A Structured Model-Based Approach To Preview Sustainability in ICT4D

Anna Bon, Jaap Gordijn, and Hans Akkermans

The Network Institute - Vrije Universiteit Amsterdam,
De Boelelaan 1081, 1081 HV Amsterdam, The Netherlands.
(a.bon,j.gordijn,j.m.akkermans)@vu.nl

Abstract. e-Services have great potential, even in resource-poor environments such as in sub-Saharan Africa. However, contextual factors pose significant challenges for development, feasibility, deployment and sustainability of e-services. Based on extensive field research over many years, we describe a structured methodology to analyze sustainability of innovative services. This is illustrated by a case of e-service innovation in a rural context in Mali, with targeted end users in regions characterized by limited internet access, strong diversity in languages spoken, high illiteracy rates and limited purchasing power.

1 Introduction to e-Service Innovation in Rural Africa

Despite the many information and communication opportunities offered by the World Wide Web, over 4 billion people are still unconnected. Many of them live in remote rural regions of the world.

Recent field studies in West Africa have demonstrated that there is a demand for relevant, timely and accurate information for rural communities (Aker, 2008; de Boer, De Leenheer, Bon, et al., 2012; de Boer et al., 2015). Information about market prices, local daily rainfall and local weather predictions, information on animal diseases and health management of e.g. cattle and sheep, are just a few examples of information, considered important by local farmers (Bon, de Boer, Gyan, van Aart, et al., 2013; Gyan et al., 2013). This demand for information may be served by context-sensitive e-services that provide relevant information to local rural populations.

Accordingly, an important issue in rural development is how such e-services can be developed and deployed in *a sustainable way*, given the local conditions that are vastly different from the usual 'normal' urban contexts that dominate scholarly research.

In this paper, we consider service sustainability issues in rural areas of Mali and neighboring Sahel countries (e.g., Burkina Faso, northern Ghana) in West Africa. Electricity is scarce or even non-existing in many rural regions and villages, and internet and computers are hardly available. Low literacy is common (e.g., in Mali adult literacy is below 35%). In Africa, a wide variety of local languages are spoken, and most of them are to date not properly supported by

the Web or other computational means. Purchasing power is limited, with an average income of less than 2 US$ a day.

A positive condition is the widespread availability of mobile telephony among rural people, and the wide availability of community radios in rural Africa (De Bruijn, Nyamnjoh, & Brinkman, 2009; Bon et al., 2012).

This paper outlines — based on extensive field research over the period 2009–2016 in rural Mali in which a voice-based microblogging e-service was developed and deployed with local stakeholders — a methodology to upfront analyze business model *sustainability* for e-service innovation in severely resource-constrained contexts.

This is important to investigate, as developers of ICT systems and e-services are often unfamiliar with this (rural African) context, and consequently many well-intended ICT projects fail. Conversely, the local envisaged end users are unfamiliar with ICT and e-services. A farmer in Mali may be interested in a new mobile e-service. However, she will only pay for the service when it creates added value for her. Another actor in business, say, an enterprise such as a radio station, may be interested in participating in future commercial voice-service delivery. However, the profitability and sustainability of an innovative e-service is not obvious beforehand for the radio station.

In sustainability analysis, some key insights are worth pointing out. First, business model analysis is commonly carried out from a single-enterprise viewpoint (Osterwalder & Pigneur, 2013); however, for sustainability it is crucial to take into account the whole socio-economic and socio-technical *network of actors* (Gordijn & Akkermans, 2001, 2003).

Second, as will be shown, analysis yields more than one business model that may be feasible and sustainable; they are associated, however, with different roles and network configurations of involved actors, and they moreover have different implications for the ICT requirements.

Fig. 1. The rural context in West Africa, without electricity or internet infrastructure.

2 Sustainability and the *e*^{3}*value* methodology

As is the case with any innovation, long-term (financial) sustainability of is key to success. To develop an economically sustainable value web, each participating actor or enterprise must be capable of making a (long-term) profit or derive other forms of use or exchange value by being part of the value web.

In general, e-services based on networked technologies are usually provided in *networked constellations* (see e.g (Normann & Ramírez, 1994)), or, as we call them, *value webs*, in which each enterprise brings in a specific core competence. All these competences of the participating enterprises in the value web jointly satisfy a customer need, which could not have been satisfied by a single enterprise.

