Development of a logistics brokering system for South Africa's displaced rural residents

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Abstract— **A key challenge in rural environments is to overcome constraints such as high transport cost, irregular or unpredictable transport services, transport of low passenger and freight volumes, low logistics service demand and supply, limited local skills availability and isolation from or limitations to accessing the information society or knowledge networks. The use of ICT and relevant service systems holds the potential to overcome such constraints, and could improve the general accessibility of rural households and enterprises (e.g. to services, peers and markets). During 2008/9 the Council for Scientific and Industrial Research's (CSIR) Built Environment unit initiated a research project to develop and test a logistics brokering system that could overcome rural transport challenges facing local residents. The system, using a session oriented service known as Unstructured Supplementary Services Data (USSD), provided a mechanism to capture demand for transport which could then be organised and be matched with the supply of transport (the local transport providers).**

The project utilised a living labs approach to overcome sustainability challenges normally associated with systems in rural areas. A service system framework was applied to develop the system: It distinguishes that different aspects need attention in the design of a new (service) system which includes a service concept, an organizational network and a technical architecture.

The paper expands on both the living lab approach; the service system framework used to develop the logistics brokering demonstrator, and lists factors that affected the outcome of the system development.

Index Terms—**Displaced rural, Information and communication technology, Logistics brokering, Mobile phones.**

I. INTRODUCTION – DISPLACED RURAL AREAS IN SOUTH AFRICA

Rural areas in South Africa, especially those defined as deep rural often experience the following realities: Literacy is low, especially among woman and female participation in the public sphere is limited. Settlements are scattered spatially and for many residents quality health care, agriculture information, and formal education are out of reach or expensive to access (high transport costs). Distances to services and facilities are long and often roads are poor and severely affected during rainy seasons. Transport services are infrequent in places which further constrains the accessibility of local residents: these conditions severely limit the ability of residents to access basic services, social infrastructure and support, attain higher education, or have regular social interaction (social networks) to name a few. Another issue to note is that South Africa is still a 'society in transition' – where it is not only a matter of economic development but also about social change [1]. Designing solutions in an African way might therefore differ from indigenous tradition and might not be similar to the western world approaches as well, but what is similar is that both need to be 'community driven'.
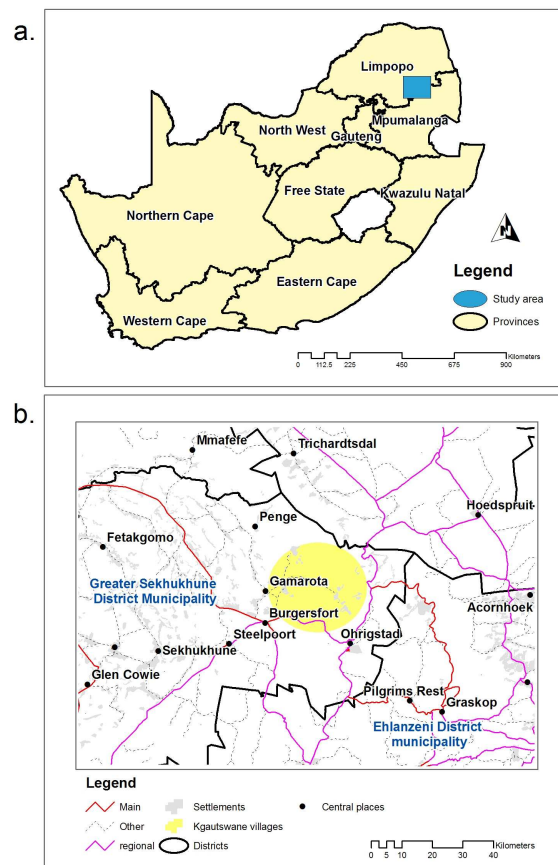

Fig. 1: Location of study area within South Africa.

One technology that holds much potential for reaching and servicing such rural communities is Information and Communication Technologies (ICTs). Although several related technologies comes to mind, two tend to dominate, namely mobile phones and the Internet. In the low-density, low travel volume context such as those found in displaced[1] rural areas; the provision of logistics services through a brokering service system is a possibility. Through the brokering service system the rural dwellers could be able to access information regarding available transport services, thereby making rural transport service delivery more predictable.

During 2008 the Council for Scientific and Industrial Research (CSIR)'s Built Environment unit undertook a project to develop such a logistics brokering demonstrator within the Sekhukhune district of the Limpopo province, a province with a high number of displaced rural settlements (Fig. 1a). The Kgautswane area (Fig. 1b) within this district was selected due to an already well established working relationship with some key local stakeholders. The area also suffers from accessibility constraints mentioned earlier.

The main objective of this project was to develop a (demonstrator) system that could overcome rural transport challenges facing local residents through providing a mechanism to capture demand for transport, which could then be organized and be matched with the supply of transport (taxi association). The focus of the system was on travel demand between the morning and afternoon peak periods.

II. APPROACHES AND RESEARCH DESIGN

To achieve the objective the design science paradigm was followed, which is used to conduct research in information systems and organizational settings. Design science strives to create innovative and valuable artifacts, whereby the researcher attempts to create things that serve human purpose, and the outputs are assessed against criteria of value or utility [2]. It is fundamentally a problem solving paradigm. It seeks to create innovations that define the ideas, practices, technical capabilities, and products through which the analysis, design, implementation, management, and use of information systems can be effectively and efficiently accomplished [3] – [4].

