Digital Inclusion: A Model for e-Infrastructure and e-Services in Developing Countries

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Abstract. A large portion of the South African population is still not connected in a productive manner to the Internet, despite the existence of a government plan for public broadband, 'SA Connect'. One reason for this could be the lack of an appropriate model, through which connectivity can be diffused in a meaningful way through all areas of South Africa. This paper presents the model developed over more than a decade of experimentation in real life settings in the Siyakhula Living Lab, a joint venture between the universities of Rhodes and Fort Hare, South Africa. The model proposes the 'Broadband Island' as basic e-infrastructure unit, which clusters nearby points-of-presence hosted in schools. In each Broadband Island is located an applications integration platform, TeleWeaver, which monetizes channels of access to the local community, to support the e-infrastructure while providing useful services to the population and the Government.

Keywords: e-Infrastructure · e-Services · e-Government · ICT4D
Networks · Teleweaver · Broadband island

1 Introduction

For citizens of the Global North, Information and Communication Technologies (ICTs) have diffused into almost every area of human life. On the back of the successful rollout of mobile and fixed broadband technologies such as LTE and optical fibre networks, urban cities are becoming virtual playgrounds for technologists to develop and deploy 'smart' applications that can enhance the lives of city dwellers. With calls on the increase for municipal, regional and national frameworks to be developed that can help realise the goals of evolving paradigms such as 'smart cities' and the 'Internet of Things' (IoT), this trend will only continue to expand and take on more diverse forms [1].

While most countries in the Global South possess nowhere near the same level of the proliferation of ICTs, many governments have nonetheless affirmed their commitment to drive the penetration of technology in their home countries. For instance, in

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2013 the Department of Communications in South Africa outlined its plan to launch an ambitious project under the code-name ‘South Africa Connect’ as part of its national broadband policy; the implementation of which was officially launched at the beginning of 2015, in the ‘State of the Nation’ address by the South Africa President [2]. The policy articulates the government’s aims to provide broadband access to 50% of the population by 2016, 90% by 2020 and 100% by 2030, with a universal average download speed of 100 Mbps by 2030 [3]. There are two key aspects of this policy that are important. Firstly, it prioritises the closing of the digital divide by ensuring that communities in marginalised areas are duly connected. Secondly, it emphasises the goal to create a strong skills base in the technology sector that can contribute to the production of content and applications, especially those that are contextually relevant. Initially, Telkom, the former telecommunications incumbent in South Africa, was named the lead implementer of SA Connect, hinting at a centralized point of control. No specific model was proposed, but implicitly the assumption was that each implementing entity would be connected directly to the Internet by the lead implementer. This model was not the most efficient, or viable, in rural and poor peri-urban areas, where the plan was supposed to bring the most significant changes. In fact, more than two years after the presidential announcement, very little progress had been made, and the government accepted that other models should be explored [4]. While the implementation is delayed, an abundant yet critical resource in many Africa countries, the youth, is getting wasted through learning in environments that are not conductive to prepare anybody for the transformation of the economy that is already underway.

A more efficient (and detailed) model has been under development for more than a decade in the Siyakhula Living Lab (SLL). SLL is a test site in the rural Eastern Cape province of South Africa where researchers and industry partners have been involved in setting up computing infrastructure since 2005 [5]. The site covers a geographic area of approximately 15,254 hectares and has approximately 15,000 people living in villages in the area. Computers and network infrastructure have been set up at 17 schools across the region, where thin-client computers are available for use by the community and Internet connectivity is provided through a WiMAX local loop with a very small aperture terminal (VSAT) backhaul [6]. An important inclusion to the SLL (which hearkens to the goals of ‘South Africa Connect’) that has serious implications for the overall sustainability of the infrastructure project is the development of highly contextualised, relevant software applications for the community. As such, a single consistent platform for use as a docking station for all applications, allowing developers to share common software resources and benefit from a standard service environment was developed. TeleWeaver is a service platform that is based on the Java 2 Enterprise Edition (J2EE) application server known as Wildfly [7] and works in conjunction with various other open source components that add value to the platform. The goal of the platform is to host various Java (and non-Java) applications and provide the underlying functionality needed for these applications to run reliably.

