zo'n 2,5 miljard mensen toegang tot het Web. Dat betekent dat zo'n 4,5 miljard mensen op deze planeet daar (nog) geen toegang toe hebben. Er zijn namelijk (nog steeds) miljarden mensen op de wereld die niet kunnen lezen en schrijven, of die geen Internet en Web hebben, of zelfs geen electriciteit.

Maar dat wil natuurlijk niet zeggen dat zij geen interesse hebben in of belang hebben bij het verwerven van nieuwe informatie en kennis van elders. Het proefschrift "The Web, Speech Technologies and Rural Development in West Africa — an ICT4D Approach" van Nana Baah Gyan, zelf wonend en werkend in Ghana, richt zich op dit vraagstuk. Hoe kunnen we informatieverspreiding en kennisdeling realiseren zoals het wereld wijde web WWW dat mogelijk maakt, maar dan in situaties waarin Internet en Web niet beschikbaar zijn, zoals in grote delen van Afrika buiten de grote steden?

Als Internet en Web niet beschikbaar zijn, moet men andere alternatieven voor massacommunicatie en kennisdeling zien te vinden. In ruraal Afrika, en in het bijzonder de Sahel-regio van West-Afrika waar het proefschrift zich op richt, is dit alternatief: mobiele telefonie + spraakdiensten + lokale/regionale 'community' radio.

Het promotie-onderzoek van Nana Baah Gyan vond plaats in het Network Institute onderzoekprogramma W4RA (Web Alliance for Regreening in Africa, www.w4ra.org), en laat zien dat zulke alternatieven levensvatbaar zijn. Centraal in het proefschrift staat de ontwikkeling van Radio Marché, een ICT-toepassing waarmee lokale boeren in Afrika beschikbaarheid en prijs van hun producten (zoals honing of shea butter) bekend kunnen maken via mobiele telefoon plus communiqués uitgezonden over de radio. Dit draagt bij aan de vorming van agrarische waardeketens, en wel met een bereik veel groter dan de al bekende lokale markt, en bovendien in meerdere regionaal gesproken talen.

Radio Marché is uitgerold in Mali in samenwerking met lokale NGO's op het gebied van regreening en met diverse regionale radiostations. De toepassing heeft inderdaad geholpen de verkoop van producten zoals honing te vergroten. Men kan Radio Marché zien als een rurale pendant van eBay of Marktplaats.nl, maar dan gebaseerd op het gesproken woord.

Het proefschrift beschrijft voorts uitvoerig hoe lokale wensen ten aanzien van ICT-toepassingen in kaart kunnen worden gebracht, met behulp van veldonderzoek en workshops met lokale

gemeenschappen, dorpen en kleine boeren. Op basis van deze *'bottom-up'* gegevens uit het veld kunnen applicaties voor informatieverspreiding en kennisdeling, zoals Radio Marché, technisch worden ontwikkeld, doch op een wijze die nauw en aantoonbaar aansluit bij levende informatiebehoeften van lokale gemeenschappen.

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Appendices

Appendix A: Setting up RadioMarché and Voice Platform

RadioMarché (RM) and the Voice Platform (VP) are two separate software that need to be installed separately and then link together. RM gives an easy-to-use interface to the VP . VP on the other hand is responsible for generating the audio communiqué and publishing it for use by callers. Below are steps for setting them up.

A.1 Installing RadioMarché

In order to install the RadioMarché interface on any computer, the following will need to be completed:

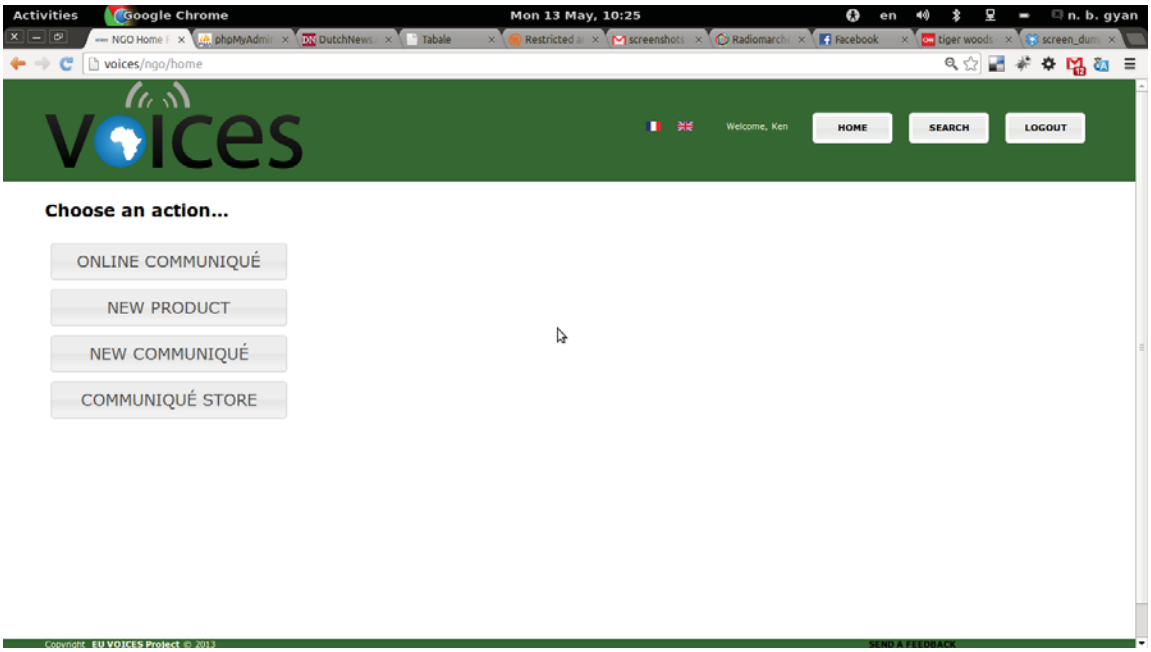

Figure A.1: NGO interface of RadioMarché

- Set up a virtual hosting environment for RM.

- Install web server modules.
- Create database.

A.1.1 Setting up Virtual Hosting Environment

An example is below (for Apache on Linux). If you use other web servers, please follow the on setting up virtual hosts.

```
<VirtualHost *:80>}
    DocumentRoot "/home/username/radiomarche/public/"
    ServerName servername <br />

    <Directory "/home/username/radiomarche/public/">
       Options All
       AllowOverride All
       Order allow,deny
       Allow from all
    </Directory>

    ErrorLog ${APACHE_LOG_DIR}/radiomarche-error.log

    LogLevel warn

    CustomLog ${APACHE_LOG_DIR}/radiomarche-access.log combined
</VirtualHost>
```

A.1.2 Installing Apache Server and PHP Modules

Web server environment modules needed include:

- mod_rewrite – for the use of .htaccess.
- mod_php5 – PHP module.

PHP modules needed include:

- curl – for accessing resources via http calls.
- gd – image creation library.
- json – for connection to VP as well as other internal functions.
- mysql – database driver connection to a running mysql database server.
- pdo_mysql – pdo adapter overlay for mysql database.

A.1.3 Creating Database

Find create_tables.sql under public/docs folder within RadioMarché folder and run.

A.1.4 Configuration

- Find the application configuration file (application.ini) in /application/configs sub.folder.
- Edit the sections where appropriate:
  - DB settings – your database settings.
  - voice.platform.base.url (note: without the ending '/') – this is the `url` of the voice platform.
- Fire up a web browser and enter `http://your-virtual-host-name` in address bar.
- Once up and running register with url `http://your-virtual-host-name/account/register`.
  This is also just simply clicking on REGISTER tab and filling in the fields.
- The action above will create entry in the database users table.
- Now login into the voices database previously created.
- Under user_type field of users table, change the entry '`guest`' to '`ngo`'. That makes you and `ngo` user who can create and publish communiqué on the voice platform.
- You now login with *username* and *password* under http://(your-virtual-host-name)/account/login. This also achieved by just clicking on LOGIN tab.
- Follow similar procedure to add more users.

A.2 Setting up the Voice Platform

The voice platform is an entirely separate software from RadioMarché. It is responsible for generating audio communiqué. Apart from `REST` interfaces it provides to other software for generating and publishing audio communiqué, it also has a web interface for testing.

To reach it's testing interface, just drop the folder inside the root folder of your web server. The interface for testing purposes only can be then reached through `http://[your-web-root-name]/web/generate_communique.php`.

In order to connect the voice platform to RadioMarché, the following steps need to be completed.