This paradigm is used to create and evaluate the brokering system (also referred to here as the artifact) in facilitating and improving (value) logistics service delivery in rural areas. To obtain knowledge on the logistics situation in rural areas, action research was applied to study the general characteristics of the rural service delivery environment using case studies. Since the goal of the work is to facilitate and improve the

development of logistics brokering services, various research instruments were employed. Exploratory case studies was used in the initial phase to get a better understanding of the main issues to be considered in developing logistics brokering services. Design science guidelines were used to design the brokering system that fulfils the user requirements identified, and to determine the real business issues (problem relevance) to be solved by the system. During the Kgautswane study, interviews, questionnaires, and observations were used to obtain both qualitative and quantitative data from the stakeholders. It is however not only design science which are important when developing information systems, behavioural science also plays an important role as it deals with the human element. It seeks to explain or predict human phenomena surrounding the design, implementation and use of information systems [5]. Both paradigms are needed to inform researchers and developers of the interactions among people, technology and organisations to be managed if the information system is to achieve its planned/intended purpose.

According to Lee [6] technology and behaviour are inseparable. Fortunately according to Smrča [7] design has become more human due to more human-centred design approaches. Thanks to this human centeredness, applications are easier to use and better suited to their purpose. Field studies enables behavioural scientists to understand organisational phenomena, as does the construction of artifacts enable design scientists to better understand the problem to be addressed. It is also in this context that a living lab approach is favoured – it is system development within *real* settings.

A. Living Labs Approach

The logistics brokering project utilises a living labs approach - rural living labs are user-centric, real-life research and development contexts, involving people, businesses and public players in the co-creation of services enhancing rural development. It also seeks to overcome sustainability challenges normally associated with systems in rural areas. According to Mulder [1] the main advantage of a Living Lab approach over more traditional user-centric methodologies, is its multi-contextual sphere in which the co-creation if ICT product and service development takes place. It is also about research and technology development institutions setting up long-term relationships with the inhabitants of the real-world context in a way that will ensure active participation by the latter in the research and development (R&D) process [8]. The ability to interact with the users is what differentiates the Living Lab Approach from other cross disciplinary approaches. Living Lab research is viewed as the place where both fundamental research and pure applied research meet, it embraces use inspired innovation research (See Fig. 2).

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[1] Displaced rural areas are associated with South Africa's past political reality where high density communities developed often long distances from towns and service centers.
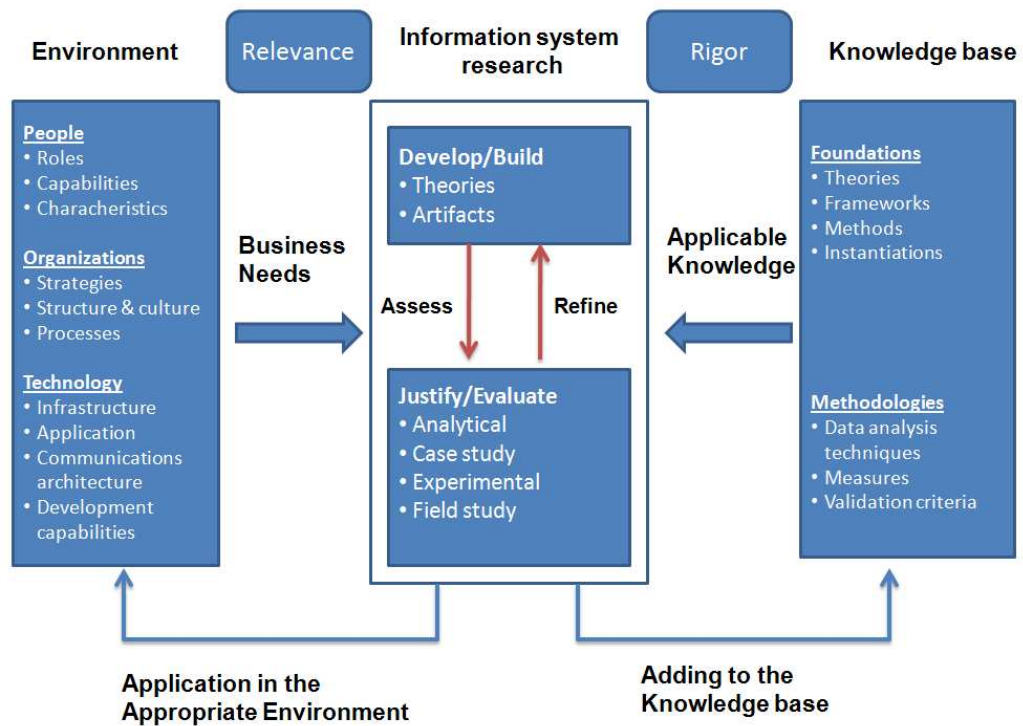
Fig. 2: Information system research framework [5]

The objective of such approaches is also to establish affordable and sustainable applications and services that can contribute to social inclusion, local economic development and ICT innovation. A further advantage is that users that are part of the Living Lab community are more committed to experimentation, open for change and innovation [9]. Fig. 2 presents the Henver, March, Park, and Ram conceptual framework for understanding, executing, and evaluating Information Systems research that combines both design-science and behavioral-science paradigms [5]. The environment defines the area where the problem or need site [10]. The environment it is made up of people, organizations, and their existing (or planned) technologies [11]. In it are the goals, tasks, problems, and opportunities that define business needs as they are viewed by people within the environment. Business needs are assessed and evaluated within the context of organizational strategies, structure, culture, and existing business processes. They are positioned relative to existing technology infrastructure, applications, communication architectures, and development capabilities. These define the problem (need) as perceived by the researcher. Formulating research activities to address the perceived problems/needs then assures relevant research.