This paper describes the holistic model of Information Communication Technology for Development (ICT4D) implementation within the SLL focusing on e-infrastructure and e-services in an effort to bring marginalized communities of South Africa into the digital fold. The paper draws on and brings together a number of papers that give partial perspectives authored by us on the model and it is organised as follows: Sect. 1

provides the relevant literature required in order to understand the model implemented in the SLL, while Sect. 2 provides a description of the SLL initiative. Section 3 describes the e-infrastructure and Sect. 4 the e-services components of the model, with reasons for the design and implementation choices. Finally Sect. 6 concludes the paper.

2 The Siyakhula Living Lab

The SLL is a long term experiment in connecting the unconnected and its team has been conducting research into providing sustainable, off-the-shelf and appropriate computing infrastructure in rural communities in South Africa, locating the infrastructure in schools. The SLL is structured such that it is a quadruple helix partnership of academia, industry, government and the community. It was initiated in 2005 to conduct applied ICT4D postgraduate research work in the two departments of Computer Science at Rhodes University and the University of Fort Hare, through the support of the Telkom Centres of Excellence (CoEs) programme located in those departments. This work then expanded into the SLL project which is a multidisciplinary initiative which also incorporates researchers from Information Systems, Education, African Languages, Communication, Anthropology and Sociology. The SLL believes that ICTs in low income and marginalised areas (of which rural communities are an example) can facilitate:

- Poverty alleviation;
- Development of local economies;
- The achievement of basic standards of health, education, access to governmental services and other developmental infrastructure and services;
- The encouragement of people (though empowering them) to invest in themselves and their communities; and
- Cultural regeneration, including the development and integration of indigenous knowledge systems into a community's "ways of doing and learning".

In order to ground the research properly in the local context, the SLL employs the 'living lab methodology', that is "an approach that deals with user driven innovation of products and services that are introduced, tested and validated in real life environments" [8].

The SLL is located in several villages in the Mbhashe Municipality of the Eastern Cape province of South Africa (located within the former Transkei Homeland), adjacent to the Dwesa-Cwebe nature reserves. The natural environment of the area (the reserve and the unspoiled coastline) are assets for the community and have the potential to promote eco-tourism in the region. In addition, the rich soil and high levels of rainfall make the region lucrative for controlled agricultural intensification and commercial forestry [9]. However, despite these natural assets, the municipality and the region is plagued with remnants of the past. The former Transkei was classified as a Homeland within the South African borders during Apartheid and systematically denied infrastructure and development. As such the region, like many rural areas (and particularly former Homelands) in South Africa is characterised by a lack of electricity, telecommunication infrastructure, and poor road networks. Furthermore, service delivery in the area is poor and limited to basic education and health care. Seventeen local schools have been targeted in the SLL and house the computers and IT infrastructure of the SLL within their grounds. Facilities are available to teachers and learners during school operating hours and to the rest of the community after school, in order to support local education and rural life. For more about the SLL please see the following papers [6, 10, 11].

3 The Model: e-Infrastructure

3.1 The Network: The Broadband Island

The fundamental constraint that any e-infrastructure in rural and marginalized areas have to fulfill is efficiency. A second one is the ability, from the very beginning (i.e. from the moment in which the infrastructure is being deployed, not only after deployment), to activate grassroot activity in the target community. A third one is that it offers a path to digital activities to the youngest segment of the population, the most inclined to embrace innovation. A fourth one is that it is easy to maintain as well as expand. We will see that these constraints are fulfilled by the model developed in the SLL.

