

# Developing Locally Relevant Software Applications for Rural Areas: A South African Example

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The digital divide between rural and urban areas within developing countries is vast. We investigate how to address this divide by introducing Information and Communication Technologies (ICTs) into remote rural areas. Our aim is to discover how to create locally relevant software applications with appropriate content for these areas. We use a user centred design approach and a modified software development lifecycle that is participatory, iterative and cyclical. This process is based on principles from Participatory Design and Action Research. This paper presents our initial experience of developing a telemedicine application for a rural village in the Eastern Cape Province of South Africa using this process. We present an overview of the methodology, describe the software application we have developed and cite several challenges we have faced. Finally we conclude that an inter-organisational and inter-disciplinary approach is needed to develop software for remote areas.

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Additional Key Words and Phrases: telemedicine, participatory design, action research

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## 1. INTRODUCTION

There is a growing Digital Divide between developed and developing countries. In Africa, for instance, there are only 1.3 PCs per 100 users and Internet penetration is low [International Telecommunications Union 2003]. Within developing countries there is also a divide between urban and rural areas. To overcome this internal division, access to Information and Communication Technologies (ICTs) must be provided to rural areas [Navas-Sabater et al. 2002; Bridges.org 2001]. This brings with it a host of challenges since these areas have unique conditions, for an example, remoteness and lack of reliable public facilities such as a reliable power supply and telephone lines [International Telecommunications Union 2000; Dray and Siegel 2003].

In the past, many initiatives attempting to empower communities through the use of ICTs failed. Reasons for failure include not providing suitable content, not addressing real needs or not fostering local buy-in from the community [Dray et al. 2003; Cogburn 2003]. The question is can we bridge this gap in these communities and develop locally relevant applications with appropriate content? We believe that we can empower rural communities through ICTs using a user centred and participatory approach in the software development process.

We have identified and developed an initial prototype telemedicine tool for a rural community in the Eastern Cape province of South Africa. The methodology we use is based on Participatory Design (PD) and Action Research (AR). It is iterative, cyclical and involves the community members of the target village in the software development cycle. This process enables us to create applications that are relevant for the area and address real needs. It will also enable us to comment on restrictions that legislation places on technologies that are appropriate for rural areas. This paper briefly describes the process we are using and explains how this gave rise to our first software prototype to enable telemedicine in a rural village. In addition, we present several challenges faced in the South African context when undertaking this kind of project as well as our future plans.

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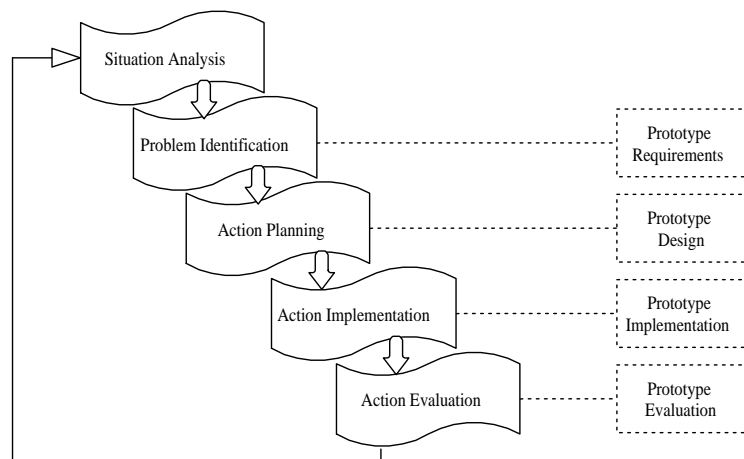


Figure 1. The methodological process is cyclical and iterative, involving stages where we analyse the circumstances of the target community, identify a problem to work on, plan an intervention, implement an intervention and evaluate the outcomes. The dotted boxes indicate stages of the process where we gather the requirements and design for prototype applications as well as the points at which implementation and evaluation of a prototype occurs.

## 2. RELATED WORK

There are several initiatives that have succeeded in creating applications for developing countries using user centred design approaches such as the Ore Project in Brazil [de Souza et al. 2003] and the CyberTracker project in South Africa [Blake 2001]. The user centred methods that we have based our methodology on are PD and AR. We chose these methodologies because we believe their emphasis on the user is applicable in rural areas.

