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# "Snap Me" as a Pointer to "Rabbit Holes" in the Singa Environment

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**Abstract:** Vulnerable children are faced with the problem of in-accessibility to the information, services and people they need to advance in life. The definition of vulnerable children is those whose basic needs are not fully provided for and those that are not in a position to self-protect themselves. This includes orphans, street children, child labourers, children who are sexually exploited, children in child-headed households, child soldiers, refugees, children from poor households and children who are neglected, to name a few. This paper describes a digital environment called "SNAP ME" that assists in finding entrance points for vulnerable children and youths to a digital portal called SINGA. SINGA exposes these children to scenarios that simulate real-world situations and enables them to learn how to cope with life's challenges. An entrance point is referred to as a "rabbit hole". In particular the environment referred to here, introduces the vulnerable children and youths to science, engineering and technology (SET) concepts, in an effort to channel them towards SET careers. South Africa currently faces a critical shortage of SET specialists. *"SNAP ME" is a server-based solution which is capable of decoding 1D / 2D barcode images that were captured by means of a camera-enabled mobile phone to reveal a hidden message or a Uniform Resource Identifier (URI) that links to a challenge and possibly leads the children to a "rabbit hole" on the SINGA environment. The bar codes are placed anywhere that is likely to attract the interest of the youths, (e.g. the spaza shop, walls, food sacks, lamp posts, match boxes, bottle tops, bus station etc). The "SNAP ME" architecture takes advantage of the modified features of camera phones and related mobile technologies such as MMS and SMS in using bar codes for access to assistance and information for the vulnerable children and youths.*

The "SNAP ME" service retrieve an MMS messages in the form of a bar code and decodes the attached image, eventually returning the resulting challenge to the user as an SMS message. The decoding service is in open source code, while the code that enables the user to take a picture of a bar code and send it as an MMS message was developed as part of this research. For a refined "SNAP ME" architecture the service-supporting application should reside on the cell-phone rather than be stand-alone. The problem is the limited memory size of cell-phones and that the software must be compatible with the particular brand of cell-phone it sits on. Also, with the current "SNAP ME" set-up, without network coverage the MMS and SMS service cannot function. The current architecture has to be modified to connect directly to mobile network providers instead of connecting through GSM/GPRS modem to avoid the issues of contract-based connection links through Value-Added Networks (VAN). For purposes of sustainability of the project, a billing system to generate proceeds or a premium-rated SMS/MMS service for access for the poor can be negotiated with the mobile service provider.

**Keywords:** Rabbit hole, SET, vulnerable youths, bar codes, digital portal

# 1. Introduction

According to the UN Convention on the rights of the child [29], children first and foremost have a right to life. It is their right to have their basic physical needs for food, shelter, safely and healthcare met. They also should to be protected from injury and harm, not only physically but emotionally as well. Children should be afforded an opportunity to fully participate in life at family, community, school and national levels. The definition of vulnerable children is those whose basic needs are not fully provided for and those that are not in a position to self-protect themselves. This includes orphans, street children, child labourers, children who are sexually exploited, children in child-headed households, child soldiers, refugees, children from poor households and children who are neglected, etc.

Africa's vulnerable children and youths are faced with the problem of in-accessibility to the information, services and people they need to advance in life. It is for these reasons that an African initiative called SINGA (short for SINGAZENZELA) came up. The mission of SINGA is to enhance the livelihoods of vulnerable children and young people by imparting to them ways and means to participate better in their own lives and to get things done without necessarily relying on adults or officials. SINGA, which means "we can do it by ourselves" in Zulu, is a project that aims to take up the challenges faced by vulnerable children by intervening in the traditional public and voluntary-sector service delivery paradigm. The SINGA platform blends together tried and tested approaches, that is, paper, analogue and digital media.

Against a background of increasing demand for a skilled workforce in SET, several initiatives have been put in place to address issues of education, recruitment, progression and retention of SET specialists. This research is about contributing towards increasing the SET base through disseminating information that is SET related to the vulnerable children and youths via "SNAP ME", a 2D bar code system that is embedded into the SINGA environment. "SNAP ME" is an architecture that takes advantage of mobile technology including MMS and SMS, bar codes and camera phones to disseminate information.