Communal infrastructure is inherently efficient, as many examples in a variety of sectors attest. Because of that, our model is built on community owned, shared e-infrastructure, accessible in appropriate communal spaces, at least for what we define 'large ICTs'. In this context, 'large ICTs' are ICT installations that provide user terminals that resemble personal computers and easily allow work related to digital content, especially the production of software or the administration of software and hardware systems. This contrasts with 'small ICTs', which are installations that only support access to user terminals such as mobile phones or hand-held tablets. Often, mobile phones and tablets are individual instruments, though the most important characteristic from the point of view of this discussion is that they are not easily used for development of real life software systems or the professional processing of digital content, at least in their current form. (Naturally, such instruments are easily integrated in the e-infrastructure we propose, via the co-location of WiFi hotspots with the 'large ICTs' installations.) One should note that while crucial for first deployment, the communal nature of the e-infrastructure we propose is transient: the very deployment of such e-infrastructure should put the target communities on a better economic trajectory and therefore move them organically to 'large ICTs' owned and used privately, like it has happened or is happening in other segments of society right now.

What would be appropriate, (relatively) open spaces that are easily reachable in most communities and do not need to be purpose-built (which would make them inefficient from an economic point of view)? The answer in rural and township areas is schools, certainly in South Africa. Reachability, which is crucial for actual use, is due to the schools number, more than one order of magnitude higher than the next possible location, the Post Office outlets for the public [12]. Schools have other important characteristics that make them a good choice for hosting communal e-infrastructure. First of all, they are a focus point in the community, because their educational core activity involves a large section of the community, directly and indirectly. Then, they are formally connected with the community through their School Boards. Finally, schools are places that directly expose e-infrastructure to the segment of society for which the benefits are expected to be the strongest and most obvious: the youth. Underexposure or, often, lack of exposure to ‘large ICTs’, prevents the youth to imagine themselves in and prepare in time for professions in the fast emerging digital economy. This is a critical problem at the moment in South Africa and has strong negative repercussions on the future of the economy of the country. Interestingly, the South African Department of Education saw the possibility (and importance, even in terms of sustainability) of opening ICT school infrastructure to the surrounding communities already in 2004, as can be seen in points 5.52–54 of the Draft White Paper on e-Education: “Government will support community access to e-schools. The objective will be to increase the opportunities for communities to use e-school resources, develop their computer and Internet skills, and take advantages of services offered through ICTs. In return the community will support the sustainability of ICTs in the e-schools” [13].

Having decided to host the infrastructure in schools, how should schools be connected? In our model, schools should be aggregated in clusters, with high speed connectivity among schools in the cluster and then one or, ideally, two paths from the cluster to the Internet. We call such a cluster a ‘Broadband Island’ as shown in Fig. 1 [14]. This respects the efficiency constraint set above and has other benefits. Firstly, it allows the deployment of general local services (such as an Internet cache or a Tele-Weaver server, as explained later) as single instances for the entire cluster. Secondly, it allows high-bandwidth streams with very little latency to be routed between schools in the cluster, supporting rich, high speed communication such as video communication for shared lecture or distributed community meetings. From a topological point of view, the Broadband Island uses the classical LAN/WAN distinction, with the LAN represented by the high speed connectivity among the schools in the cluster and the WAN the connection(s) to the Internet. A LAN/WAN topology originated historically from the difference in cost of local and wide area connections. While such a difference is fading in other context (making the ‘cloud’ more and more viable in the process), it remains strong in the context of interest here, marginalized areas. Again, as discussed about communal vs private availability of ‘large ICTs’, one has to expect that the difference in cost between LAN and WAN connections will reduce and then disappear in marginalized context too. At that point, the topology in the model will change and the Broadband Island might disappear.