A.2.1 Configure Communiqué Platform

- Edit /lib/setup.php file to reflect your settings.
  - Location: radio_mali/lib/setup.php
  - NB: notice the $localapps flag that should be set to 0 (1==development set-up) and corresponding session should be updated
- Edit /audio/voice/.htaccess

A.2.2 Configure Radio Platform

- Edit /lib/setup.php file to reflect your settings.
  - Location: radio_mali/voices/lib/setup.php.

  - NB: notice the $localapps flag that should be set to 0 (1==development set=up) and corresponding session should be updated
- Edit /audio/radio/.htaccess

Appendix B: Local Platform Set-up Instructions

Instructions below are steps for setting up a working local platform which can be used to host voice applications. This set-up can only support only two concurrent calls at a time and might not be suitable for large and complex applications which might require more calls at a point in time.

Tools required are

- A computer running an Ubuntu 9 or 10 operating system.
- An office route GSM gateway.
- Ethernet cable.

B.3 Installing Prophecy Software

Prophecy is free software provided by Voxeo[9] to run `vxml` applications. It's a replica of their much bigger evolution platform. This free version supports only two simultaneous calls at a time. Beyond that, licences are needed to open more ports. Also, the official support of Linux environments is either on CentOs or RedHat Linux. Details for this can be found here.[10]

Apart from these the above mentioned operating systems, there is also a possibility to install some versions of the software on other flavours of Linux such as Ubuntu. For example, a detailed installation guide for Ubuntu 9 operating system can found here.[11]

The instructions below follow the steps for installing on Ubuntu. To do this, set-up instructions are as follows:

- Download the Linux version of prophecy software from Voxeo (http:// voxeo.com /prophecy/).
- Execute the binary file to install bunch of services, a number of them including voxeo-vserver, etc.
- For advanced users, if desired, use runlevel to configure the start-up of the various services of prophecy namely.
- The various services are started in the following order:
  - Voxeo-vdirectory

[9] http://www.voxeo.org

[10] http://docs.voxeo.com/prophecy/11.0/frame.jsp?page=appendixdlinux.htm

[11] http://spring-java-ee.blogspot.nl/2010/01/installing-voxeo-prophecy-9-on-ubuntu.html

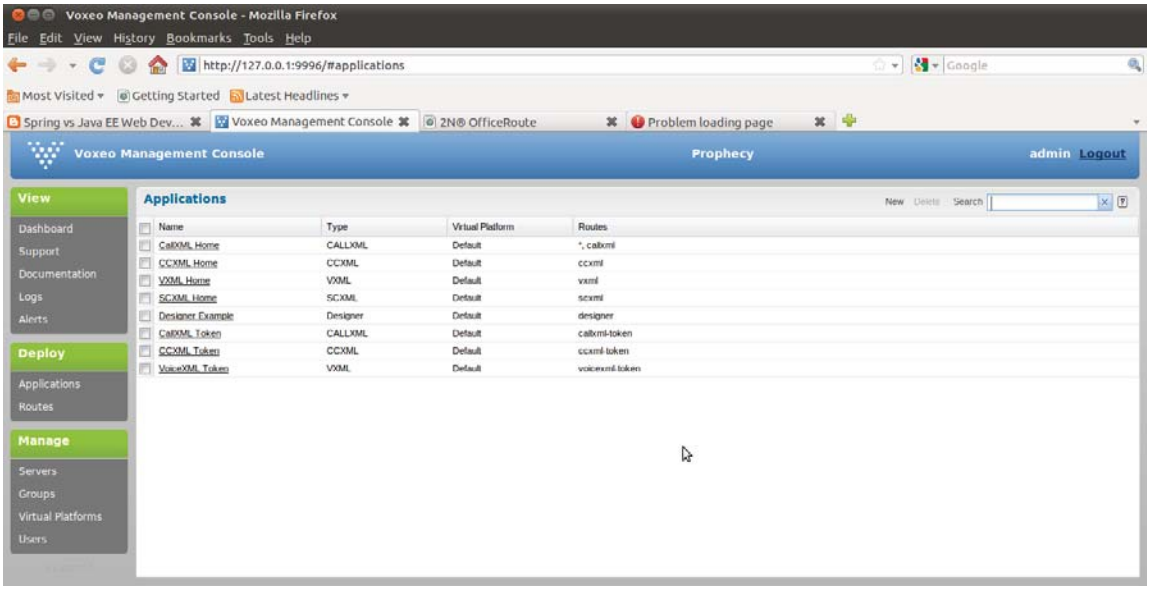

Figure B.1: Registering a new application with Prophecy

- Voxeo-vserver
- Voxeo-vmc
- Voxeo-vsipmethod
- Voxeo-vxml

B.3.1 Setting up Application Within Prophecy

Once Prophecy is up and running, an application can be set up. Note that an xml application is needed for this.

