

A Low-resource Aware Framework for ICT Service Development in Rural Africa

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Abstract. Technological innovation and information & communication technologies (ICTs) are considered enabling factors for social and economic development, even in very poor parts of the world. However, successful ICT deployments in low-resource regions, with low levels of literacy and poor infrastructures are scarce. In this paper we argue that a user-centered, iterative approach, bridging the gap between developers and local users, is the path to successful, contextualized ICT service development, in benefit of local needs and goals. Based on field experimentation in rural regions of West Africa we present a framework to iteratively and collaboratively develop ICT systems, adapted to local needs and context.

1 Why ICT deployments often fail in low-tech regions

While user-centered approaches are commonplace in software engineering, (e.g. [1–3]), end-user involvement is uncommon in ICT deployments in low-resource environments, in developing countries (e.g.[4–6]). Given the high incidence of reported failures of ICT deployments in developing countries [7, 4] we propose a user-centered, iterative approach, that matches ICT service development in low-resource environments with local goals, user needs and context. In this paper we present a framework describing the iterative steps in this collaborative process.

The paper is structured as follows: in section 2, we briefly explain our research approach. Section 3 discusses the proposed framework, exemplified with our experiences from rural Africa. Section 4 presents lessons learnt. Section 5 summarizes the conclusions.

2 Research approach

The presented framework results from extensive field research in Ghana, Burkina Faso and Mali between 2009 - 2015. A flexible, reflective (action) research design was used (see e.g.[8, 9]), to understand and influence a real-world problem in its (initially unfamiliar) context [10]. Collaboration with end-users was central, and based on user-centered innovation methodologies: Living Labs [11], Agile

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Development Methods [12, 13] and use case and requirements analysis [2]. The presented framework is flexible, and can be adapted to different (high, and low-tech) contexts.

3 A framework to develop ICT services in low resource environments

We propose a low-resource aware framework for ICT service development in rural Africa, which differs from ‘mainstream’ software development in an industrial or organizational setting, in a few essential points. First, at the start there is no clear-cut idea what should be developed at all; only an idea that ICT might be of use. Second, most ICT developers are unfamiliar with the local (African rural) context. Third, there is a cultural distance between developers and users (in language, background, education etc). Fourth, technical infrastructure is often deficient. Fifth, it is pioneer work, so, few examples are available. Defining the objectives together with the envisaged end-users, and knowing each other’s context is crucial. Therefore, large part of the system development is done *in situ*, e.g. within the (rural) context of deployment, through creative workshops, rapid prototyping, demos, and focus group discussions. The six phases of the framework are described below:

3.1 Phase 1: Context analysis - Understand the low resource environment

Phase 1 is about learning and understanding the context and its constraints, and about teaming up with key-users and local partners. Because user-involvement is key, the first question is: are the communities interested in participation and co-creation of new technologies? Only if yes, we can proceed. Next three other important questions must be answered: (i) how is the local infrastructure? (ii) what is the general level of literacy/computer literacy/formal education of local users? (iii) what is the purchasing power/how much money are people prepared/able to spend, to get relevant information?

Tools to be used A visit to a representative site, and a meeting with the envisaged users marks the start of the field research. The research tools used are focus group discussions, interviews and group sessions. The researcher/developer must take an open attitude, to get as much information as possible from the meetings. The workshop sessions are usually chaired by a local person, who is part of the core team. During workshops and group meetings the ICT developers respect local habits, protocols and traditions.

Deliverables to be produced A core team is established. It includes several key-users, requirements engineer(s), information analyst (s), a project manager, hands-on ICT developers, local content experts, local ICT service providers (e.g. local radio stations, local ICT businesses).



Fig. 1. A typical requirements analysis workshop with farmers in Guabuliga village, northern Ghana, December 2014

Case: Context analysis in Ranawa, Burkina Faso A context analysis was done e.g. in 2009 in Ranawa, a rural community of 2300 inhabitants, in the Central Plateau of Burkina Faso. This rural village is representative for a low-resource, low-tech community. People live from subsistence farming and produce millet, sorghum, sesame and have some livestock.

After a walk through the fields, we did a focus group discussion with the village chief and twelve villagers, under a tree. Translations were made simultaneously from the local language Moré to French and vice-versa by our local partner – staff members from a local non-governmental organization (NGO) named Réseau MARP – who introduced us here.

In Ranawa up to 98 % of households use mobile phones for social interaction and business, e.g. to ask for market prices in town, to negotiate with potential customers about prices of commodities. On average 1000 - 5000 francs fCFA (2 – 10 euros) is spent per month on mobile telephony. Some people in the village earn money by selling airtime (telephone units) in small units. However, there is no electricity in this village. Phones are charged by a person with a motor cycle battery (phone charging is his business).