The knowledge base is composed of foundations and methodologies. Prior IS research and results from reference disciplines provide foundational theories, frameworks, models, methods, and instantiations used in the develop/build phase of a research study. Methodologies provide guidelines used in the justify/evaluate phase. Rigor is achieved by appropriately applying existing foundations and methodologies. This is also the area where new methodologies are developed and where knowledge is generated. The contributions of behavioral science and design science in IS research are assessed as they are applied to the problem in an appropriate environment and as they add to the content of the knowledge base for further research and practice. Design-science research addresses important unsolved problems in unique or innovative ways or solves problems in more effective or efficient ways. The key differentiator between routine design and design research is the clear identification of a contribution to the knowledge base of foundations and methodologies.

According to Markus, Majchrzak, and Gasser, L [12] existing knowledge is used where appropriate; however, often the requisite knowledge is nonexistent.

For design science to be effective, it needs to suitably address the following (design) problems:

- requirements and constraints that are ill-defined due to incomplete understanding of the environmental contexts
- complex interactions between sub-components of the problem and its solution
- inherent flexibility to change design processes as well as design artifacts (i.e., malleable processes and artifacts)
- a critical dependence upon human cognitive abilities (e.g., creativity) and social abilities (e.g., teamwork) to produce effective solutions

Technology has influenced the nature of work over decades; with the advent of new ICTs the ways of working is influenced. For example; villages previously unconnected to the telecommunications grid now have cell phone access. As technology becomes easier to use, more affordable and widespread, new sustainable development solutions become a reality [13].

Technology is not the real challenge according to Fourie [14]: The human factor remains the greatest barrier to development and the major reason for project failures. ICTs need to be available, affordable and accessible to the rural poor. ICTs can assist by helping the rural poor in their daily life, by giving them a voice and by increasing their empowerment – but this needs to be carefully planned, implemented and managed. Some systems, especially large information systems are developed in a top down manner (also known as the waterfall model). Working out user requirements is the most difficult as these do not take the users into account, which results later in more disruptions or rework [15]. A systems development project in a research environment is ambiguous in the beginning to allow creative solutions to evolve. Often (and in the case of this project) several potential solutions are considered, and only the most suitable prototyped.

B. Service system approach

It is not the development of systems that is a concern, rather the sustainability of service systems. Past experience has indicated that systems often fail due to incomplete design – or simply not taking local realities into account. Some research is also needed in terms of design, development and the management of service systems. This project therefore looked at approaches that could be applied to ensure appropriateness of systems. Beyond the system is also the need to manage and monitor it. To start of it is important to understand the term "service system". Van Der Kar and Verbraeck [16] reviewed several definitions: According to Kotler [17] it is 'any activity or benefit that one party can offer to another that is essentially intangible and does not result in the ownership of anything'. Grőnroos [18] defines it as 'activities of more or less intangible nature that normally, but not necessarily take place in interactions between the customer and systems of service provider, which are provided as solutions to customer problems. In this project, services are also viewed from a more systems engineering perspective – largely due to the relationship with the University of Delft's Systems Engineering group (Faculty of Technology, Policy and Management). Due to the convergence in the service industry it is becoming more challenging to design effective service systems. The design object (the service system – Fig. 3) is a combination of the service concept itself, the organisational structure, and the information technology architecture [16]. Focusing on only one of these is ineffective and the boundaries between these are also not clear (yet mutually interdependent).
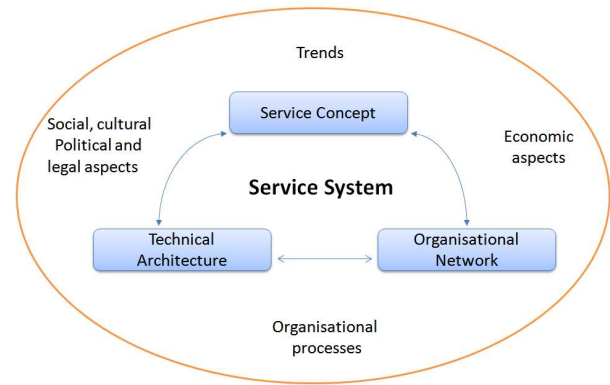

Fig. 3: Elements of the service system [16]

The service system framework (as described by Van Der Kar and Verbraeck [16] was applied to develop the system (see Fig. 3). A service system distinguishes that different aspects need attention in the design of a new (service) system where trade-offs are made between the service system elements. Firstly, a service concept is needed – this determines the strategy used to create value for the users. Secondly, an organizational network must be in place (or established) that supports the service. Thirdly when looking at services supported by ICT, a technical architecture should be provided. The organisational network and technical architecture are determinants of the actual service delivery.

It is also important to note that the system operates within a wider environment that is dominated by issues such as local politics, operational issues and ethical considerations. These need to be taken into account in the design of the system. This became especially evident during the initial interactions within Kgautswane: the extent of such 'environmental issues' had to be limited – boundaries had to be set for the system in order to proceed with its development. Where possible the current organisational networks were used in the design of the system.

C. ICT-based system and the role of the human service broker

From research conducted during the preceding two years and contributions from the work of Muniafu [19], it was clear that automated systems would be less likely to work from the start – rural areas such as Kgautswane relies more on personal relations and relationships. Locals are sceptical of new 'solutions'. In addition, the C@R project also made use of a local human service broker known as the Infopreneur[2]. People in such areas prefer to work with people that are familiar to them. Also the type of application/system can be complicated and the use of a

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[2] Infopreneurs are self employed social entrepreneurs utilizing ICT to enhance the range of services thy offer and are the basic enablers and delivery channels for integrating services in under-serviced communities in sustainable commercial manner.

broker would add an element of flexibility to the system.