The LAN part of the network, i.e. the Broadband Island, is implemented through fixed wireless links. Wireless is the obvious choice, given the total absence of telephone lines in large part of the poor rural areas of South Africa and its very sparse presence and low quality in poor peri-urban areas (‘townships’ in South African terminology). Fixed wireless is obvious too, because of the advantages of fixed over mobile wireless for the scenarios on hand. Operating with specified and non-mutable geometries, fixed wireless make possible to achieve higher speed at lower costs than mobile wireless. As reported in [14] the technology used in the SLL, is fixed WiMAX, which proved to be very good and inexpensive. A very important aspect of fixed WiMAX was the simplicity of basic deployment, very close to the simplicity of WiFi. The WiMAX hardware we happened to use required a licence for the frequency at which it was operating, so we need to associate with a small network operator, Unfortunately, the market did not support WiMAX, for a series of non-technical reasons that we will not discuss here, so the specific technology will not be viable in the future and had to be replaced in our model. Among the various possible candidates, a realistic choice at the time of writing this paper is outdoor WiFi, for which good, inexpensive hardware is available. An important advantage of WiFi compared to other possible fixed wireless technology is its simplicity, both technical and regulatory, which allows the network to be deployed by small, 'grassroot' organizations, as opposed to large network providers, as it would be the case with LTE, for example.

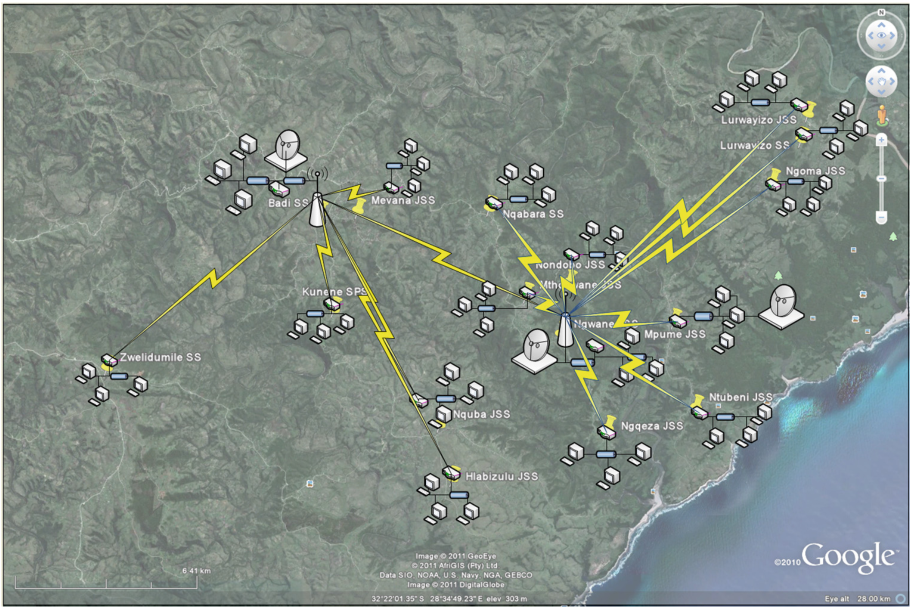

Fig. 1. The Siyakhula Living Lab Broadband Island [14]

3.2 The 'Large ICT' Installation: The Digital Access Node

Once the Broadband Island has been deployed, 'large' computing infrastructure need to be put into the schools (now community access points and called Digital Access Nodes (DANs) within the island). While the computing infrastructure will have to server at a minimum a dual purpose (support teaching in the schools and allow access to services by the broader community), a general architecture to maximize efficiency was needed. So, a thin client topology was chosen, with the possible variation of 'thin/thick' clients as explained later [13]. Centralized computing topologies such as thin client (and their variations) have advantages, from an efficiency point of view, compared to classical fat clients (independent PCs) found often in schools installation. Firstly, they support statistical multiplexing, making the computing resource better utilized. Secondly, they allow much easier administration of the installation, both in terms of initial deployment and ongoing maintenance. Finally, they make the theft of the end-user station less attractive to thieves, for its inability to work as standalone station. Even in the thin/thick implementation, where the end-user terminal has more power than a thin client and is actually executing the application code served by the central server, the end user terminal cannot be used as stand alone.