Likewise, innovative mobile/web services in Africa consist of networked constellations. These value webs may look different from a high-tech e-commerce setting, as they involve actors such as radio stations, low-tech intermediaries (e.g. middle-men, local organizations etc.) and paper-based transactions. The speed of transactions may be slower than in Internet-based e-commerce, especially by the absence of on-line payment services. However, we argue that the concept of value web is valid in low-tech, constrained rural contexts, as will be shown by the case of a voice-based radio platform, deployed in Mali.

To accurately analyze different (business) scenarios for a given e-service, and evaluate/predict their feasibility and sustainability, we propose a model-based assessment of network profitability based on the *e*^{3}*value* methodology. *e*^{3}*value* [1] is a conceptual modelling tool for qualitative and quantitative assessment of the feasibility and sustainability of a business idea (Gordijn & Akkermans, 2003, 2001). Figure 2 gives an illustrative example of a simple *e*^{3}*value* model, showing a customer buying an ice cream at a snackbar, and paying for it. The snackbar in turn obtains the ice cream from the ice cream factory and also pays for it. The example explains the various basic ontological concepts of the *e*^{3}*value* method (The following text is an excerpt taken from (Gordijn & Akkermans, 2003, 2001)).

The model in Figure 2 shows various *actors* in a *value network*. Each actor represents an individual entity, which is responsible for profit-and-loss. This can for example be a customer, an ice cream factory, a shop, any business. Actors can be represented as single or multiple entities: in the latter case they represent a whole market segment. A market segment is in fact a set of actors that share the same economic utility function. Market segments are represented graphically in the *e*^{3}*value* ontology as a 'stack of actors'. (For the sake of simplicity, the market segment is not represented in the example of Figure 2).

Actors in a value network exchange value objects with each other. These value objects (e.g. an ice cream, money) represent an economic value for the actors in the model. Actors exchange (provide or require) value objects via value ports. Value ports are grouped into value interfaces. These value interfaces model the economic reciprocity, which exists in every business transaction. Evidently, an

[1] See http://e3value.few.vu.nl

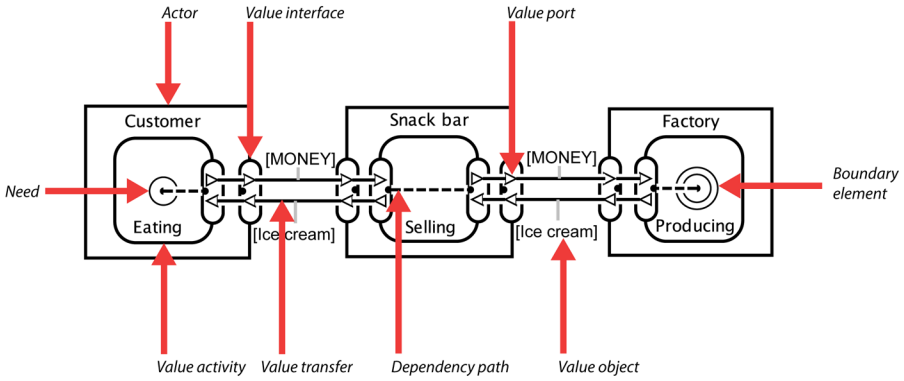

Fig. 2. An educational e^3value model.

actor provides a value object, only, if he or she gets something in return, of equal or higher value. In Figure 2 a customer and a snack bar exchange an ice cream for money. This occurs through a value transfer. This models the actual transfer of the value object (the ownership of the ice cream is transferred from the snack bar to the customer). Given the reciprocity principle, when an ice cream is transferred, money is transferred in the opposite direction[2].

A customer need initiates the business process: in this case, the customer wants to have an ice cream. To satisfy this need, an exchange of value objects (ice cream against money) via an interface. This is modelled by connecting the value interfaces by dependency paths. It becomes clear that the snack bar must obtain the value object (ice cream) from the ice cream factory. A boundary element at the ice cream factory, indicates where this value transfer actually ends (which demarcates the scope of the model).

The e^3value model makes it possible to calculate a net cash flow for each actor in the value network, and can therefore serve as an indicator for feasibility of the value network as a whole.