The Ranawa community estimates mobile telephony essential for life and work. The villagers express themselves open to innovation, to new systems of communication and to access to relevant information. However, there is a lack of infrastructure (electricity, internet). Illiteracy rate is high, especially amongst women and elderly people. Communication is only speech, in local language Moré. We notice an interested attitude towards new technologies. Extra costs are acceptable, but only if new technologies bring real advantages.

3.2 Phase 2: Use case and requirements analysis - Find useful ICT services for a community

After the first phase, several representative communities are invited to participate in the search for ICT services that they consider useful, *and* are (technically/businesswise) possible to implement and deploy in their environment.

Co-creation workshops are done in the users' context, to elicit goals, needs and constraints. During the workshops demos of contextualized systems are

given, e.g. voice-based, phone/radio systems. Participants are asked if this could be *useful*. Promising ideas are detailed using elicitation techniques, and use cases and requirements are collected. Participants are asked to prioritize use cases according to relative expected usefulness.

Tools to be used A portfolio of understandable and *concrete* examples of ICT-applications is demonstrated, to trigger creativity, to encourage brainstorming and group discussions about possible useful ICT solutions.

Deliverables to be produced A long list of use case scenarios (e.g. 10 to 20) is collected. Then, after evaluating user priorities against technical feasibility and cost of development, three best use case scenarios are selected for further elaboration and rapid prototyping.

Case: A mobile messaging service for rural Mali This was one of the use case scenarios that came out of the workshops, see Figure 2. This is the key idea: a Malian organization, Sahel Eco, regularly invites farmers for a training. However, the invitees live remotely and have only mobiles and no internet. Several invitees are illiterate, and not all of them speak the same language. The inviting organization Sahel Eco has a computer with internet connection.

The use case scenario, modeled after this key idea, has a web interface to record a voice message in different languages, and to enter phone numbers of recipients. The system streams the voice messages simultaneously to the selected phones. To facilitate communication, a meaningful name was given by the users to this use case: *Tabale*, in Malian Bambara language this means 'village drum that gathers all people for a meeting'. A logo was designed for Tabale.

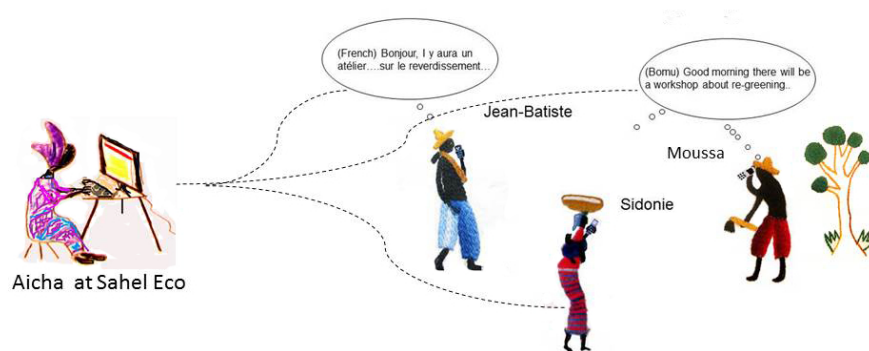


Fig. 2. Informal sketch of the Tabale use case scenario

3.3 Phase 3: Requirements specification and validation - Understand a quick win

Mockups and prototypes are built for the selected use case scenarios of the previous phase, in co-creation with the end-users. We ask e.g. the users to translate the dialogues in their own language. We ask them to give examples of local data, e.g. local names of trees in a tree application. This aims at making the mock-ups familiar, contextualized and meaningful.

There must be specific attention for requirements that in western countries are considered to be fulfilled by default: e.g. when voice application are used, the quality of audio must be assessed. Additionally, technical constraints can be asked for. For instance, not every phone feature may work the same as in western countries. Also, batteries and hardware potentially may not survive the hostile physical environment. Sometimes, uptime of infrastructural services are an issue. All the potential failure points should be asked for and properly dealt with.

Tools to be used Tools are co-creation workshops/hacking sessions in which the developers and users work together, to sketch scenarios (see Figure 2), record voices, design interfaces, build prototypes. Users provide info for maximum contextualization, in content, look and feel (e.g. language, dialect, content, local names etc).

Deliverables to be produced The information provided by the co-creation sessions is used to improve the system, the network architecture and to revise the UML models.

Case: Co-creation To build the Tabale prototype Malian voices had to be recorded, for the voice-based menu. Since the target users of Tabale are from different regions, different menus were made, to respond to each user's own language preference.

3.4 Phase 4: 1st cycle deployment - Deliver a working prototype

When the first full prototype is ready, it is tested in a production environment. Technical flaws and business viability are of concern. The network configuration is tested: are technical facilities available? E.g. Internet connectivity, do phone interfaces work, quality of audio for live broadcasts etc. What is the uptime, over a longer period? Organizational/technical capacity of the envisaged local providers is assessed.