- Go to http://localhost:9990.
- Default username: admin and password: admin.
- Click on `Applications`.
- Click on `Add new` and fill in the following:
  - (Logical) name: e.g offering
  - Virtual Platform: default
  - Type: VXML
  - Setup URL 1 or 2 or 3: of the existing `vxml` application (local) or remote.
  - Specify route by click on `New` and filling in with a name. This is the external ID of the application needed to contact the application. Note down this Route name.
- Click on `Save`.

B.3.2 Setting up a GSM Gateway to Prophecy

The steps below show how an 2N®OfficeRoute gateway device can be connected to the computer in order to direct calls to the running `vxml` application. The device uses the Session Initiation

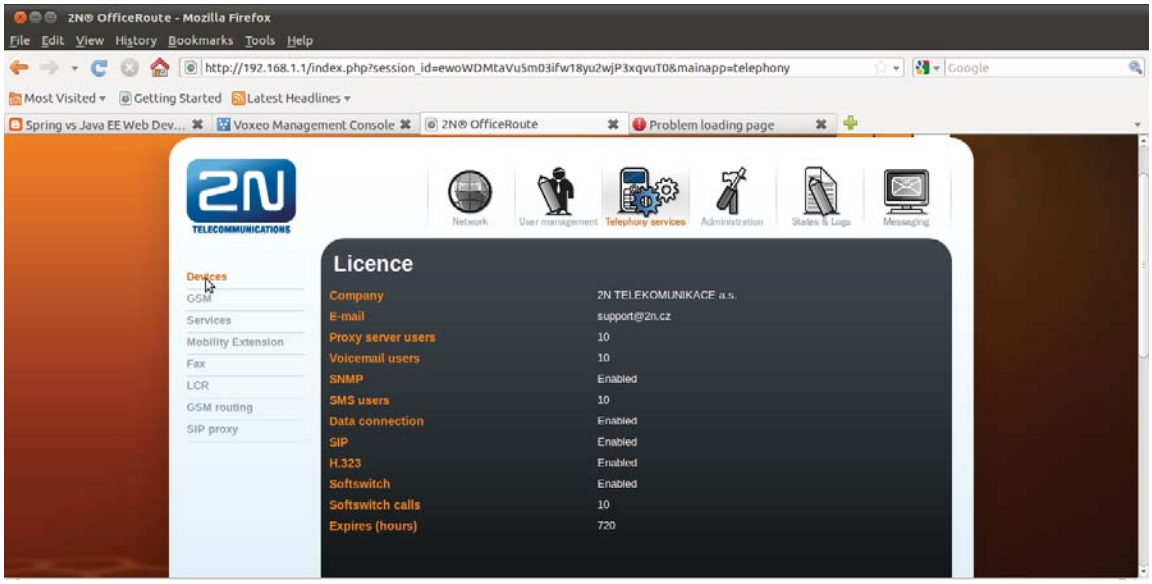

Figure B.2: Setting up an SIP line with 2N®OfficeRoute

Protocol (SIP) to connect to running services of Prophecy.

- Find out the IP address. Default is 192.168.1.1.
- Login into 2N®OfficeRoute web server. Default username/password is Admin/2n.
- Set up an SIP line.
  - Go to `Telephony Services`.
  - Go to `Devices`.
  - Click on `SIP lines`.
  - Click on `Add SIP Line` and fill in the following:
    SIP server address: enter address of Voxeo name server, e.g. 192.168.1.100.
    SIP domain: enter address of Prophecy server, e.g. 192.168.1.100.
    SIP name: this refers to the Route name of application in Prophecy entered earlier.
    Display name: any convenient name.
    Leave default settings and then click on `Save`.
  - Note down the [line ID] and [name] parameters.
- Set up an GSM service (SIM card).
  - Go to `Telephony Services`
  - Go to `GSM routing`
  - Go to `Operator`
  - Click on `add` and enter the following:
    Enter local service name, e.g. "any name".
    Operator number that need to be the same as SIP name "offering".
    Set VoIP line: select line id from `SIP` line ID.
    Enter description (optional).

Note down service name and click on `Save`.