3 Developing a Micro-blogging e-Service in Rural Mali

In the framework of the W4RA[3] research program, an interdisciplinary, international team (consisting of requirement engineers, information analysts, web developers, speech technologists, sustainable land management specialists and business experts) developed innovative e-services in Mali, in close collaboration

[2] The relative timing of the various transfers is not represented in the model, only the nature of the transaction as a whole

[3] The Web alliance for Regreening in Africa, http://w4ra.org

with local radio journalists, local African non-governmental organizations and smallholder farmers.

The co-creation took place during extensive workshops and focus group discussions in Bamako, Segou, Konobougou, Tominian and San, in Mali. The workshops aimed at understanding the context, reducing cultural distance between all stakeholders, elicitation of the ICT and business requirements, showing prototypes, and evaluating technical architecture and business models. Various e-services were deployed during an extensive field experiment in West Africa, between 2009 and 2016[4].

One of the developed e-services was a voice-based micro-blogging service, that allows people from rural villages in Mali, without Internet, to send a voice message (by mobile phone) to the local radio, for broadcasting. The use case data for this voice-based micro-blogging service were collected in 2011 and 2012, in collaboration with local Malian non-governmental organization Sahel Eco and three Malian radio stations, who requested a (mobile) service where customers can phone in and leave a spoken announcement for broadcast. The radio journalist can access and manage the incoming (spoken) messages via a web or mobile/voice interface. The radio station charges a fee for broadcasting the message. The name given to this service was Foroba Blon[5].

In this study three examples of a voice and radio-based e-service are shown, developed and deployed in rural Africa, in close collaboration with the local end-users. During the workshops, several actors were identified, who would make up the value web for e-service delivery and consumption. The following information was collected during various focus group discussions with radio journalists, local NGO staff members and farmers.

Fig. 3. Radio Sikidolo, in the village Konobougou, Mali.

[4] For a full description of the e-services and the use case and requirements analysis for these services, see (Bon et al., 2013; Gyan, 2016)

[5] The Foroba Blon e-service was part of the project with the same name, funded by the International Press Institute, see http://w4ra.org/foroba-blon-community-radio-in-africa-and-the-web/

3.1 Rural radios, the potential service providers

Rural radios are important local information providers/hubs in rural Africa, in the absence of other mass media. The Malian community radios in our study reach about 80,000 listeners, within a radius of coverage of 100 to 200 km. They create programs and broadcast local and regional news, music, round table programs and paid announcements. Some of these radios in rural Mali have computers and a connection to the Internet, some only have computers without Internet connection, some have no computer facilities at all, depending on their business size and location. All radio stations are situated within the coverage area of (2G) mobile telephony.

Fig. 4. Radio Moutian in Tominian, Mali.

Rural Radios in Mali are publicly funded (ORTM[6]), community-based or privately funded. Some radios receive donor aid. All radios sell broadcasting airtime. Different fees are charged for commercials than for private announcements.

Three radio stations were involved in this research project:(i) Radio ORTM Segou, a state owned radio, that has computers and a fixed Internet connection (DSL). Radio ORTM Segou broadcasts programs in French and Bambara, the most widely spoken language in Mali; (ii) Radio Moutian, in Tominian, an independent radio, selling airtime for announcements and receiving some private gifts from third parties. Radio Moutian has a computer but no Internet connectivity. Programs are mainly broadcast in Bomu, a local language in the Tominian

[6] https://en.wikipedia.org/wiki/Office de Radio diffusion et Télévision du Mali.

region; (iii) Radio Seno in Bankass. This radio is independent from the Malian state and has only analogue equipment. There are no computers, there is no Internet connection here, but the radio has many listeners in the area around Bankass. The language spoken here is Dogon. The activities of the three above mentioned radio stations are related to different types of customers and business contacts.

3.2 Village reporters as service providers

Journalists or trusted village reporters work for the radio and leave local news or interviews on a regular base. In the current situation, all incoming phone calls are attended by a radio staff member and annotated in tabular form on paper.Radio reporters in the villages provide mobile phone access to villagers (non-commercial radio-listeners), who want to send an announcement to the radio, but do not own a mobile phone. These radio reporters also arrange the payment for the broadcast between the villager and the radio.