This paper generally describes the "SNAP ME" technology and its place in the SINGA environment in the area of SET information dissemination. The next section gives an overview of the SINGA environment, related mobile and bar code technologies and explains issues around SET among youths in the South African environment. The following sections describe the methodology and the architecture of the "SNAP ME" technology. At the end is a discussion on the technology and the way forward in terms of research.

# 2. Background and Related Work

The next three sub-sections of the paper describe the SINGA environment, bar code technologies and SET issues among the youths, which all play a role in the design of the "SNAP ME" architecture.

## 2.1 The SINGA environment

SINGA's objective is to make it possible for the poorest and most vulnerable of Africa's children to play a central role in defining and accessing the information, services and people they need to advance in life. SINGA is about providing scenarios in which a child discovers how to "do things" that normally would have been difficult in a real world situation. These digitalised scenarios or challenges enable the child to learn and grow as an individual, to develop an inner resilience, to access peer-based support networks and to navigate successfully through other support systems that will enable him/her to cope with life's challenges.

In Lewis Carroll's "Alice's Adventures in Wonderland" [1], Alice follows a mysterious white rabbit into a "rabbit hole" to enter this wonderland; a world inhabited by many strange characters. This usage has helped make the phrase "rabbit hole" refer more generally to any portal into a different or strange world. The SINGA experience begins with the child discovering a "rabbit hole". "Rabbit holes" are in the form of people, billboards, newspaper adverts, bottle/can labels, radio spots, etc. All "rabbit holes" lead to information which leads to more challenges. SINGA challenges are games, visual cues, physical objects and puzzles intended to attract children through curiosity and mystery to participate in the SINGA experience. Each challenge is designed such that the children can learn something from performing it. These challenges can be solved singly or in groups.

The SINGA digital platform (Figure 1) consists of 4 main areas – My World, My Things, My People and My games. My World is the environment where a child can build a unique view of their life, and a map to other resources where they are in control and feel safe. My World is accessed either through a browser or using the cell phone's voice and text message capabilities. My People is an environment where a child can interact with people in the community, family, peers, make new friends and learn and support from other children. A key component of the My People element is the buddy list. The buddy list is the electronic address of all those people the child may wish to contact. Some addresses are provided by default, e.g., the nurse, teacher, doctor, etc. My Things is a safe place where a child can store digital objects such as their birth certificate, letters, photo album, cookbook, memory box, etc. My Things will be securely deposited in a trusted repository – a digital vault. My Games is an environment where a child can learn, play and explore and learn about life in a funny way through challenges.
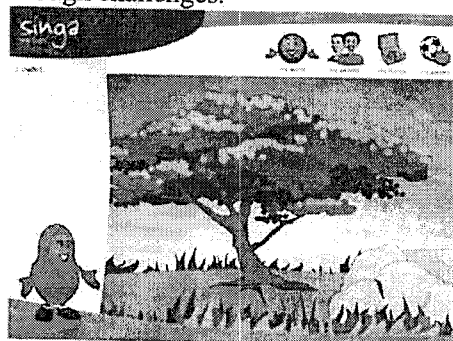


Figure 1: The SINGA platform

SINGA is designed for delivery using access methods that include:
- MediaTiles based on SINGA IP broadcasts by cell-phone operators
- Digital Doorways, the 4-seater computer terminals, that supports wireless networks and is placed in community centres for free access
- Life stations, that include game consoles for situations beyond networks.

Examples of services that can be provided in the SINGA environment include:
- Interactive real-time support via SMS-like chat clients
- SINGAPEDIA, which is local knowledge stored in a wikipedia-like environment
- Automated FAQs and checklists, e.g. cellphone downloads, SMS and chat clients

## 2.2 Related Bar-Code and Mobile Technologies

A bar code is an optical representation of machine-readable data and can be seen on the majority of products that are on sale in the retail industry to speed up the checkout process. These linear symbologies or so-called one-dimensional (1D) barcodes represent data in vertical parallel lines with varying space and line width [25]. A lesser well-known two-

dimensional (2D) barcode or matrix code is also an optical representation resembling something like a crossword puzzle of even more machine-readable data and can normally be seen on larger packaging containers to assist with warehouse logistics and quality control. Various organisations are nowadays using these data matrix codes on printed advertising media to navigate potential visitors towards their Internet web sites. This is done by encoding a Uniform Resource Locator (URL) into a data matrix code that could later be decoded by an application on a camera-enabled mobile phone to allow the user to access a particular web site. One advantage would be that users can view the Internet content without the need to enter long web addresses on a limited mobile handset keyboard.