The main disadvantage of the thin client model and its variations is the single point of failure introduced by the central server. We explored a number of ways to mitigate for this, the best being realizing the central server as a cluster of small, easily replaceable servers. This solution allows to use cheaper, possibly refurbished hardware for the central server, but does have some complexity in the daily management of the installation on the part of the users, at least until a fully automated, hot pluggable cluster server solution is available. In the meantime, a low-tech solution is to have one or two spare servers available in the Broadband Island, ready to be deployed if one node experiences a server failure [13].

It is important to note that the decision of using a thin client architecture or its variations does not bring any constraint on the physical location where the various user stations are deployed, within a DAN. They can be clustered as in a classic school lab or Internet Café, or located each one in a classroom as support for teaching, for example.

To complete the installation of the computing infrastructure in our model, we locate a WiFi hotspot in the DAN and immediately surrounding area. This allows the use of the Internet, as well as authorized other e-services using personal devices when they are available, during as well as outside the opening hours of the DAN.

Unsurprisingly, the software run on the computing infrastructure is Free/Libre Open Source (FLOSS). The operating system is Linux, in the Ubuntu distribution. Besides the obvious cost reduction at the time of installation and upgrades, the philosophy of FLOSS is naturally aligned to the spirit of sharing, transparency and grass-root, distributed involvement which underlies the model described in this paper. FLOSS has another important advantage: it might help orienting the younger segment of the target communities towards careers in the digital economy, especially software development.

Access to the infrastructure is naturally regulated and requires users to authenticate themselves after registering in any DAN belonging to a specific Broadband Island. (Registration typically starts with the users directly associated to the schools hosting the DAN, pupils and teachers.) User information for authentications are kept in a Lightweight Directory Access Protocol (LDAP) directory. We will see in the next session on e-services how this can be leveraged by the application layer by our main applications integrator, TeleWeaver.

4 The Model: e-Services

4.1 TeleWeaver: The Business Model

The deployment of e-services on top of the e-infrastructure described in the previous section has been a focus of the SLL from the start, because without applications the infrastructure is useless and so unable to sustain itself. Obvious initial applications were office productivity suites [14] as well as Voice and Video communication over IP [15] through customization of standard software. It was clear, however that real income streams were necessary, both to support the e-infrastructure and to make it work for the hosting community, and these revenue streams had to be provided by the application layer. Initial work in that direction produced an e-commerce website for local artists and artisans to advertise their work and sell it online [15]. To this end, support for micro-tourism could be added easily. While this has clearly potential, it is predicated on the existence of valuable production of artifacts or tourist attraction, or the presence of activities that make viable, for example, the selling of accommodation. This is generally seldom true for the communities of interest. Even when it is true (or partially true, as it was in the case for micro-tourism in the area of the SLL, which happens to be in a magnificent natural area, if rather hard to reach), the stream would be rather small.

So, a more general revenue model was necessary, independent from the presence of specific, sellable products or services in the community and able to bring in revenue streams of the size needed to support ICTs. As noted above, however, the work done by us and other trying to diffuse ICTs in poor communities, rural and not, has the hope of starting a virtuous cycle that will make possible to have products and services present in those communities. But this is a longer term perspective, which is unhelpful with the initial sustainability of the e-infrastructure. As described in [16], we adapted a now well established Internet business model, where the resource to be monetized.