3.3 The potential customers

The proposed voice-based micro-blogging e-service has three types of customers (actors as a market segment).

1. Non-commercial radio listeners living in the surrounding rural communities buy a few minutes of airtime and pay a broadcast fee per minute airtime. Their average income is usually between 1 and 2 US$ a day. The information is usually brought to the radio on paper, or communicated via phone and subsequently written down on paper by the radio staff. These announcements can be e.g. about weddings, funerals or other messages to the public.
2. Non-governmental organisations (NGOs) buy airtime to broadcast public announcements about informative and educational topics, such as agriculture and public health information. They pay the radio a fixed monthly subscription fee for recurring broadcasts.
3. Commercial services broadcast advertisements on the radio. These were not taken into consideration in the model, but are a potential, future source of income for the radios. The fees charged for commercials are 150 percent of the fee for private announcements[7].

4 Evaluation of business models

The first release of the voice-based micro-blogging system, Foroba Blon, based on local business ideas and requirements expressed by the radio journalists, was tested and taken into in production by Radio Sikidolo, in Konobougou, and radio Moutian in Tominian, in Mali. The technical architecture of the Foroba

[7] Source: personal information by Adama Tissougué, Radio Sikidolo, May 2016

Blon platform has been published [8]. The technical architecture of the Foroba Blon platform has already been published (Gyan et al., 2013; Bon et al., 2012).

We received extensive feedback from the radio journalists about the assets and the problems they experienced while using the Foroba Blon system. This feedback was used to construct value models, based on real and estimated costs, and used to predict feasibility[9].

Fig. 5. Members of the Foroba Blon team at Radio Moutian, Tominian, Mali, February 2012.

Three business models for potential e-services were designed and analyzed for Foroba Blon. The first model uses a village reporter, who owns a mobile phone, to send messages from people who do not own a mobile phone to the Foroba Blon system. For this, the village reporter obtains a small fee. The second business model supposes professional users, such as a NGO, who wants to send messages. These professional users pay a small fee for sending their messages. The third business model is about a news provider who wants to obtain news items from the local region. The news provider can be a newspaper or a television station who wants to have content (the news items) to broadcast. For receiving local news, the news provider pays a fee.

The three business models are evaluated for feasibility and sustainability. Each of the models is associated, however, with different roles and network configurations of involved actors. Each model brings therefore, different implications for ICT requirements.

[8] A documentary about Foroba Blon can be viewed at http://w4ra.org/citizen-journalism-in-rural-areas-in-mali/

[9] Source: personal information by Adama Tissougue, Radio Sikidolo, Mali, May 2016

4.1 The village reporter-based business model

Figure 6 presents the e^3*value* model for the village reporter service. Senders, being individuals without access to a mobile phone, can contact a village reporter. A village reporter is a person who normally collects news items for a particular local area and reports these items to a local radio station. For this purpose, the village reporter owns a mobile phone, and is also trusted by the local radio station.

A sender is for instance a herder in Mali (e.g. Konobogou). He wants to broadcast a message on the radio, e.g. because he is missing one of his cattle. By reporting this lost animal on the local radio, the message will reach about 80,000 people, the listener's base of this small radio Sikidolo, in Konobougou. The chance of finding the cow and reporting this is substantial. The sender is willing to pay 1000 CFA for one minute of broadcasting a message on the radio, plus the cost of the phone call (100 CFA[10] per minute) to have access to the FB platform via mobile phone. The alternative would be to travel to the radio station to leave the message personally. The travel to reach the radio station would cost him (the sender, in casu herder) on average 4000 CFA.

This idea for this business model is that customers (senders) who do not have a phone, can use the mobile phone of the village reporter to send their announcement they want to broadcast to the radio station. The village reporter gets paid a percentage of the broadcast per delivered message. Note that the 'delivered message' transfer points *towards* the sender, as delivery of the message is of value to the sender. In case a business process diagram (so not an e^3*value* value model) would be presented, the message itself would flow into the direction of the village reporter and local radio station.

Additionally, the village reporter pays a fee to the local radio station per delivered message, and (denoted by #1) pays a fee to the mobile operator (Telco) for delivering a telephone call. Because senders have to pay more to the village reporter than the reporter has to pay to local radio station and telco per message, the village reporter has a small profit per delivered message.