Examples of matrix codes include QR Code, Data Matrix code and Semacode. QR Code [3] is derived from Quick Response as the creator intended to allow its contents to be decoded at high speed. QR Codes storing URLs appear in many places about any object a user might need information on. A user having a camera phone equipped with the correct reader software can scan the image of the QR Code causing the phone's browser to launch and redirect to the decoded URL.

A Data Matrix code [4] is made up of a two-dimensional matrix code consisting of black and white square modules arranged in either a square or rectangular pattern. The information to be encoded can be text or raw data. The usual data size is from a few bytes up to 2 kilobytes. It can store up to 2335 alphanumeric characters. This is common on printed media such as labels and letters. The code can be read quickly by a scanner which allows the media to be tracked, e.g., on a parcel.

Semacode [5] is machine-readable ISO/IEC 16022 data matrix symbols which encode URLs. It is primarily aimed at being used with cellular phones which have built-in cameras. A URL can be converted into a type of barcode resembling a crossword puzzle, which is called a "tag". Tags can be quickly captured with a mobile phone's camera and decoded with a reader application to obtain a web site address. This address can then be accessed via the phone's browser.

Currently, a phone with a camera does not automatically have a decoding mechanism. Reader software has to be downloaded onto the cell phone. But sufficient memory is required on the cell phone for storage of the downloaded software. The software that is downloaded must also be compatible with the cell phone. Even for the same cell phone brands, specific models would require specific software. For example, a Nokia N95 using the series 60 Symbian operating system and a Nokia 5200 using the Nokia OS would need different types of software. Reader software in the future will be distributed with new phones in their operating system (OS).

### 2.3 Alternatives to Embedded Reader Software

Multimedia Messaging service (MMS) [6] is a standard for telephone messaging systems that allows sending messages that include multimedia objects (images, audio, video, rich text) and not just text as in Short Message Services (SMS) [7]. MMS-enabled mobile phones enable subscribers to send messages with one or more multimedia components to other subscribers on the cellular network. The contents of these messages should conform to MMS standards for compatibility between messages sent from one phone to the next. For example, one phone can send an MPEG-4 video [8], but the other party who is receiving the MMS may not be able to interpret it. Mobile phones with built-in camera or MP3 players are vey likely to also have an MMS-messaging client – a software program that interacts with the mobile subscriber to compose, address, send, receive and view MMS messages.

By utilising the MMS capabilities that one can find on most of the camera-enabled mobile phones, it becomes possible to build a specific MMS-based service that can be used to remotely to decode a 2D barcode or matrix code. The following concept can be

demonstrated where a user can take a picture of a 2D barcode, compose an MMS message and forward the message to a decoding server that is loosely connected to the cellular network provider through a GSM modem [23]. The modem attached to the decoding server, reads the MMS and forwards the 2D barcode image to the decoding engine. The image is decoded by the matrix decoding engine and the result is a string text message. The string message is sent back to the originating cell phone as an SMS. Therefore, in this case, there is no need to install software on the mobile phone – every cell phone with a camera can perform this function. The specific service provider looks after the software-related issues.

*2.4 The State of SET Among Youths in South Africa*

South Africa has three broad bands of education: General Education and Training, Further Education and Higher Education and Training. School life spans 13 years, from grade 0, otherwise known as Grade R or reception, through to grade 12 or matriculation level. General Education and Training runs from grades 0 through to grade 9. Further Education and Training takes place from grades 10 to 12 and also includes career-oriented education and training offered in other Further Education and Training institutions, that is, technical colleges and community colleges. Diplomas and certificates are qualifications recognised at this level. Higher Education and Training or tertiary education includes education for undergraduate and postgraduate degrees, certificates and diplomas. It is undertaken predominantly in the universities [9].