In order to develop a system the user related needs had to be captured – the interaction with users (of public transport) provided a good indication of the extent of the 'problem'. For any system development it is important to be sure of what problem is being addressed. Top-down approaches will simply not work in an environment where users ultimately decide on using or not using the system. The users must be convinced that it contributes or improves the current situation. For services to be accepted they have to reflect the local user needs [19].

To extract this information, engagement with different groups were necessary, particularly the residents and the local taxi association. The system also had to consider other requirements such as:

- The service should contribute to the business of the current suppliers and not contain costs which are a burden on any other party. It had to operate sustainably.
- The system should contribute services that meet local needs and relate to the current way rural logistics operates.
- Support in the long term has to be transferred to the broker.

It is clear that when undertaking such an exercise the outcome is always uncertain especially when working in a multifaceted human realm.

III. DEVELOPING THE KGAUTSWANE LOGISTICS BROKERING SYSTEM

In this section the design and development of a logistics brokering system is discussed. It is a system designed in a rural context as a real world system and derived from the inputs sourced from within this rural living lab. Its design is based on the service system framework (discussed earlier). Firstly, the context is elaborated followed by the requirements, the design and the system.

A. The importance of context

The key conclusions from the field survey process were that using a logistics brokering system would provide opportunities to improve the overall logistics situation. From the initial investigations it became clear that such a service would require an easy to use and manage system that would not require too much input from users or processing by the broker. The system would, facilitated by the service broker, fulfil the logistical needs of the rural areas it serves. Although some value was drawn from literature it became evident that local realities were specific and would play a commanding part in the system. Previous research undertaken as part of the Collaboration at Rural (C@R) project indicated the extent of technologies available in the Kgautswane region. Communication relies on mobile phones, which is widely used in the region. Bandwidth is low which places constraints on the amount of information that can be

accessed over this infrastructure. The Infopreneurs, based at the Kgautswane Thusong Centre[3], have access to personal computers, mobile modems, printers etc typical of a local ICT enterprise.

A challenge faced in coordinating rural logistics service processes, as observed through the surveys and interactions with several local groups, relates to the identification of local travellers wanting transport and ensuring that such demands could be managed to form viable local trips (for the service providers, namely the taxi association). The nature of the formal transport service providers is known but the extent of demand during the day (the focus of the system) was unknown. The challenge was therefore to setting up a system that could obtain/source such demand and cost-effectively schedule the transport of people from with Kgautswane's geographically dispersed settlements.

The challenge therefore was how the service broker could best provide logistics services using an ICT-based intervention to enable the consolidation and synchronization of service demand and supply (initially pertaining only to passenger transport). It is hoped that such a system would reduce the operational inefficiencies and time costs for passenger transport during the day, whilst being a financially viable services. Muniafu in an earlier work detailed the typical (South African) rural logistics technology challenges as represented in Fig. 4.
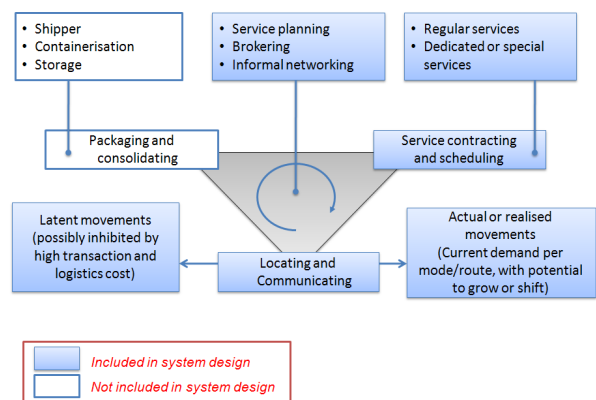

Fig. 4: Triad of rural logistics technology challenges [20]

From engaging the local stakeholders, information was obtained and used to identify the functionality for the initial system. The key elements that would be addressed by the system would be location and communication, service contracting and scheduling, and linked components. Again it is important to note that a thorough understanding of the context is needed. Similar to the research by Muniafu [19] in this project there is a need to

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[3] Community centers aimed at bringing the services of government, closer to outlying areas where people live.

facilitate the service brokers in: determining the demand for logistics services in a given area; determining the logistics service supply situation (dependant on Taxi association); matching the demand with supply opportunities (or rather generating supply opportunities) and communicating this with the logistics suppliers. All of these have to be incorporated in the design of the logistics brokering system to meet the logistics challenges faced in the region (for passenger transport). Although rural logistics also involves freight, it was decided to initially focus on the passenger transport as it appeared to be a more pressing need in the region. It was however anticipated that the system be expanded later to include freight logistics elements.

B. Eliciting user requirements

The main challenge in the design of any new service is the process to obtain the user requirements. Den Hengst, Van Der Kar, and Appleman [21] state that the people involved in the process be carefully chosen to ensure that the most objective requirements emerge. Group sessions are also good for such a process. The suggestion is that the participants be carefully chosen to avoid biased or one-sided inputs. In literature it is suggested that Group Support Systems (GSS) be used as it contains several tools that can assist in structuring activities, generating ideas etc. This according to the experiences in Kgautswane is not so easy to achieve.