The local radio station broadcasts each message to its receivers. The explosion element (denoted by #2) indicates that one message received is broadcast to many receivers. Also, the local radio station needs to have Internet access in order to obtain voice messages from the voice service platform (see below). Therefore, the local radio station pays a fee to an access provider for having Internet access.

Foroba Blon acts as a service platform provider for handling voice messages. To this end, the local radio station pays a monthly fee to Foroba Blon. Foroba Blon needs to host its platform and needs IP transit (Internet connectivity and connection to the phone network). Such hosting is outsourced to the hosting provider for which Foroba Blon pays a fee.

Implications for ICT requirements

The village reporter-based business model was designed and built following an existing practice and workflow at Radio Sikidolo, which came up with the initial

[10] CFA is the currency in Mali, 655 CFA equals 1 EUR

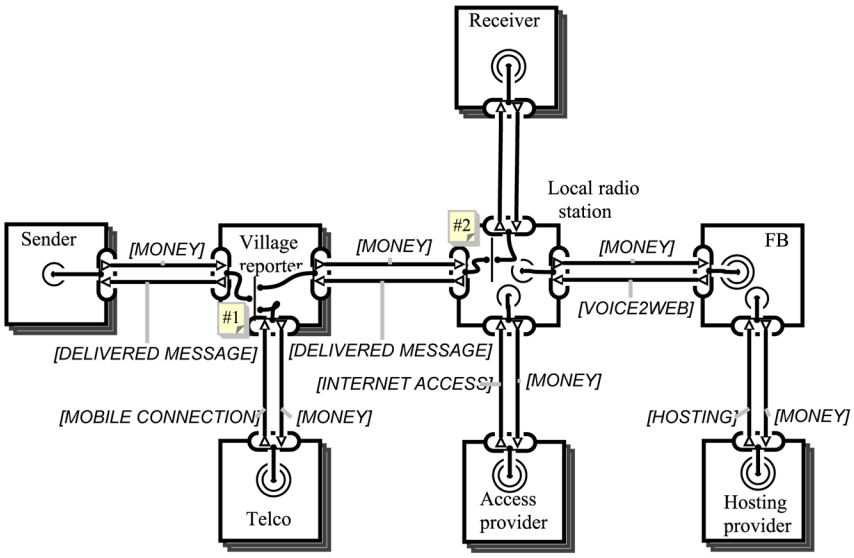

Fig. 6. The village reporter as a middle man between news senders and the radio station.

idea. The first cycle deployment was done and radio journalist Adama Tessougué tested the system with a number of village reporters. He was pleased with the system and came up with some technical adjustments and new requirements, which affect the technical design and the business model:

- A notification message must be sent as an sms to the radio, once a new message has been issued. Since Radio Sikidolo had no Internet at the time of first deployment (2012) so he had to phone in to the Foroba Blon system. When testing the system, the radio spent several phone-calls to access the Foroba Blon system, while no messages had been issued. Since the cost of a phone call in Mali are relatively expensive, this was an important cost-driven IT requirement.
- A mobile payment system, so that the broadcast service can be paid to the radio, was one of the requirements, to avoid cumbersome cash transactions between the radio and the village reporter. Moreover, paying in advance discourages people to phone in to the Foroba Blon service and leave fake messages. During the first cycle, mobile payment systems were not available for mobile operators in Mali (the main ones here are Orange and Malitel). In 2013 local mobile operator Orange launched Orange Money as mobile payment system in Mali [11]. Operator Malitel followed soon with an similar service. This facility is, however, not yet implrmented in Foroba Blon. An application programming interface provided by the local mobile operators

[11] http://www.orangemali.com/omoney/

(Orange, Malitel) allows further development of modules for mobile payment (based on mobile airtime).

4.2 The radio-based advertisement business model

The second value model for Foroba Blon has a different type of customer, e.g. a commercial business that want to advertise a product or service, an NGO, or governmental department that wants to send information to a broad audience, e.g. on health, agriculture, education etc). In fig. 7, in our model the customer is called the sender, as the customer wants to broadcast a message (e.g. an ad) to a large audience.