PD emerged from Scandinavian approaches for empowering workers in industrial settings by allowing them to influence what technology was introduced into the work environment [Clement and Van den Besselaar 1993]. It emphasizes that the most productive ideas arise when there is collaboration from people with diverse backgrounds. It also concentrates on addressing problems that exist and arise from the situation in the workplace rather than from problems as perceived by outsiders [Greenbaum 1993; Williams 2002; Muller et al. 1991].

Most PD projects have used a AR methodology [Muller et al. 1991]. AR is generally attributed to Kurt Lewin and similarly to PD, the emphasis is on involving stakeholders in every part of the AR process as they are experts in the local culture, beliefs and practices [Lewin 1948; Stringer 1997]. Carr and Kemmis [1991] describe this method as a spiral of cycles of diagnosing a situation, planning an intervention, implementing the plan, observing results and reflecting on the results. Evaluations of each implementation stage form the basis for correctly planning the next step in the process. Each evaluation may lead to modifications in the ultimate goal.

AR and PD are applicable because the research focus arises not from the researcher alone but rather from the people and the community that an intervention aims to uplift. Thus, by addressing real needs, these methodologies focus on adapting technology to service workers' requirements. This is opposed to adapting workers to technological advances that may not be aligned with real-world needs. If we replace a worker with a community member, we can see that this provides a basic framework for conducting research in rural communities.

## 3. A SOUTH AFRICAN EXAMPLE

This section describes how we developed a software application using a methodology based on PD and AR.

### 3.1 The Target Area

We identified the Tsilitwa village in the Eastern Cape province of South Africa as the target community for our research. The village was chosen because of an existing project undertaken there by the Council for Scientific and Industry Research (CSIR). The CSIR together with a consortium implemented a community network in Tsilitwa linking several sites to each other and a neighbouring village using an 802.11b wireless ethernet (Wi-Fi). This was to allow Voice over Internet Protocol (VoIP) phone calls between the sites since there are no reliable phone lines in the area. The participants in our project include the people responsible for maintenance of this network as well as health care workers in Tsilitwa and the neighbouring village. The following section presents an overview of the process we are using.

### 3.2 An Inter-Organisational and Inter-Disciplinary Approach

Our methodology is cyclical, iterative and participatory. The first stage is situation analysis where we assess the present circumstances of target community. Next, we identify a problem area requiring a software solution and gather requirements for a prototype application. We then design the prototype in the action planning phase. In the action taking phase, we implement the prototype and in the action evaluation stage we conduct field trials to see if the prototype is appropriate for the problem. The feedback from the evaluation informs the next cycle, beginning at situation analysis. The process is iterative because we go through many cycles in order to refine the prototype. An overview is shown in Figure 1. We document the entire process using notes, interviews, audio recordings and the different versions of the software we develop. The focus is on qualitative results as opposed to empirical experimental data [Baskerville and Wood-Harper 1996]. However, we also collect quantitative statistics by instrumenting our software to record usage data.

The participatory aspect is the involvement of the target community members in the software development life cycle. This is achieved through discussion groups, semi-structured interviews and consultation by cellular telephones. However, community members in a rural situation may not be able to express their needs in terms of technology, since they are unfamiliar with it and lack technical expertise. Compounding this problem in our case is the fact that the researchers and the community members speak different first languages. Even within the community, different languages are spoken. This makes it very difficult to be sure that the developers and the community members understand each other. To facilitate interaction with the target community, we identified the need for a *Human Access Point* (HAP). This is an individual trusted by the community that can act as an interpreter between the researchers and the community members. In our case, these individuals include members of the CSIR who are familiar with the target community as well as motivated locals who worked on the previous project. We also use a *show and tell approach*, where we gather the most useful feedback by demonstrating paper and functional prototypes to the community members. This ensures that our ideas regarding different software solutions are successfully conveyed to community members. The approach is completed by a political aspect to ensure that the software we develop is deployable regardless of the technologies used. This means influencing policies that restrict, for instance, VoIP. We have contracted a Non-Government Organisation (NGO) called Bridges.org to assist us in influencing Telecommunications policy, to externally evaluate the project and advise us on best practice in using ICTs for development in rural areas [Bridges.org 2004]. They also provide input on how to make the project sustainable. This holistic approach is mutually beneficial for the target community and the researchers. The community involvement empowers individuals since they exercise a proportion of control in how the software is developed. Also, through their contributions, they are able to see how the software is going to benefit them. This means the software is more likely to be used. The researchers benefit by learning which technologies and services are appropriate for rural areas and how to develop these kind of applications.

