IST-Africa 2018 Conference Proceedings
Paul Cunningham and Miriam Cunningham (Eds)
IIMC International Information Management Corporation, 2018
ISBN: 978-1-905824-59-5

An Open-Source Tool-set for Meaningful Monitoring and Visualisation of Rural ICT Projects

Kim GUSH
CSIR, Meiring Naude St, 0184, South Africa
Tel: +27 12 8412864, Email: kgush@csir.co.za

Abstract: Monitoring and servicing of technologically complex rural installations poses unique challenges. This paper presents some discussion and a selection of open source tools aimed at assisting help-desk personnel in the monitoring and support of rural infrastructure on a long-term basis. The tool-set is being used by a service desk in a rural ICT deployment initiative, providing tangible results. The monitoring system comprises a centralised data gathering and visualisation approach, customised to assist the service desk in various ways, The tool-set helps operators visualise network infrastructure status, assists in the timeous deployment of maintenance teams and in understanding usage behaviour. An example of connected devices showing high usage versus low usage is presented. Recommendations for projects of a similar nature include the establishment of a competent help desk with access to the necessary monitoring and communication tools.

Keywords: Monitoring, visualisation, open source, tool-set, rural, ICT

1. Introduction

"...a wealth of information creates a poverty of attention..."
— Herbert A. Simon

The Council for Scientific and Industrial Research (CSIR), in conjunction with a South African national department, is deploying complex technologies in remote South African communities. As part of this initiative, computer labs and self-contained solar-powered computer containers provide much-needed computer infrastructure in under-serviced towns and villages. Users are able to interact with a computer, sometimes for the first time in their lives, acquiring new skills and furthering information and digital literacy through Internet access and the availability of locally cached educational content. The challenge is to provide long-term sustainable technical solutions in the most needy communities while simultaneously dealing with limited resources and funding.

Monitoring and servicing of rural installations poses unique challenges, including the difficulties of road access (long drive times, difficult roads), connectivity issues (e.g. cellular phone coverage not being available in some areas) and reliability of support staff on site. Sites require adequately trained administrators, good communication between administrators and project support teams, functioning technology and timeous repairs to equipment if there is a malfunction. Community administrators (champions) tasked with monitoring the equipment often require supervision themselves. A successful site will be well utilised, well managed and well maintained. This requires *informed* monitoring of both equipment and personnel by the entities responsible for the success of the initiative. "Continuous monitoring and evaluation play an important role in keeping the project on track and revealing the impact on the rural community" [7]. A well-functioning system with effective management and consistent monitoring and evaluation (M&E) serves as an indirect incentive to field workers [3]. The following information and actions will assist in the smooth functioning of the installation, directly benefiting both users and maintainers of the infrastructure:

- Informative and timeous administrator feedback from site
- Accurate and near real-time technical feedback from site
- Knowledge about aspects of a site requiring attention
- Attending to issues as timeously, and efficiently as possible

2. Objectives and Context

2.1 Objectives

The aim of this paper is to present some discussion on knowledge discovery from data and describe a selection of open-source tools aimed at assisting infrastructure help-desk personnel in the monitoring and support of rural ICT installations on a long-term basis. The paper covers the tool-set in some detail and provides some discussion around the complexity of human-technical systems and recommendations for similar projects.

2.2 Context of Application

Examples and observations presented in this paper are from a set of rural information and communication technology (ICT) installations. Sites were installed in phases over a number of years and observations done in 2017. The sites comprise:

- Solar-powered computer-equipped containers (Digital Doorway containers)
- Computer lab deployments in low income areas
- School-based hotspot installations with content server and Wi-Fi access points.

The ICT platforms in question were deployed "(i) As information and communication resources; (ii) As learning centres; (iii) As access points to ICTs; (iv) As practical tools for development; and (v) As a tool for bridging the digital Divide." [4].