Science education in South Africa starts at primary school level. Outcomes-based education (OBE) forms the foundation of the curriculum in South Africa at grades R to 9 and sets outcomes to be achieved at the end of a process which encourages a learner-centred and activity-based approach to education while focussing on skills development. Science at this level is aimed at fostering an appreciation of the relationships between science, society and the environment, the development and use of science process skills and application of scientific knowledge. It covers mathematics, natural sciences, social sciences, management and economic sciences and technology, to name a few [10]. Between grades 10 and 12 learners are taught physical and life sciences. The physical sciences influence scientific and technological development. Scientific enquiry and problem-solving skills similar to those used by scientists at work are developed at this level. Pupils are able to understand relationships between science and technology, the society and the environment [11]. Life sciences involve the systematic study of life in the changing natural and man-made environment. This enables learners to understand biological, physiological, environmental, technological and social processes that impact on the environment [12].

Technical subjects, commonly known as trade subjects are taught at Further Education and Training (FET) schools. The new technology subjects focus on technological processes from conceptual design to practical problem-solving and application of scientific principles. The technology subjects in the new National Curriculum statement include Electrical Technology, Mechanical Technology and Engineering Graphics and Design. These three subjects are referred to as manufacturing engineering and technology subjects [13].

In 2006 in South Africa, 528 525 pupils wrote matriculation exams at the end of grade 12 and 66% of these passed. In 2006, of 169 118 pupils who wrote the mathematics exam, only 52% passed representing 32% of the total number of candidates entering matriculation [14]. By 2006 when the enrolment figure had increased by 120 000 pupils, the pass rate had dropped to 52% [15]. The number of these students who passed higher grade mathematics stood at 25 217.

In South Africa, the University of the North's Science foundation year is a basic programme in science at university level as an effort to increase the quality and quantity of entrants from previously disadvantaged communities into university science programmes

[16]. Students undergo extra lessons in science in the first year of their university curriculum to strengthen their science base. The Expo for Young Scientists is an annual science fair where learners have a chance to show others projects about their own scientific investigations and discuss their work with a larger audience [17]. The SET week [18] is an initiative of the Department of Science and Technology (DST). The main objective of the week is to persuade young people to pursue scientific careers that would contribute towards the development of the South African economy. It also promotes a public awareness and appreciation of the role and contribution of science and technology in people's lives. Some of its key activities include interactive exhibitions, science shows, workshops, theatres and career information sessions. The DST in partnership with the National Research Foundation jointly manages and implements an internship programme aimed at empowering unemployed graduates in the SET field with skills and workplace competencies. The internship programme also aims to address the shortage of skills within the science system, thus responding to the skills priorities for the National System of Innovation (NSI) [19].

Under the Department of Education, the Dinaledi project [20] seeks to produce 50,000 mathematics and science graduates at senior certificate level by 2008. Dinaledi, established in 2001, is the main initiative of the Department of Education to improve the performance of the schooling system in respect of maths and science. Some schools are selected for Dinaledi status, and provided with additional resources for teaching these subjects. Currently 490 of 6264 secondary schools – or 7,8% - are part of the programme. The National Festival of Science, Engineering and Technology (SciFest Africa) [21] is an event to create a new mindset about SET, allow scientists to make science accessible to and within the reach of ordinary people, and to show that SET underpins our daily activities. Science Unlimited offers the youth a life-changing experience by one week of activities that enthuse youths into SET [22].

## 3. Methodology

### 3.1 Aims and Objectives

The purpose of this study was to enhance the digital SINGA platform with technology that would ease the access to SET challenges with a view to promoting SET among vulnerable children and youths. This enhancement is in the form of "SNAP ME" technology. The objectives of the study were:

- Designing the "SNAP ME" architecture
- Designing and developing the server side software to decode the barcode and matrix code captured on a mobile camera phone

### 3.2 Procedure

A literature survey was conducted to establish a theoretical framework behind SINGA, bar code technologies, SET among youths, the relationship between mobility and bar codes and SET solutions to these challenges. The information collected was then utilised in the design of the architecture of "SNAP ME". Open source code and code developed in-house was incorporated into the architecture to decode the barcode and matrix code captured on a mobile camera phone

## 4. "SNAP ME" Technology and Its Uses in SET Education

"SNAP ME" assists in finding entry points or "rabbit holes" into a SINGA experience. 2D matrix codes are printed onto various printable media and distributed where children could stumble upon them. In order to decode any of these 2D matrix codes the child will have to ensure that the right software application is installed on a mobile camera phone or

alternatively capture the image and forward it to a "SNAP ME" service that could decode this matrix code. The SINGA challenge would then be revealed either as a text message or a URL pointing to the specific web page hosting the challenge