Often the participants are illiterate, which makes the use of some tools impossible. Then there is the cultural makeup of the area. Often people would indicate positiveness in the hopes of getting 'something' out of it. They perceive such research as leading to something good and are not as objective, honest or critical as would normally be the case (or the case in other settings). Honest and open discussions are often not possible at the first discussion and this therefore requires some relationship building and the creation of trust. This process is made harder by strangers entering such environments and creating expectations which often does not materialise or lead to anything. Strangers are then viewed with some mistrust. A further challenge in the region is that of language – English is not the preferred language and results in long meetings where translation is required. Translation in itself can distort the intent of the original message. In the case of Kgautswane the presence of local Infopreneurs made this easier as they also understood the intended system objectives.

The Kgautswane requirements was sourced using more basic activities which included; stakeholder interactions (such as the taxi association), surveys conducted with the use of locally trained research assistants and inputs from the Infopreneurs. The requirements elicitation process depended on the Infopreneurs and the Thusong centre manager for arranging meetings, group sessions and surveys. Such reliance can both be positive and negative: Negative in the sense that the process could be biased

through selection of participants that would favour such a system; positive in the sense that if not for their assistance the process could be extremely difficult to arrange or would receive no support from locals.

The main actors in the region identified for user requirement elicitation were:

- The rural transport providers
- The Infopreneurs (future logistics brokers)
- The Thusong centre manager
- Groups such as representative from the youth, aged, support groups etc.
- Individuals such as farmers in the area

The groups were not always strictly selected, at the time they were also suggested. The process used in the group sessions (held in the Thusong facility) was in the form of group meetings. The meeting themselves had structure and followed planned activities. Only posters and flip-charts were used in the discussions and no 'complicated' group support systems were used. Issues were recorded and provided insight and input into the development of the system.

C. System development and contextual challenges

One of the crucial issues when dealing with the development of, or introduction of an ICT system is that it should be able to make a real contribution or value. From investigations in the region the predictability of transport demand, especially during the off-peak hours, are problematic. Transport suppliers do not know the nature of off-peak demand which also creates the value offering of the system: providing and matching demand for public transport within-and out of Kgautswane after the morning and prior to the afternoon peak period. It must also be emphasised that transport services within Kgautswane are also influenced by other environmental factors such as the condition of the gravel roads. All roads in Kgautswane are gravel and some are in poor condition, thus at times resulting in a reluctance of service providers to undertake trips. They prefer not taking trips that might result in low ridership. The demography of the region also adds to the difficulty experienced by transport users: long distances from the main road (to some villages), villages dispersed within Kgautswane. The intention of the transport brokering system was as a centralised information booking, scheduling and coordination service for public transport users. The system would 'fit into' existing services and not impede or cater for the peak transport periods. The system (and service) will be delivered from a central office such as the Thusong centre. The system should be accessible via a mobile phone and should also be managed /accessed remotely. Although a system such as this holds much potential in future and could affect transport services in the region, the key challenge was its development and the buy-in/ support from the local taxi association. The Thusong centre is appropriate as the 'home' of the service and although the region experiences problems such as bandwidth constrains, periodic

unreliable infrastructure, etc. the centre is well equipped with ICT systems and can provide such a transport brokering service (along with other services currently already provided by the Infopreneurs). The service itself does not have to be hosted in the rural environment, as it is not influenced by the same constraints as the rural area in question. The system should aim to achieve the coordination of (new) trips and the provision of information through the ICT-enabled service to customers.

Developing such a logistics brokering system would inevitably also lead to raising expectations with stakeholders. The technological environment was also limited with few people having access to personal computers and the Internet. The only viable technology that could be considered at the time (as communication medium) was mobile phones. The use of mobile phones is widespread in the Kgautswane villages but is however predominantly entry level phones, which excluded the use of more modern mobile phone technologies

A further constraint was costs – whatever system would be used had to be affordable to the user whilst be sustainable in the long term. This was also done to make the research more manageable. The brokering system as initially envisaged also depended on the services of a (human) broker – the local Infopreneur who would play a vital role in the execution of brokered transport services.

D. Designing with the service system framework

After initial sessions with a number of stakeholders and after the data collection phase where surveys were administered within Kgautswane several issues became clear as mentioned they include the following:

- Peak travel times are catered for by taxi and bus services, during this period there is also no spare capacity left for taxis to perform other services.
- There remains unsatisfied demand during the day between peak periods where users often sit without taxis providing a service.
- A system should focus on capturing and brokering a service in this intermediate period.
- Bakkies[4] would not feature in a passenger freight system (not a legal acknowledged form of public transport)
- Support from the taxi association is essential for such a system

The service system was therefore also aimed at leveraging ICT to mitigate some of the mismatch between supply and demand experienced in Kgautswane resulting in; trips with low numbers of passengers, lack of information on public transport trips occurring. The intended logistics brokering system had to be simple to use, affordable, and based (largely) on existing ways of doing things, it had to solve a real problem and create a type of leverage or dependence (Example: if you use the

system the service will be delivered on time). This was quite a challenge taking into consideration the informal nature of such transport transactions currently. The anticipated service should provide the following services:

- Service that can capture logistics transport demand (mainly passenger transport)
- Service which can consolidate and cluster demand (i.e. combine to trips sought in the same period to have a more optimal trip)
- Supplying the brokered trip information to the service provider to deliver the service
- Service that provides information to users regarding trips provided.