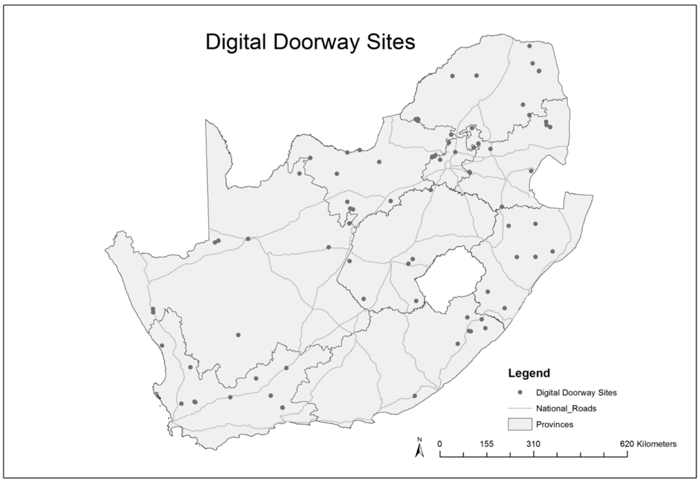

Figure 1: ICT Installations around South Africa

At time of writing, sites are deployed throughout the nine provinces of South Africa (see Figure 1) and consist of 60 Solar containers, 10 ICT Labs and 17 School Wi-Fi hotspot installations. Of these, approximately 70 sites support VSAT Internet connectivity enabling them to transmit near-real-time data (comprised of many parameters) back to a monitoring server and support desk. There is thus a large amount of raw data available for analysis.

3. The Data Value Chain and Knowledge Discovery

According to Miller and Mork, “The task of turning raw data into quality outcomes is made more complex with larger, faster, and more varied data, which doesn’t automatically translate into more useful information” [6]. Their paper proposes a data value chain with the elements of data discovery (collect and annotate, prepare, organise), integration, and exploitation (analyse, visualise, make decisions). Goals of this include the optimisation of service delivery and enabling quality decision-making.

The aim is usable knowledge discovery from data (KDD). The knowledge discovery process is often interdisciplinary and spans computer science, statistics, visualisation, and domain expertise [1]. The Digital Doorway sites can be described as complex socio-technical organisms consisting of high-tech computer and transmission technologies, combined with complicated social dynamics within the community and challenging support and maintenance issues. A centralised data gathering and visualisation approach can pick up trends and commonalities, discovering new knowledge that can then be used by experts in various domains (social science, engineering, technical) to increase the impact and effectiveness of both existing and future installations.

The existing base of solar containers, ICT labs and school installations mentioned earlier, serves as a valuable test-bed for monitoring and visualisation of a working system of this nature.

4. System Description

4.1 Overview

At the heart of the monitoring system is a mechanism for the automatic collection and transmission of data from remote software agents on site, for subsequent processing, consolidation and visualisation. The system can assist support staff at a monitoring centre by highlighting sites requiring immediate or long-term intervention. Specially appointed community persons on site provide a 2^{nd} mechanism for relaying actionable information from the site. Information can be sent via cellular phone, and the appropriate actions taken. This feedback loop incorporating social and technical elements is illustrated in Figure 2.

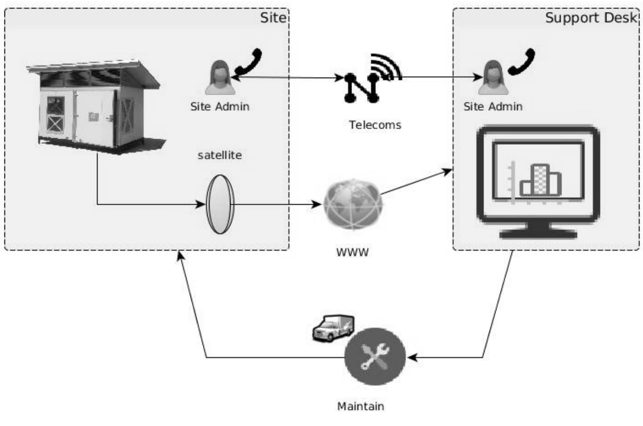

Figure 2: Social and Technical Feedback Loop

As the number of deployed sites increases, the volume of incoming data increases to the point where the support desk is overloaded with data. In addition, there is ever increasing complexity of monitoring & coordinating the support and maintenance of sites. Asset tracking, site administrator contact maintenance and ticketing of incidents are all vital components of the support service, requiring *appropriate tools.*

The monitoring system comprises soft (social) and hard (technological) aspects. The soft side involves local site administrator telephonic feedback and user feedback via messaging (SMS) service. The hard side involves automated monitoring capabilities, data recording, transmission and processing. An effective operation requires the right tools for monitoring and analysing the big picture (entire network), as well as the ability to drill down to specific data where required. Timeous maintenance of on-site equipment requires tools for distilling large amounts of data into pertinent and usable information and isolating specific sites that require attention.