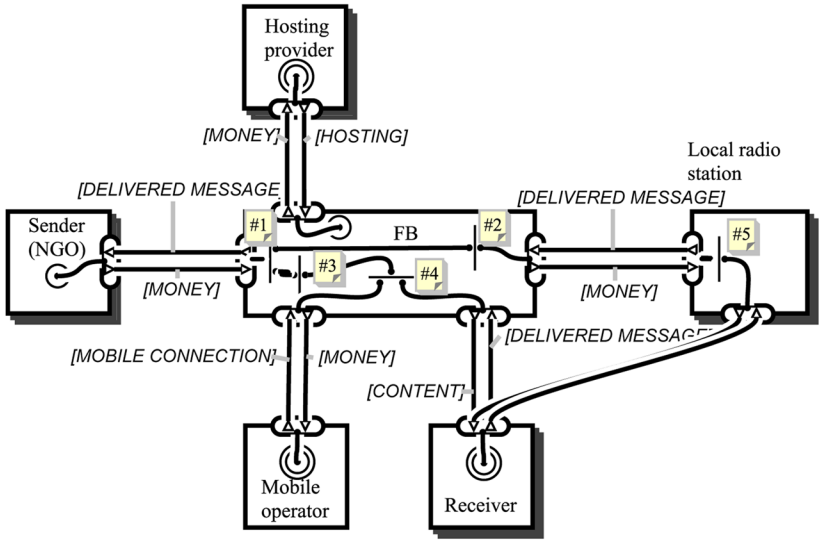

Fig. 7. The sender pays directly to Foroba Blon.

The sender obtains from Foroba Blon a delivered message and pays a fee in return. Note that in this model, Foroba Blon is the commercial entity the sender deals with it,in contrast to the village reporter-based business model where the radio station is the party the sender deals with. Then the AND fork annotated with #1 indicates that two things happen: (1) the message is broadcast via radio stations, and (2) the message is sent via mobile phones to receivers.

In case the message is sent via radio stations, the upper dependency path is followed (inside Foroba Blon). The explosion element marked #2 indicates that one message can be broadcast via multiple radio stations, thus reaching a larger audience. The local radio station delivers the message to its listeners (the receivers) and gets paid for that by Foroba Blon.

The message is also sent via mobile phone connections to subscribers. This is represented by the lower dependency path inside Foroba Blon. The explosion element marked as #3 shows that one message is sent to multiple receivers. The AND fork annotated with #4 indicates that for the delivery of a message to a receiver, there are value transfers necessary for the mobile connection (with a mobile operator) and for the message delivered to receiver.

The receiver provides the service of a *delivered* message to Foroba Blon (or the radio station). Similarly, Foroba Blon offers a delivered message to the sender. As message delivery is of value to the sender, the related transfer points towards the sender. It supposed that content of the message is of value somehow to the receiver. Consequently, there is a value transfer from Foroba Blon and the local radio station to the receiver representing the economic value of the content of a message.

Implications for technical/user (ICT) requirements Based on user feedback and evaluation of the models, the technical architecture is refined and re-adjusted. New requirements that came up after the business model was designed were as follows:

- Since the sender in this case has an Internet connection, a new requirement is a web interface where the sender can enter the message to be broadcast;
- A new requirement by the NGO was to add the possibility to stream the message to a number of phone recipients, in stead of sending it to radio for regional broadcast; with this addition, the message can be optionally sent to a limited number of recipients, if the sender wants to reach a limited number of known contacts (e.g. to invite 50 recipients for a meeting or event).

4.3 The citizen journalism-based business model

This business model supports citizen journalism in e.g. rural Mali. This model shows an information pull, in which local reports by village reporters and local citizen journalists are requested by the customer, which is e.g. a large media company (the news provider).

The news provider (e.g. Al Jazeera, CNN, ORTM, BBC, Wereld Omroep) needs news items (content) for their programs. Part of this content is obtained from regional reporters in the field. This is especially interesting regarding unstable political situation in northern Mali, where incidents may take place, reported by eye-witnesses and village reporters, or during presidential elections, e.g. in Ghana or Kenya, or during e.g. ebola-outbreaks in the country. News providers pay a fee per news item to Foroba Blon. The role of Foroba Blon is to obtain voice-based news messages from local radio stations. Local radio stations are paid a fee per delivered news item. In order to facilitate delivery of news items by local reporters via mobile phones, Foroba Blon has a contract with a mobile operator. The value model in Figure 8 shows that Foroba Blon pays per news item a mobile operator fee for a telephone connection. Note that Foroba Blon pays for the phone connection, not the reporter. In reality, this is implemented