Naturally, we needed to find who the 'advertisers' were in our context, that is who was interested and was actually already spending money trying to reach members of the communities in which we deploy e-infrastructure. Government departments, their units and subunits all do, and actually the spend is already or will be important, especially if one includes the 'brick & mortar' investment in front-end offices as well as mobile units for hard to reach areas, and related personnel. An initial illustration is offered by the 'information dissemination' function of the Department of Health, where the nature of the interaction with the communities of interest in this context is directly advertising [17]. Such function will run information campaigns using a variety of channels, including travelling personnel. The most common channels will be newspapers, street posters, radio and television. In a sense, this function within the Department of Health does run advertising campaigns, with the costs of an advertising campaign as well as the difficulty of reaching the correct target. If a channel is made available to deliver the message, possibly in a targeted manner, the Department of Health could divert the money spent over other channels to the new channel.

A more general model, and how the various parts fit together and how the cash is generated, is illustrated in Fig. 2.

In Fig. 2, the Broadband Island is represented by a single DAN. The 'owner' of the Broadband Island, in the sense of the entity that started it, injecting the cash for the e-infrastructure and the procurement of the TeleWeaver platform, is a Municipality, for the sake of illustration. (It could any other entity such as an NGO, the local Department of Education district, a cooperative or a private investor when the model has proven to be viable.) The software house building and maintaining the core of TeleWeaver and part of its ecosystem of services is called Reed House Systems (RHS) (historically, a software house project within the two Universities behind the SLL). Finally, the three entities at the bottom of Fig. 2 are examples of a very small set of public or private

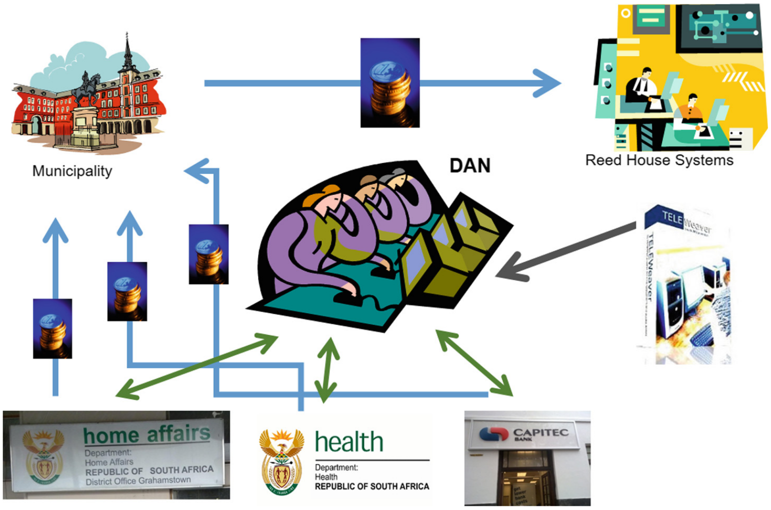

Fig. 2. The TeleWeaver business model

institutions with an interest of interacting with the users of the Broadband Island: the Department of Home Affairs, the Department of Health and Capitec, a South African bank catering especially for segments of society with lower financial power. The arrows with money overlapping them represent payments (with cash flowing to the entity at the tip of the arrow), the others represent interactions about specific services or products offered by the entities connected by the arrow.

After establishing a Broadband Island, the Municipality pays for a license of TeleWeaver, which gets deployed in the Broadband Island and activates bidirectional channels of communication with the three entities at the bottom. For example, the Department of Health will be able to use a healthMessenger application to run information campaigns on HIV/Aids, or to collect information about the health status of the individuals making use of the Broadband Island [17]. Each applications hosted in TeleWeaver have a pre-approved contract with the entity gaining benefit from the application, which get activated on installation, with the details of the specific Broadband Island and its ‘owner’. This contract specifies how the channel is paid for: maybe for each recorded interaction (an info message clicked by a user in the Broadband Island, the reporting of a birth etc.), or maybe on a fixed, monthly base, independent of the number of transactions. The payment is done to the owner of the Broadband Island, making the installation viable, provided that a minimum number of services get activated. In fact, because the income from a Broadband Island will depend on the number of services, the interest of the owner will be to devise and promote more and more services over time. The better and better viability of the installations within this model will make the model more and more interesting to the entities using its channels, in a virtuous circle. (As an aside, the ‘weaving’ of the monetized access channels, to support the financial viability of the e-infrastructure described in the previous section, is the reason for the name of the integration platform, TeleWeaver.)