E. The service concept and proposition

The following describes the system components and the roles played by the various stakeholders. The service concept as conceptualised was simple but relies on key relationships between the various stakeholders. The transport user is the main client and the need for transport originates here. Under normal circumstances the user would go to the road and wait for taxi transport, not knowing if such transport would be coming or not. Through the system the user would communicate his/her need for transport using a mobile phone (Fig. 5). The information would be accessed by the Infopreneur who would undertake the clustering and scheduling. The Infopreneur would see if a trip already exists at the time and with matching destinations to that of the user. Through the system the user can also see what if any trips have been scheduled. This would provide an opportunity for the user to join a trip. The trips once scheduled and fixed, are passed on to the service provider who would then be responsible to deliver the service (trip).

To make the system work there needs to be trust relationships – between the transport user and the service provider (taxi association): The user wants to be sure that if they use the system and book a trip that the taxi would in fact be there and on time. The service provider also needs to have trust that if they undertake a trip, the users who booked would be there. Without such trust relationships the system would not work. The Infopreneur or broker in this context simply plays a coordination role – he also has to undertake to do his part namely, to process the requests and forward the booked trip information to the service provider. As the use of the infrastructure has a cost attached, it is also important to note that users will pay for it

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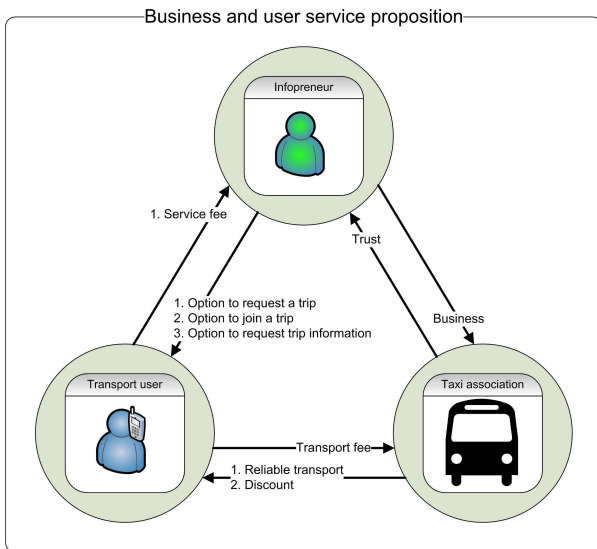[4] Vehicles better known elsewhere as small pick-up trucks.

Fig. 5: The business and user service proposition.

The booking system cycle - Fig. 6 indicates the current cycle for the system starting with the requests for trips and ending at the trip being undertaken as booked. As brokering cannot be done in a very short time period it was necessary to deal with brokering transport in a longer time period. Essentially there needs to be time allowed for making requests. Request cannot be made for trips in the same week, but only for trips in the following week. The week leading up to Friday provides the opportunity for users to put in their request for transport into the system, the system collects and stores these requests until the Friday when the Infopreneur then processes the requests and schedules the trips. The trips are finalised and information sent to the users via Short Message Service (SMS) confirming and providing them with the necessary information regarding the trip. The trips information is given to the service provider who then through its own systems assigns the trips to the taxi that undertakes the trip.

The taxi driver is given a booking sheet containing the information on the trips; where pickups will be, and how many there will be from the location. When a trip is booked the requestor receives via SMS a number (ID-code) which is given to the driver upon entering the taxi. This number is system generated and also on the list that the taxi drivers uses. The use of this number is to ensure that passengers that booked the trip is picked up and not confused with incidental passengers also waiting for transport. The booking cycle is therefore always a week, allowing users to plan ahead, book and providing the opportunity for information to be brokered and passed on to the service provider.
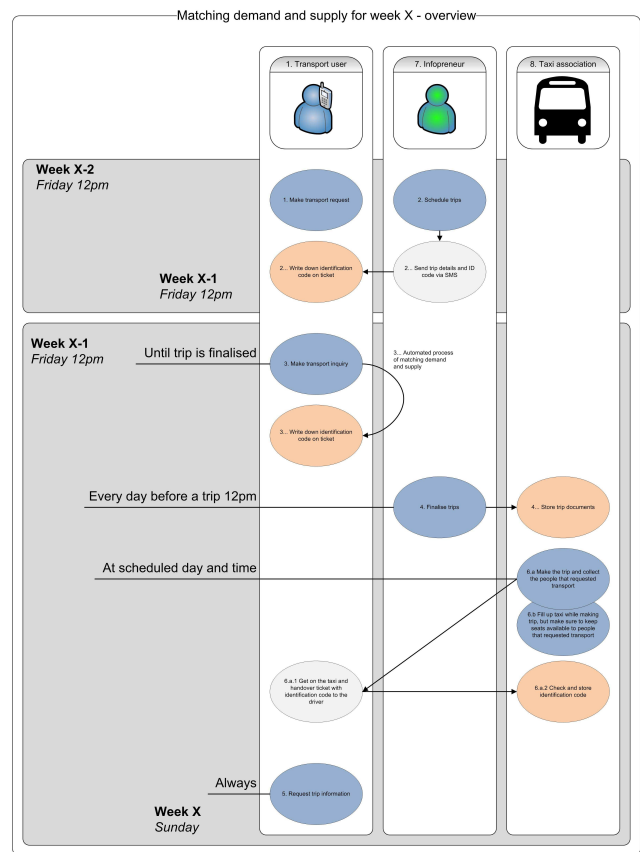

Fig. 6: The system booking and service cycle.