4.2 The Tool-Set Components

The network of previously described rural ICT hubs relies on a combination of local support and centralised support and maintenance. The latter has relied on increased levels of real-time monitoring since inception and uses the following open-source tool set:

- Linux servers for both data gathering and back-end processing
- PandoraFMS (www.pandorafms.org) real-time monitoring tool
- iTop tool (www.cambodo.com/itop-193) for asset tracking and ticketing
- MYSQL database (www.mysql.com)
- Apache web server (www.apache.org)
- Customised browser-based 'dashboard' tool
- Various map visualisation tools and support scripts

4.3 Details of the Monitoring and Visualisation Process

On-site sensors and scripts gather information about various parameters into customised modules. These include server uptime and status (online / off-line), user terminal status (online / off-line), number of connected devices, solar panel and battery voltages, network usage and board temperature. All these modules are collated on site into a single XML file which is transmitted via VSAT connection to the Pandora server at the support-desk location. This happens every three to five minutes. Similarly, data-sets from each of the VSAT-enabled sites around the country are sent in the same way resulting in over 2000 data modules being received every three to five minutes. The data is extracted from the agent file and stored in a database. Low-level data visualisation happens through a browser-based graphical user interface. The data forms the foundation for the quantitative side of the monitoring and visualisation process.

Information retrieved via telephonic and messaging communications is logged by support staff into a second tool, the iTop site-management application. Calls are linked to specific configuration items (assets) in the network. The ITop tool provides a customisable and efficient mechanism to track site equipment, location details, administrator contact details and incident history through a ticketing mechanism. Figure 3 provides the tool-set context.

Data from both tools mentioned above are combined and displayed in a “dashboard” overview page, which allows for rapid trend analysis and fault or incident identification.

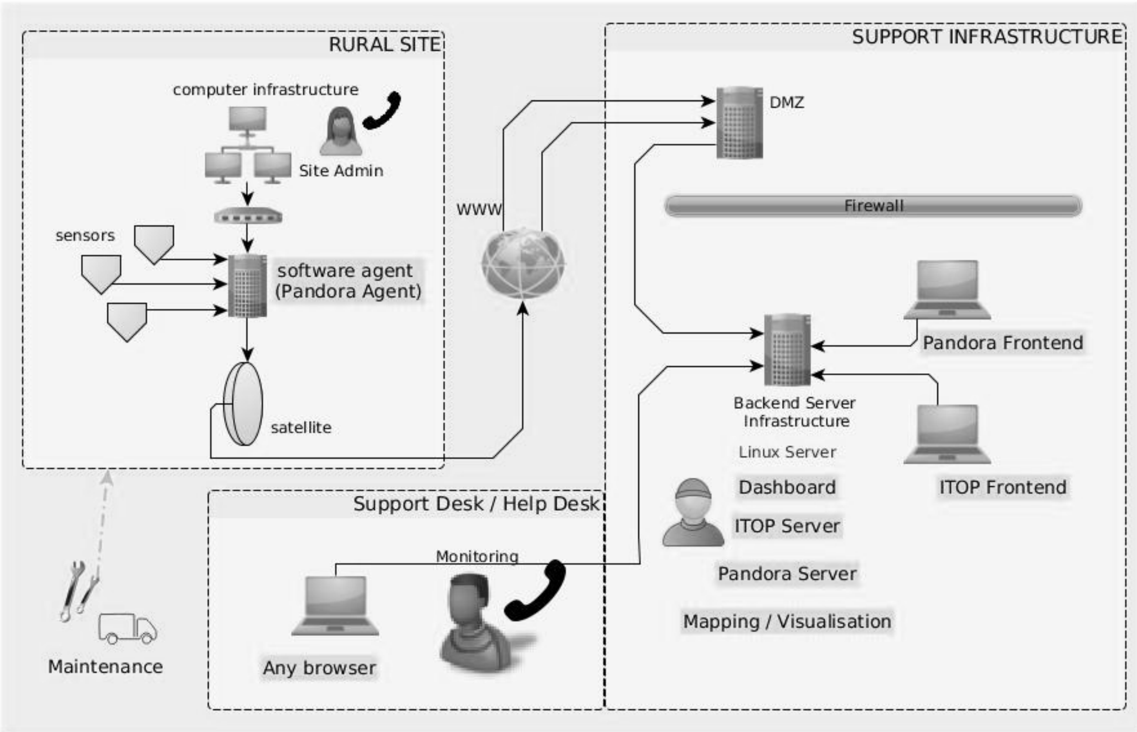

Figure 4: Tool-set context

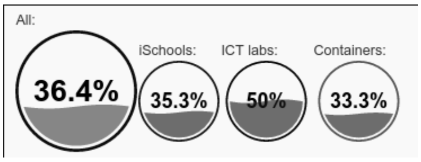

Figure 3: Indicator gauges displaying low network connection values

The dashboard combines both hard and soft data, grouping information in such a way as to facilitate effective analysis by support desk operators. Summary gauges (Figure 4) provide quick references and highlight major network status changes (e.g. VSAT problems affecting all sites). In the dashboard, each site and its associated data are displayed line by line; highlighting status changes over a period of one week, relevant site details, recent contact and ticketing history and other information. Incoming SMS messages are displayed on the dashboard and update in real-time as new messages are received.