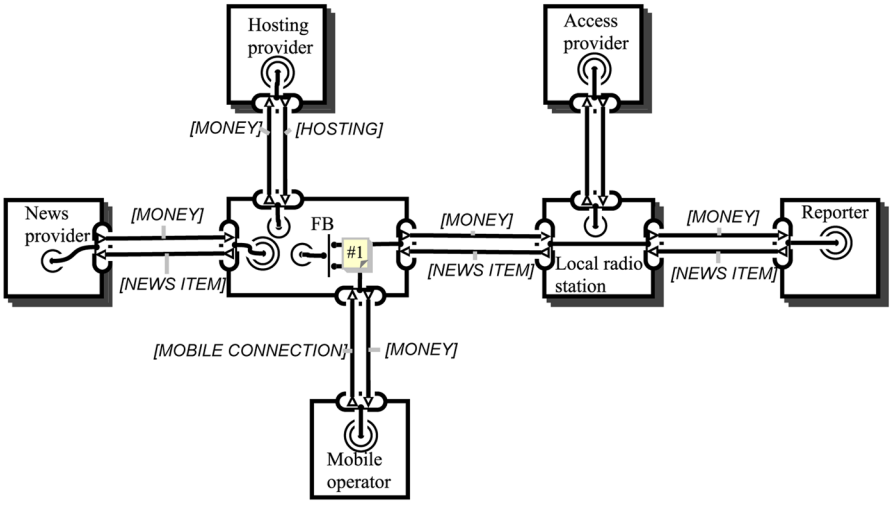

Fig. 8. The news provider pays for obtaining regional news items.

as a toll-free number that reporters can use for free, while Foroba Blon pays for this toll-free number.

Local radio stations in turn obtain news items from freelance reporters. In turn, these reporters are paid a fee per news item. The radio station also organizes and enriches each news item with some meta-data, such that it can be easily be accessed online by the customer.

Implications for ICT requirements The technical design of this business model is similar to Foroba Blon model 1, only the business case is different, because different values are transferred. The village reporter now sells his voice report to the news provider, in stead of buying broadcast airtime from the radio. This asks for the following additional technical requirements:

- A payment module should be built into the web interface of the customer, in which the radio and the individual reporters are remunerated for each relevant report they enter into the system;
- The radio station, who operates as the intermediary between the village reporter and the customer, has an Internet connection, to do the management of the content, and the payment to the village reporter;
- A toll-free number is provided by the telecom operator for the village reporter, who no longer pays for entering a message. He receives a payment for each spoken news item entered into Foroba Blon and accepted by the customer.

4.4 Discussion of the development process of the models

The first model we designed and built was based on an idea from the local radios. The service replaces an existing (legacy) work flow, which was an existing, cost-effective, legacy broadcasting service from the radio to the rural community. The customer and the radio station experience improved efficiency once the Foroba Blon service was operational. Radio journalist Adama Tessougué tested the Foroba Blon system with a number of village reporters in Konobougou and surrounding villages. The second and third value models are examples of new services that were adaptations of the initial service. Value models 2 and 3, described above, were non-existing previous to the Foroba Blon deployment. These models represent a local innovation — or rather a local reinvention — as a consequence of the introduction of an innovative technology in this local rural (constrained) environment.

In models 2 and 3 the village reporter (or farmer, or rural community member) is no longer the customer or sender in the value model, but a service provider or a targeted market segment. The farmers provide the listener's-base, for the customer (NGO, or advertiser, etc.) who wants to send information or advertisements. In models 2 and 3, the radio no longer pays for the Foroba Blon service, but receives the payment from the Foroba Blon provider to provide a service. The telecom provides the phone calls to and from the Foroba Blon platform and receives payment from Foroba Blon provider, so that reporters can use toll free numbers e.g. to enter information in model 3, or to receive or access information in Foroba Blon model 2. A service provider that wants to deploy the Foroba Blon mobile/web platform in Mali, will try to maximize the profitability of its services and deploy these three services simultaneously. However, numerous other types of voice-based radio services can be designed and deployed, once the Foroba Blon voice-based platform is up and running, and the technical obstacles have been solved.