Tools to be used On technicalities: Logfiles provide information on system uptime, on number of access by users, on the number of users, time of usage. Logfiles may reveal unforeseen technical problems. On usefulness: interviews with providers and key-users are done, to assess user satisfaction, unexpected problems, and to elicit essential requirements that were previously missed.

Deliverables to be produced A first cycle deployment report includes technical data on system usage and subsequent fixes. The system is released as new version, after processing user feedback.

Case: Users evaluating Tabale system User-evaluation revealed requirements/issues that could not have been found in an earlier stage. Example of issue found during evaluation: *Issue:* Tabale offers three options: Yes, No, Don't know. The option 'Don't know' is ambiguous. It can mean either (i) farmer does not know if he will attend (he pressed DTMF option 3); or phone call was not received. *Proposed solution:* A category 'missed call' is added. System calls back after an hour, if call is missed'.

3.5 Phase 5: 2nd cycle - Deployment in production environment

With all issues fixed, a new version is deployed. Now the relevant questions to key-users and service providers are: are users prepared to pay for this service? Does it bring value to all business partners involved? What are the revenues over a certain period (e.g. 2 months)? Are there any (unexpected) costs for the provider? How is the work load for maintenance of the system? Is more training needed? Is the documentation useful?

Tools to be used Log files and face-to-face key-user interviews are important tools. Surveys with end-users provide information on actual results. Given common illiteracy, visiting users face-to-face is frequently needed during the evaluation phases.

Deliverables to be produced Report on system usage and user evaluations. The system documentation is made available as open source, online. Documentation and tutorials are delivered to stakeholders.

Case: RadioMarché, a market information system in Mali A voice-based market information system was built and deployed in 2011- 2012, according to this proposed framework. In October 2012, five months after its deployment, the system was evaluated with local users: radio journalists, local organization Sahel Eco, and farmers. A survey in various villages revealed that the system was well-used and had boosted the sales of honey in the region of Tominian ¹. One of the farmers in an interview reports a significant increase of sales of honey, due to the system ².

¹ For the evaluation report see: http://w4ra.org/wp-content/uploads/2014/08/Web-ofVoices-Working-paper_v0.11.pdf)

² A full evaluation of the RadioMarché system, deployed in rural Mali, can be found in http://w4ra.org/wp-content/uploads/2014/08/VOICES_D5.4_v1.3-m-agro-pilot-final-EU-subm-14Jun2013.pdf p. 42

3.6 Phase 6: Scaling up results

After successful deployments, the results will be diffused to other regions. Experience exchange workshops are organized, bringing key-users and potential users together. For global dissemination, conferences, tutorials and seminars are organized. The global community of web developers is invited to participate in further development of contextualized ICTs.

Tools to be used Exchange workshops will be organized, farmer-to-farmer visits, local radio broadcasts, conferences and symposia, video documentaries, radio broadcasts, webinars are organized to disseminate the results to respective targeted communities: (i) rural communities (ii) development agencies (iii) ICT developers, (iv) local ICT service providers (v) potential business developers (vi) research community (v) global community of web and ICT developers.

Deliverables to be produced For dissemination, video productions, a website, popular and scientific publications, folder materials are produced. All software is released as open-source for further development and adaptation. Documentation is available online.

Case: Uptake and dissemination After the end of the research project, Amadou Tangara, key-user and co-developer of Tabale, continued to use the Tabale service, not only to invite participants for a meeting, but to organize group sales of forest products for farmers in the Tominian region in Mali. Tangara traveled to Burkina Faso to demonstrate Tabale to other rural communities.

4 Lessons learnt and suggestions for improvement

The important lesson learnt from the field research, is the importance of continuous communication among stakeholders. Involvement of local ICT developers and ICT business developers is crucial for long-term sustainability. A problem, was the relatively high cost of development, due to a large developers team and long project duration. However, despite high initial research and development costs, deployment costs can be reduced by (i) building contextualized, affordable solutions and (ii) facilitating local uptake of ICT services. Technical and business training of local partners, throughout the development is part of the approach to ensure sustainability beyond the six phases of the presented framework.

5 Conclusions

Extensive field experimentation in rural West Africa has shown that at least three conditions must be met, in ICT deployments in low-resource contexts: (i) developers obtain a good understanding of the particularities of the local (low-tech) context (ii) users, despite their unfamiliarity with ICTs are involved in

the definition of goals and in the co-creation process. (iii) the cultural distance between users and developers is bridged through open communication and cross-learning. We propose a flexible framework, which can be adapted and re-used in other (low-tech, low-resource) environments.

This paper presents results of an ongoing project to support local communities by enhancing information, communication and knowledge sharing for rural development.

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³ Web alliance for Regreening in Africa <http://w4ra.org>