- Connect GSM to services.
  - Go to `Telephony services`
  - Go to `GSM routing`
  - Go to `GSM`
  - Click on `Add` and fill in the following.

    Select a `GSM` module, e.g. 1.
    Select service name.
    Set up description.
    Click on `Save`.

Appendix C: Data on RadioMarché

C.4 RadioMarché Usage: One Year Activity Log on RadioMarché

The table below shows the use of RadioMarché between the period December 2011 to November 2012.

Table C.1: RadioMarché Usage for Period December 2011 – November 2012

Date	Product	Quantity Sold	Total Price
22/12/2011	Tamarin	1005	1750
22/12/2011	Beurre de karite	50	1000
22/12/2011	Amande de karite	3000	150
8/1/2012	Tamarin	105	1000
10/1/2012	Beurre de karite	80	2000
10/1/2012	Tamarin	200	500
12/1/2012	Graine de nere	470	425
12/1/2012	Amande de karite	4900	575
12/1/2012	Miel liquide	260	4000
12/1/2012	Beurre de karite	940	2600
12/1/2012	Tamarin	100	250
31/1/2012	Beurre de karite	80	2000
31/1/2012	Tamarin	200	500
31/1/2012	Miel liquide	12	1230
1/2/2012	Tamarin	1100	750
1/2/2012	Beurre de karite	650	2000
1/2/2012	Graine de nere	120	450
22/2/2012	Miel liquide	60	2000
19/4/2012	Miel liquide	180	4000
22/7/2012	Beurre de karite	1160	5666
22/7/2012	Graine de nere	4980	4050
22/7/2012	Amande de karite	1356	1300

22/7/2012	Miel liquide	104	4000
30/7/2012	Beurre de karite	1006	4800
30/7/2012	Amande de karite	441	400
30/7/2012	Miel liquide	140	8000
11/8/2012	Miel liquide	45	4000
11/8/2012	Graine de nere	80	600
11/8/2012	Beurre de karite	80	700
17/8/2012	Beurre de karite	290	1400
17/8/2012	Miel liquide	40	2000
23/8/2012	Miel liquide	42	2000
23/8/2012	Beurre de karite	250	700
28/8/2012	Beurre de karite	693	1400
28/8/2012	Miel liquide	45	2000
9/9/2012	Beurre de karite	135	1400
9/9/2012	Miel liquide	80	2000
24/9/2012	Miel liquide	80	2000
24/9/2012	Beurre de karite	300	600
25/9/2012	Beurre de karite	800	1200
25/9/2012	Miel liquide	200	2000
22/10/2012	Beurre de karite	500	600
22/10/2012	Miel liquide	52	2000

C.5 Feedback on RadioMarché October November 2012

For the actual recorded feedback from project stakeholders in Mali, see http://dx.doi.org/10.6084/m9.figshare.1470034

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The Web, Speech Technologies and Rural Development in West Africa — An ICT4D Approach

INFORMATION dissemination in its right format and context, especially in rural Africa, is crucial sometimes even for the survival of market value chains and whole communities. However, many proffered and popular solutions, including the World Wide Web (WWW), are often outside the reach of many rural dwellers in Africa.

Africa's mobile telephony infrastructure and subscriber base is one of the fastest growing in the world. Radio technology is another technology that has taken a firm foothold in everyday life in much of sub-Saharan Africa. With this success comes opportunities to reach many with relevant information and aid information dissemination and knowledge sharing efforts in innovative ways. In the context of this research, I describe an ICT for Development (ICT4D) initiative in which indigenous knowledge on soil reclamation is shared on a farmer-to-farmer basis in re-greening efforts in parts of the Sahel threatened by desertification using voice-accessible ICT services.

In this thesis, I investigate (in Chapter 2) the history of speech systems (broadly referred to as Spoken Dialogue Systems) and what their applications have mainly been in developing countries. Chapter 3 describes strategies for requirements harvesting for an instance of an ICT4D project under rural conditions, the results of which led to an actual implementation of voice-based ICT tools for rural farmers in Mali (in Chapter 4). In Chapter 5, I evaluate the impact of the project on the lives of stakeholders involved as well as the potential such tools and systems hold for future research. I conclude in Chapter 6 with generalisations derived from this research, the contexts within which such a research can be undertaken, and lastly, what ICT4D generally means for education in West Africa and beyond in its broader meaning.

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The Web, Speech Technologies and Rural Development in West Africa

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