5 Concluding Remarks

An important goal of the presented approach is to get to e-services through local value webs that are economically sustainable, also under highly resource-constrained conditions such as in sub-Saharan Africa.

Consequently, a sign of success (and an external validation) is where other parties (such as commercial entities) consider the e-service as useful and viable. The key user of the service, Radio Sikidolo in Konobougou, Mali, has used the Foroba Blon system with 50 village reporters, to make radio programs and broadcast reports from neighboring villages. Moreover, the Foroba Blon e-service was used by Al Jazeera for monitoring the presidential elections in Ghana (2012) and Kenya (2013). The Foroba Blon service has won the News Innovation Contest 2011 from the International Press Institute [12].

[12] http://www.ipinewscontest.org/news/congratulations.html

The presented approach shows that it is possible to obtain important assess future sustainability in a structured and systematic way at an early stage. A key characteristic to be able to do so is the analysis of the *actor network as a whole*, and investigate different possible configurations and scenarios.

Acknowledgements

The research for this paper is part of W4RA, Web alliance for Regreening in Africa(http://w4ra.org). It was partially financed by the International Press Institute, by the EU through the FP7 programme and by the Vrije Universiteit Amsterdam. The present paper is a shortened and revised version of a book chapter to appear in Yuval Cohen and Shai Rozenes (Eds.): Strategic Alliances and Value Co-Creation in the Service Industry, IGI-Global, 2016. The authors thank Victor de Boer, Chris van Aart, Wendelien Tuyp, Amadou Tangara, Stéphane Boyera, Mary Allen, Nana Baah Gyan, Adama Tessougué, Max Froumentin, Aman Grewal, Radio Sikidolo in Konobougou, Radio ORTM Ségou, Radio Seno in Bankass and Radio Moutian in Tominian, SBC4D and 2CoolMonkeys BV for their great contribution to this research project.

References

Aker, J. C. (2008). Does digital divide or provide? the impact of cell phones on grain markets in niger. *Center for Global Development Working Paper*, *154*.

Bon, A., De Boer, V., De Leenheer, P., Van Aart, C., Gyan, N. B., Akkermans, H., et al. (2012). The web of radios-introducing african community radio as an interface to the web of data. In *The semantic web: Eswc 2012 satellite events* (pp. 219–232). Springer.

Bon, A., de Boer, V., Gyan, N. B., van Aart, C., et al. (2013). Use case and requirements analysis in a remote rural context in mali. In *Requirements engineering: Foundation for software quality* (pp. 331–346). Springer.

de Boer, V., De Leenheer, P., Bon, A., et al. (2012). Radiomarché: Distributed voice-and web-interfaced market information systems under rural conditions. In *Advanced information systems engineering* (pp. 518–532).

de Boer, V., Gyan, N. B., Bon, A., Tuyp, W., van Aart, C., & Akkermans, H. (2015). A dialogue with linked data: Voice-based access to market data in the sahel. *Semantic Web*, *6*(1), 23–33.

De Bruijn, M., Nyamnjoh, F. B., & Brinkman, I. (2009). *Mobile phones: The new talking drums of everyday africa.* African Books Collective.

Gordijn, J., & Akkermans, H. (2001). E3-value: Design and evaluation of e-business models. *IEEE Intelligent Systems*, *16*(4), 11-17.

Gordijn, J., & Akkermans, H. (2003). Value based requirements engineering: Exploring innovative e-commerce idea. *Requirements Engineering Journal*, *8*(2), 114-134.

Gyan, N. B. (2016). *The web, speech technologies and rural development in west africa, an ict4d approach*.

Gyan, N. B., de Boer, V., Bon, A., van Aart, C., Akkermans, H., Boyera, S., ... Allen, M. (2013). Voice-based web access in rural africa. In *Proceedings of the 5th annual acm web science conference* (pp. 122–131).

Normann, R., & Ramírez, R. (1994). *Designing interactive strategy - from value chain to value constellation*. Chichester, UK: John Wiley & Sons Inc.

Osterwalder, A., & Pigneur, Y. (2013). *Business model generation: a handbook for visionaries, game changers, and challengers*. John Wiley & Sons.