IV. TECHNICAL COMPONENTS AND DESIGN

A. Using Unstructured Supplementary Services Data (USSD)

After scoping visits to Kgautswane, it became apparent that mobile phones had to be the communication instrument (medium) for users. Although the Short Message Service (SMS) is a widely used data application in South Africa, it has cost implications and was not seen as an affordable system to use within the impoverished rural communities of Kgautswane. Several other communication options were considered including the use of human language technologies and Unstructured Supplementary Services Data (USSD). Eventually it was decided that USSD was suitable given the type of mobile phones used – it is also an established technology with several local service providers to support and assist in development. USSD allows for the transmission of information via a Global System for Mobile communications (GSM) network. In contrast to SMS, it offers real time connection during a session. USSD is a session oriented service, and can support a sequence of exchange of information [22]. USSD messages are simple to form and easy to send. User can directly enter the USSD string and press 'call' to send the message. In terms of costs it is also cheaper than SMS.

B. Technical design

Fig. 7 illustrates the components of the eventual system. A transport user wanting transport request this by dialling the USSD number on his mobile, the request is sent via the GSM network to the Service provider's menu server.

If data is requested (example: a transport inquiry – see Fig. 7) or data needs to be stored, this is done using the service provider's database. Finally this data is made available through an application that runs on the local personal computer of the Infopreneur and he makes contact with the service provider database using a General Packet Radio Service (GPRS) internet connection. The Infopreneur lists the transport requests that have been made in the week. Based on these transport requests the web application would then visualise these requests, facilitate the grouping of requests and the scheduling of trips. After finalising a trip the Infopreneur would hand over a trip document noting trip details such as route, passengers and arrival times, to the taxi association. The taxi association then arranges for a taxi to make that trip using their normal work procedures through the queue marshal[5].

C. Technical architecture

Here we briefly list at the elements that compose the technical architecture and functionality namely; the data layer, business logic layer and the presentation layer.

Data Layer - The part of the system that contains the information that is entered remotely also allowing for changes when updates are made or new information added to the database. The information stored in the database includes the structural options for the system namely the towns and settlements that can be selected as either origins or destinations. It also has rules such as the number of seats that can be booked for a trip. It records the details for each submission namely the mobile phone number, time, date and the origin and destination selected along with the relevant day and time period for the trip. The database layer is accessed via web services.

Business logic layer - This layer addresses the main part of determining the demand for service and creates a business process such as scheduled transport trips. The infrastructure used to communicate with the user is USSD which is provided by a local service provider, Truteq. The costs for using the system are recovered from the user directly. In this layer the brokering activity takes place with the use of a website with incorporated functionality to display requests and to process it until a confirmed trip is arranged. The communication between the user and the database takes place over the mobile phone network. The Infopreneur accesses the website with PC and linked modems.
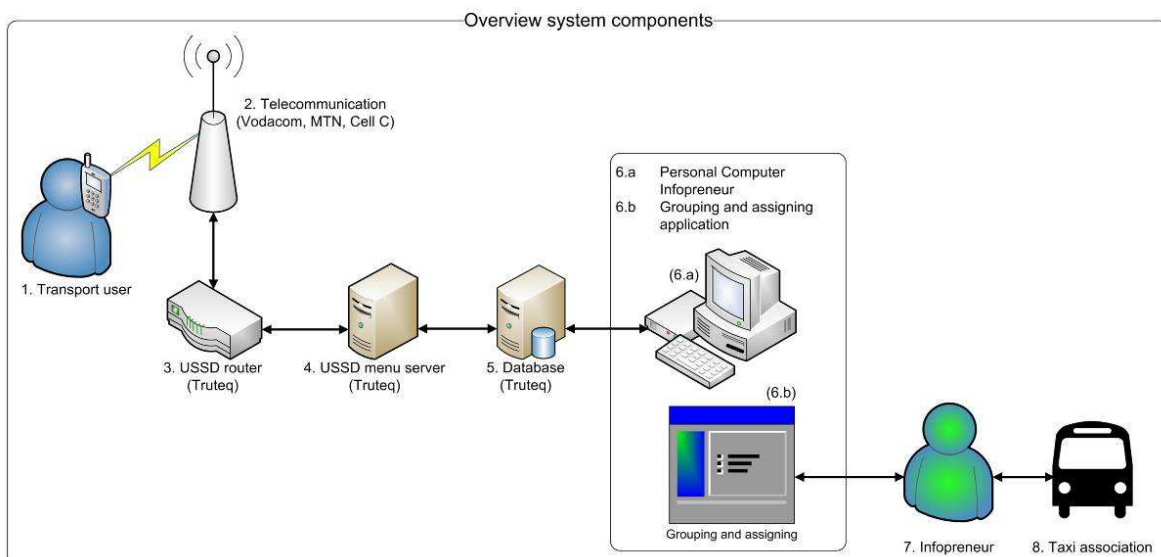

Fig. 7: Technical overview of the system and its components.

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[5] Person appointed at the taxi rank to assign a trip to a taxi driver

| Start. Menu |
| Welcome to the KTL transport service |
| 1. Request a trip (5 to 14 people; Dec 22 to 28) |
| 2. Join a trip (1 to 9 people; Tomorrow to Dec 21) |
| 3. Trip info (Today) |

| B.1 Menu |
| From where do you want transport? |
| 1. Paeng |
| 2. Sefateng |
| 3. Ga-Kwedi |
| 4. Masakeng |
| 5. Ga-Molai |
| 6. Makgongwane |
| 7. Maribaneng |
| 8. Moshate |
| 9. Makgwareng |

| B.2 Menu |
| Where do you want to go? |
| 1. Paeng |
| 2. Sefateng |
| 3. Ga-Kwedi |
| 4. Masakeng |
| 5. Ga-Molai |
| 6. Makgongwane |
| 7. Maribaneng |
| 8. Moshate |
| 9. Makgwareng |
| 10. Ohrigstad |
| 11. Burgersfort |