### 3.3 The Process in Action

This section describes how we have used our approach in our target community. In our first field trip, we were introduced to community members by the CSIR and shown the sites linked to the Wi-Fi network. We identified the problem area as being communication for health. A basic telemedicine system was implemented by the CSIR to link the primary health care clinic in Tsilitwa with the nearest hospital, 20 km away. This system allows for telephone calls between the clinic and the hospital using VoIP. In addition, one way video transmission from the clinic to the hospital is possible via a low cost webcam. This system was found to be useful but problematic since frequent power failures render it useless for large amounts of time. In addition, telemedicine is an additional workload for the doctor who is already solely responsible for the entire hospital. It is therefore difficult to schedule times when a telemedicine consultation can occur. Through our discussion groups and interviews with the nurses from the clinic and the doctor from the hospital, we identified ways to improve this telemedicine system.

We attended several meetings with Bridges.org and the CSIR and decided that combining a store and forward approach with VoIP would improve communication for health in the area. Store and forward would allow messages to be sent between the hospital and the clinic while VoIP would allow for phone calls similar to the previous telemedicine system. We developed a paper prototype of our proposed telemedicine solution and presented it to the participants in the project on our second field trip. We used the analogy of voicemail to describe the store and forward component. Since all of the participants have cellular phones, they were familiar with this concept and the prototype was well received. When we returned from this trip, we proceeded to design and implementation of a functional software telemedicine prototype. The prototype had two main requirements to support: synchronous voice calls and asynchronous sending of messages. From the contributions of the community nurses and the doctor, we gathered that messages were to contain text indicating the patients illness and medical history, digital pictures of the patient or particular problem area and voicemail. Voicemail was

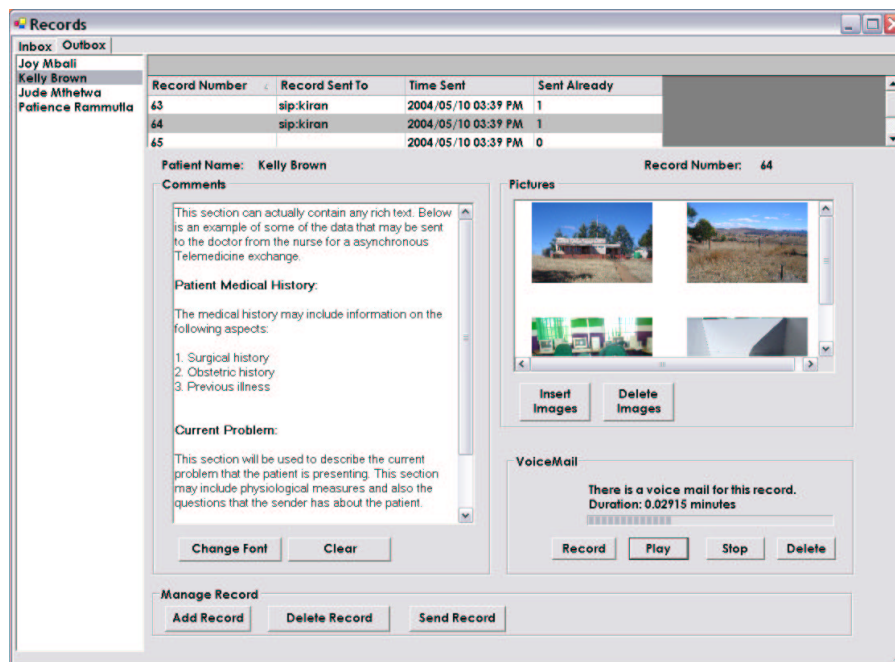


Figure 2. This screenshot shows the records dialogue in the initial MuTI prototype with a dummy record. Records are organised per patient in an inbox and outbox. Each record can contain text about the patient, voicemail and images of the patient.

included to save time on typing and digital images were requested due to their high resolution.