"SNAP ME" is aimed only at the process of sending the captured image as a Multimedia Message Service (MMS) message to a specific "SNAP ME" mobile service that decodes the 2D matrix code and sending the result back to the sender as a Short Message Sending (SMS) message (Figure 2).
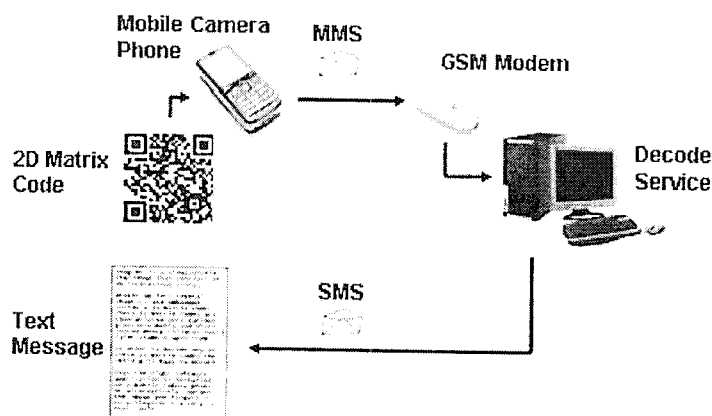


*Figure 2: "SNAP ME" Decode Service*

The "SNAP ME" decode service consists of the following main components:

- A component that holds the main service functions is responsible for retrieving the MMS messages via a GSM [23] modem and sending the decoded text messages back to the sender as a collection of SMS messages.
- A component that is responsible for decoding the received 2D Matrix Code images.

The first component in the decode service is the starting point of the SINGA service application and holds all the main methods responsible for retrieving MMS messages, decoding the attached images and eventually returning the resulting challenge. A local GSM/GPRS [24] modem is used as the gateway to loosely connect to the mobile network provider for retrieving the MMS messages sent by pupils. This service component is continuously listening for incoming MMS messages that are in turn sent to the second component responsible for decoding any attached 2D Matrix Code images. The resulting embedded SINGA challenge or URL is then returned to the first component to generate an SMS message that can be returned to the requester.

The code to decode a given image into text message is open source code and was downloaded from the Internet. The front-end that enables access to the mobile service provider and the modem to ensure that the user can take a picture and send it as an MMS was developed as part of the research. The software for getting the MMS message from the modem was written from scratch. Although such software can be bought off the shelf the costs are inhibiting.

The research achieved the following:

- Investigation of the ZXing (pronounced zebra crossing) open source software to decode 2D Matrix Code images.
- Development of the MMS notification message parser software for handling the binary MMS header message sent by the mobile networks MMSC to the receiving GSM/GPRS modem.

- A command line shell class was developed on the decode service component side to use one of the operating systems predefined PPP modem connections to make a GPRS connection to the mobile networks MMS-specific APN connector
- Software was also developed to retrieve the multimedia message (MM) using jWAP open source libraries [28] to handle the underlying WAP wireless session protocol (WSP) specification.

Alternative SNAP-ME implementation services could offer the following information services to potential users:

- Providing historical information about a tourist attraction. This information could have been compiled by learners in a community as part of their learning experience and uploaded to the "SNAP ME" platform
- Providing information on government operations and service delivery in areas of health and education, for instance
- Providing information on transport schedules and costs.

To improve the dissemination of SET information, the quality of the image could be improved and with the addition of image recondition software to the "SNAP ME" back-end service, it might be possible to use the "SNAP ME" service for identifying objects in the real-world. The "SNAP-ME" service could then follow an even bigger non-formal education by providing scientific and engineering explanations to real live objects. For example, a picture of google-earth can result in explanations on Geographic Information Systems (GIS), remote sensing technologies, weather patterns or even vegetation distribution.

## 5. Economic and Sustainability Issues

The latest statistics show that cell-phone coverage in South Africa is fast approaching 100%. The majority of South Africans are in possession of a mobile phone or have access to a friend or relative's mobile phone. Therefore the "SNAP ME" platform has a place in the South African environment. It is also relatively easy to purchase a low-cost prepaid SIM card in South Africa without the need to negotiate a contract with one of the mobile network operators. This alternative option allows a learner to borrow a mobile phone and swapping the SIM card prior to requesting information from the "SNAP-ME" service.