Of course, TeleWeaver does not exclude income streams linked to channels through which local products and services get distributed: in other terms, the e-commerce services mentioned at the beginning of this sections can be simply re-implemented within TeleWeaver, using the same infrastructure (and so offering good efficiency). The reason for foregrounding services linked to Government (especially) and private entities interested in users belonging to the communities we target with our work is that, at the start, the revenues from channels to Government and private entities can be expected to be much bigger and have a realistic chance to support the e-infrastructure. In other words, they are better channels for 'bootstrapping' the diffusion of large ICTs in marginalized areas.

4.2 TeleWeaver: System Architecture

The business model illustrated above requires the support of a highly distributed, highly modular software platform that has open interfaces to the outside world. The distribution is necessary because DANs could potentially be deployed in several areas in a geographical region. The modularity is needed in order to simplify the process of incorporating diverse applications into the platform, by providing the basic enablers that most applications would need in order to function. Finally, the openness is crucial to the value proposition of the platform since external entities such as those depicted in Fig. 2 above would need to reliably push and pull data to deployed nodes in a region, preferably using their own existing systems, assuming these systems are capable of standard communication mechanisms that are prevalent in industry [15].

These broad overarching goals would take an exorbitant amount of time to develop, test and maintain through custom software. In addition, while the business model is novel, many of the technical challenges implicit in its realisation have largely been solved in various 'middleware' platforms that have emerged over the years. Middleware is a classical architectural model which permits the development of modular applications that rely on pre-provisioned service enablers that abstract away the details of the underlying operating system and networks upon which those applications are executed.

While there are several middleware solutions to choose from, the Java language, and in particular, the Java Enterprise Edition (J2EE) has a long history in these contexts, with several popular and well supported solutions available. A notable example is JBoss Application Server, now re-branded as Wildfly, which is fully J2EE compatible and enjoys wide support by virtue of the backing it receives from the parent company RedHat, as well as its adoption by the open source community. Regular and incremental release cycles make Wildfly an attractive platform and a solid basis to build from.

TeleWeaver makes extensive use of Wildfly's services in the development of two levels of services and applications [15]. Core services are those that TeleWeaver ships with, and are recognised as services that all applications that reside inside the platform make use of. The most critical core service is the user profile which sits at the heart of the value proposition of the platform. Rich user data that profiles community members is what makes TeleWeaver attractive to partners such as those depicted in the business model diagram above. The richer the data, the more targeted services can be delivered to communities. In its current state, the user profile is a combination of both static and dynamic data and a service module implemented as an enterprise Java application. The static data is implemented using LDAP while the dynamic data is stored within a relational database. The goal of this construction is to partition user information into data that does not change frequently (such as personal details) which are stored in LDAP, while data that pertains to an individual's use of specific applications would be stored in a relational database. The enterprise application then maintains the association between these two, managing updates and coordinating the linking of these two sets of data.

The second core service is the web service adapter which sits between the platform and external services that need to communicate with TeleWeaver [15]. The adapter itself was not developed from scratch, as Wildfly ships with a Java restful web service stack called RESTEasy, but the adapter needs to be configured to work with applications, in particular in the authorisation of ingress requests.

The deployment model that Wildfly supports also makes it ideal for the context because it inherently supports a distributed approach. Wildfly can run in either standalone or domain mode, the latter of which allows Wildfly nodes to run as domain controllers, while others run as host controllers under the control of a domain controller. This distributed architectural model allows Wildfly hosts to work in concert, sharing information and syncing data in order to realise a super-network of TeleWeaver entities. This feature makes TeleWeaver appropriate for its context, given the distributed nature of DAN nodes.

A diagram summarizing the architecture of TeleWeaver is presented in Fig. 3.