#### 4. MUTI: MULTI-MODAL TELEMEDICINE INTERCOMMUNICATOR

We implemented our initial prototype called MuTI, Multi-modal Telemedicine Intercommunicator, in C# on the Microsoft .NET Platform to allow rapid prototyping. MuTI has several components in order to carry out the functionality required from it. Voice calls are implemented using VoIP and file transfer is implemented with a simple proprietary client/server architecture. The initial interface was designed to look similar to an email interface since participants were familiar with this concept, having used email previously when a cellular Internet connection was made available for a short period by the CSIR. MuTI's main advantage is its multi-modality. Telemedicine consultations can be conducted synchronously if both parties are available and if the power and network are up. If the power or network is down, or if both parties are unavailable to take part in a synchronous communication, MuTI allows a store and forward approach for the data. Text, voice and images can be captured at any time and they are forwarded when a connection is available.

If MuTI improves communication for health, there will be cost and time savings for patients since they do not actually have to travel to the hospital to see the doctor. This is significant in Tsilitwa since a large proportion of the patients are unemployed or living on government grants. Also, inter-village travel is erratic and expensive for locals. On our third visit, we gathered baseline data and tested the initial MuTI prototype seen in Figure 2. We also introduced laptops to both the clinic and the hospital because they have a long battery life. This provides data capture time for several hours in the case of a power failure which can last from several hours to several days. The initial feedback received from interviews with the doctor and nurses in the area was positive. With the previous system, the doctor was constantly interrupted during telemedicine consultations by emergency calls since he is the only doctor at the hospital. He felt that MuTI would allow him to process and reply to messages in his own time and that he could aid more patients through telemedicine. The nurse at the clinic agreed that MuTI would increase the processing of patients and felt that the digital images and text would help the doctor accurately diagnose problems with a patient. Both parties also felt the voice calls with MuTI were of better quality than with the VoIP phones.

##### 4.1 Future Work

In the next cycle, we will use the feedback from the third visit to improve the MuTI interface and instrument the software to gather usage statistics of the system. We will administer questionnaires to the users to assess the usefulness of the new system and gather information on how to improve the system for the following visit. We are also working to get a satellite internet connection in Tsilitwa.

## 5. CHALLENGES IN THE RURAL CONTEXT

The project has presented us with many challenges. Due to the number of organizations involved and the large distance that must be travelled to visit the village, scheduling field trips is difficult. Time constraints therefore have to be relaxed and milestones have to be flexible during the project duration. Also, merely introducing technology into an area tailored to user needs is not sufficient. Along with the software development process, time must be allocated for extensive training of individuals to use the software. In addition measures to ensure sustainability and maintenance of equipment need to be put in place. There are also basic logistical problems. For instance, the hospital has a shortage of doctors and telemedicine merely places an additional burden on the doctor. This issue has to be taken up to government level in order to be resolved. Another problem is the legislation governing the use of certain technologies such as VoIP. Currently, VoIP may only be used over public networks by Telkom [Govt. 1996; 2001]. This restricts the extensibility of MuTI. For an example, if Tsilitwa obtains internet connectivity, we cannot legally use MuTI over the Internet due to its VoIP component. Legislation also restricts other services that could be developed for rural areas using Wi-Fi and VoIP. All these issues are important but not impossible to overcome.

## 6. CONCLUSIONS

To conclude, creating relevant applications for rural areas in developing countries like South Africa is challenging. PD and AR principles and an iterative participatory cyclical process provide a basic framework for introducing ICTs to bridge the technology gap in these communities. We have presented MuTI, which is an example of what can be achieved using this process with an inter-organisational and inter-disciplinary approach focussing on qualitative results. It incorporates technologies suited to the Eastern Cape area, namely Wi-Fi and VoIP, which are currently restricted by legislation. We have also raised several issues associated with this kind of development which can inform future research in this area.

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