Another approach to income generation for sustainability of the project is for the SINGA service provider to request a premium-rated number that is connected to zero billing for sending an MMS/SMS through that number from the cell-phone network service providers. Alternatively the SINGA service provider could purchase bulk SMS/MMS services from the cell-phone network service providers through sponsorships. These sponsors could be the government on a human rights basis, and donor agencies. Some of the cost to the user of the "SNAP-ME" service could be sponsored by presenting additional advertising information. This might also include URL links to the product or service providers advertising web pages.

## 6. Discussions and Future Research

There are many pros and cons to the "SNAP ME" setup that is proposed in this research. With the current set-up it takes time to upload/download multimedia messages and MMS could cost a lot of money. Without network coverage the MMS service cannot be used. Therefore it is advisable to put the application on a cell phone rather than have it as a standalone service. The advantage of having a decoding engine on the cell phone is that once a picture is taken, there is an immediate response back. That will improve dramatically or enhance the user experience.

There are various companies developing decoding software that can be deployed onto a mobile phone, hence introducing competition between them to continuously improve. At the same time uploading software onto a mobile phone is in general more difficult that sending a MMS message and would also be utilising valuable memory resources on the mobile phone and can cause lack of memory. A major challenge is that reader software in general needs a well-focused image of the 2D Matrix Code in order to decode the data. Most of the camera-enabled mobile handsets do not capture a sharp image at close range, making it very difficult for any reader software to decode. One would need to add an additional higher cost macro lens on most of the mobile handsets to improve on picture quality alternatively investigate software means to improve on picture quality.

The proposed system looks at youths being able to access information on SET. Each piece of information on SET is associated with a URL. The limitation to the size of information accessed under each URL is governed by the fact that the cell phone has a limited size of memory. For business purposes we could have a central server which houses these URLs and each piece of SET information will have its own URL.

The future research involves the adoption of Mobicents [25] in order to move toward a more standards-based platform. The Mobicents Converged Application Server is a robust open source component model platform that is fully certified for JSSLEE 1.0 [26] compliance and also implements some of the proposed JAIN SLEE 1.1 [27] features. It uses resource adaptors to interact with external resources via different protocols.

This project uses a GSM/GPRS modem instead of connecting directly to the mobile networks service provider backend services as this option would need prior establishment of a contract-based connection link through a Value Added Network (VAN) provider. An SMS and MMS resource adaptor will have to be developed to allow a modem connection to the mobile network service provider messaging services.

A billing system will be introduced to generate proceeds. Premium rated SMSs where the prices can be dictated for cheaper access for the poor can be negotiated with the mobile service provider.

# 7. Conclusions

This paper is about "SNAP ME" technology which is an architecture that is an enhancement to the SINGA environment. The SINGA is a digital portal that makes it possible for vulnerable children and youths to discover how to do things that normally would have been difficult in a real-world situation. "SNAP ME" decodes barcode images that are taken using camera phones. These images represent URLs which link the vulnerable children and youths to information on SET. These barcode images will be placed at different sites that are likely to attract the interest of these users.

The issue of sustainability of the "SNAP ME" project is of vital importance, considering that the target group of users are people of no constant and reliable income. The research proposes mechanism of income generation such as billing customers, including links to advertising web pages and getting sponsorship form the government or donor agencies for subsidised rates of access to the service.

The research also considers areas of further research. The "SNAP ME" service retrieve an MMS messages in the form of a bar code and decodes the attached image, eventually returning the resulting challenge to the user as an SMS message. The decoding service is in open source code, while the code that enables the user to take a picture of a bar code and send it as an MMS message was developed as part of this research. For a refined "SNAP ME" architecture the service-supporting application should reside on the cell-phone rather than be stand-alone. The problem is the limited memory size of cell-phones and that the software must be compatible with the particular brand of cell-phone it sits on. Also, with the current "SNAP ME" set-up, without network coverage the MMS and SMS service

cannot function. The current architecture has to be modified to connect directly to mobile network providers instead of connecting through GSM/GPRS modem to avoid the issues of contract-based connection links through Value-Added Networks (VAN). For purposes of sustainability of the project, a billing system to generate proceeds or a premium-rated SMS/MMS service for access for the poor can be negotiated with the mobile service provider.

## Acknowledgements

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