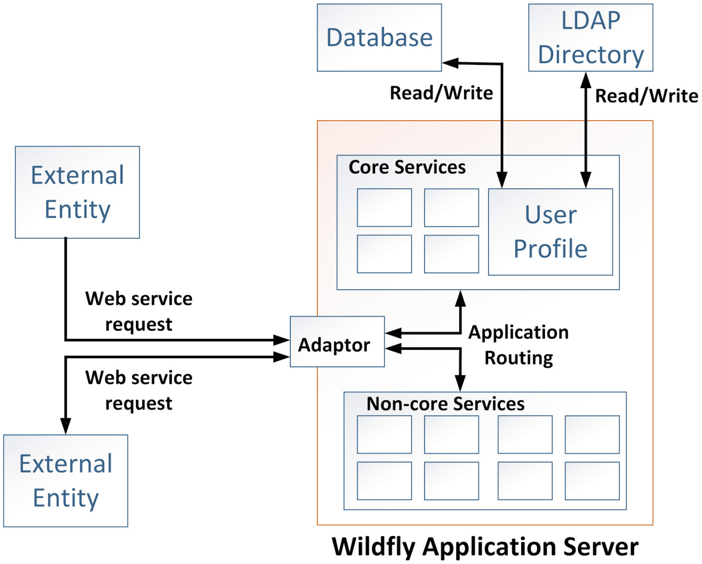

Fig. 3. An architectural view of TeleWeaver

5 Discussion

One fundamental aspect of the model for e-infrastructure presented in this paper is that everything, from the Broadband Island, to the computing infrastructure in the schools, except possibly the WAN technology, can be easily built and operated by small companies or community organizations, maybe with some initial technical support) [14]. This is fundamental for at least three reasons. Firstly, it would trigger local economic development, which remains a major challenge. Secondly, it would make the e-infrastructure (and then the services on top of it) accepted as part of the assets of the community, which will trigger protection from vandalism and meaningful utilization, starting a virtuous cycle with a real transformative power. This was seen quite clearly on the SLL main site in the Mbhashe Municipality, if in an initial form - as it should be expected in socio-economic environments that have been static and dominated by lack of hope in change for a long time. Thirdly, but equally importantly, it will break the ‘bottleneck effect’ created by centralizing the control of the deployment of e-infrastructure. Of course, as discussed in [14], lack of centralization might have disadvantages, but they are in our opinion manageable and less important than the block of the operations on the ground.

The reader will also have noted that the revenue streams depicted in Fig. 2 accrue to the owner of the Broadband Island from which the interactions with the external interested entities originate, and not, say, to the software house creating the actual software channels, RHS in Fig. 2. This is an important way in which the model of e-services presented in this paper differs from the model used by mainstream Internet companies, such as Google and Facebook, which similarly monetize user access to interested parties. (Of course, the interested parties are very different.) Such a decision was taken for a number of reasons, the fundamental one being the desire to reflect the general distributed architecture at a financial level too. As a consequence, the model we are proposing can start being implemented without the need of large financial means, is more resilient and activates in a direct manner local economic growth.

While the focus on e-services in this paper is their potential to guarantee sustainability to the e-infrastructure, the e-services are of course of importance in themselves to the interacting parties - users and external entities. The presence of the e-services (not only the ones hosted in TeleWeaver), in other words, bring a positive contribution to the communities hosting the e-infrastructure, becoming in themselves a transformative force.

6 Conclusion

The paper has presented a model developed over more than a decade through work at the SLL, in the real life setting of a deep rural community of South Africa. We feel that the model has the potential to break the impasse in which SA Connect, the national public broadband plan, seems to find itself, at least in poor provinces like the Eastern Cape.

If the model is rolled out on a large scale, in our opinion it has the further potential of fostering a local ICT industry for local content and might help usher in South Africa economy a more modern, knowledge based economy.

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