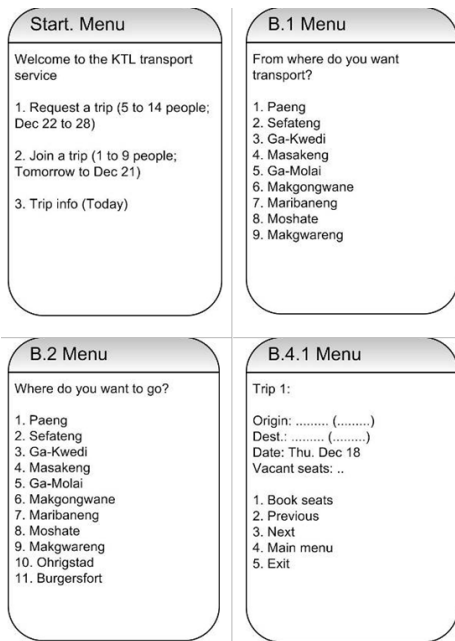| B.4.1 Menu |
| Trip 1: |
| Origin: .... (.........) |
| Dest.: .... (.........) |
| Date: Thu. Dec 18 |
| Vacant seats: .. |
| 1. Book seats |
| 2. Previous |
| 3. Next |
| 4. Main menu |
| 5. Exit |

Fig. 8: Examples of some USSD menu option screens.

Presentation layer - The interface layer contains two levels of interface: First the transport user interacts with the system through the USSB interface modified for the specific tasks. This is essentially custom text menus that appear on the mobile phone screen (Fig 8). This does not require the download of phone specific software in order to be read or accessed.

At the level of the broker (Infopreneur) the interface to the system takes place though a website. The website is simplistic and follows a sequence of steps necessary to broker requested trips. The broker accesses the system using GPRS modem connected to a PC. The broker can also handle trips manually should he/she be requested to enter a transport request.

D. Organisational network

This is a crucial part of the system: these are the actors involved in making the logistics brokering system viable. These include the following;

The Infopreneur - Is responsible for running the brokering service. He/she acts as the intermediary between the transport users and the logistics service providers (taxi association in this case). Without a person in this space the system will not work – there always has to be a person performing this processing function. This actor is also responsible to assist those who would want to use the system but do not have the know-how or the technology (device), thus requiring human support. This person ensures that the system works the right way and delivers the service as scheduled. This person needs to monitor the system, its use and records problems or deficiencies. The Infopreneur can receive a minor financial benefit from such a system – this is however not the objective. The Infopreneur should not incur costs to provide this service.

The transport user (customer) – Is the main beneficiary for the system. Responsible to request transport through the use of the system. In return they receive information on a booked transport service. These can include all residents in the Kgautswane area. They pay for the service whilst accessing it via mobile phone. The cost for the trip is paid separately by the user when doing the trip on the day in question.

The logistics service provider - This actor provides the requested service namely the transport. The local taxi association is this actor and is also key to making the system work. They need to assign the trips internally through their own structures. The trips must be undertaken on time and as scheduled. Information is also recorded on the usage of the system. This information can later be assessed and analysed by the developers to evaluate it usefulness etc.

The communications provider - Represents the actor that facilitates the communication between user, broker and service providers within this dispersed rural environment. This service is provided by the mobile phone operators in the region. The second player here is the service provider that provides the test based USSD infrastructure on the infrastructure of the mobile phone operator. They are responsible for keeping the network operational which allows communication between the other actors.

The application provider/developer - This role is performed by the CSIR BE with assistance from Softwave solutions. They are responsible for constructing the website, and the customised USSD menu system, which is used to offer users the service. They are also responsible for building the database which is used to record requests and assigning and finalising trips.

Whilst in development, the CSIR will be responsible for the maintenance and support.

V. CONCLUSION

The following outlines the main findings of this project; it also indicates the future activities related to its implementation. Firstly, the system was developed within the current transport reality and it does not place current operations at risk. The system operates in a wider environment that is dominated by issues such as local politics, operational issues and ethical considerations. These played an important part in the development process. The process therefore also utilises the existing institutional structures within the Kgautswane region as far as possible.

The analytical phase indicated that there is a definite

need for transport during the day, periods that are often not serviced as service providers are not aware of the transport demands across Kgautswane. The analysis and interactions with numerous stakeholders allowed the research team to come up with possible solutions also taking technology into account. Initially two technologies appeared to have much potential namely; Spoken Dialog System and Unstructured Supplementary Services Data. After reviewing both, it was decided that USSD was the most suitable technology.

Substantial effort was put into developing the system. Interactions with Truteq and Softwave led to the construction of a basic system that was accessible to users within Kgautswane. Currently the application has entered a test phase where users and service providers will be monitored and subsequently questioned to determine the viability and practicality of using such a system. There are still constraints that affect its use, including literacy (inability to use the menu system) and the fact that users need to change behaviour from planning to travel on the day, to behaviour that requires pre-planning and using a more scheduled services.

On the public transport service provider's (taxi operators) side there also needs to be a change in behaviour – from one where everyone along a road is picked up to one where preference is given to users that have booked a trip. On the system development side much have been learnt – especially on how to approach a system development project in an impoverished and constrained rural environment. Top down approaches will not work and users need to be part of the development process. During the next months the system needs to be implemented and tested. Changes will be made where necessary. Over the longer term the system also needs to be monitored as this is where the real impact can then be observed.

VI. ACKNOWLEDGMENT

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