A properly functioning help and support centre is able to process this information, analyse the visualisations, generate network-specific knowledge and initiate the appropriate interventions where necessary.

5. Discussion – Complex Challenge of Interfacing Technology and People

The provision of technically complex ICT infrastructure in remote communities involves a level of support that goes beyond mere equipment maintenance. Applying the aforementioned data value chain (see Section 0) to the subject of this paper, we can extract the following real-world parallels:

- Data discovery – software and hardware agents transmit real-time data back to a server. Local support provides more qualitative feedback through telephonic conversations and short messages.

- Data integration – automated storage and aggregation of data combined with manual input by support desk personnel.
- Data exploitation – real-time visualisation of the network and time-delayed identification of problem sites (as recorded by support desk) combined with a ticketing system, telephonic support facility and maintenance plan. Historical variations in various data parameters can be extracted from a database.

The help-desk can provide a "a user-friendly point of entry" for communities requiring information and assistance [5]. Regular contact between the help-desk and local site champions has proven valuable in maintaining trust relationships between both parties. This contact provides added incentive for the champions to fulfil their duties.

5.1 Help-Desk Model

A multi-tiered help-desk model [8][9], may be useful in delineating the major levels of support and intervention. The tool-set integrates with a four-tier model. At tier 0, the champion relies on self-help (training manuals, online help etc.) before escalating a query to tier 1 (telephonic support). At tier 1 the help-desk operator attempts to resolve the issue over the telephone. If this is not possible, the call is escalated to tier 2, requiring a site visit by inspection and maintenance personnel. Recurring issues, design changes and other major support interventions are escalated to tier 3 and normally require longer to resolve than issues in the lower tiers.

The monitoring dashboard allows for rapid review of any open tickets assigned to a site. The ITop tool allows for help-desk tickets to be created, assigned, escalated, resolved and closed.

5.2 Monitoring for Usage Behaviour and Technical Insight

The monitoring and support tools implemented in this project are able to provide insights into the usage behaviours of the ICT equipment on site. For example, one of the measured parameters at each location is "number of devices connected to the server". This includes known devices (e.g. fixed terminals, printers, management board) as well as users connecting wireless devices (phones, tablets) via the Wi-Fi access point (AP). A high value for this parameter indicates that many user devices are connected to the AP. In order to ascertain whether the content server is actually being used, however, it is necessary to look at the variability of this parameter over a period of time. Drilling down to a particular parameter at a particular site is possible via the real-time monitoring tool and supports historical charts. Values from an active site should typically go higher during the day and lower at night. Examples are shown below (Figures 5 & 6):

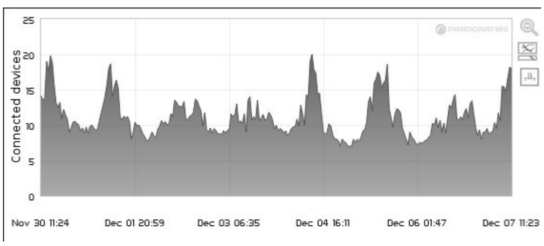

Figure 5: High usage per day: max 10 to 15 devices connected (excluding fixed connections)

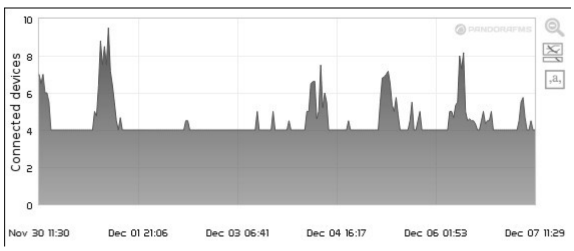

Figure 6: Low usage per day: max 1 to 5 devices connected (excluding fixed connections)

Monitoring of technical parameters is greatly aided by time-based visualisations. The value of this data set increases over time as more values are added. For example, reviewing the solar panel output voltage (y-axis) versus time (x-axis, one week) reveals that the system is functioning well. The day-night cycles are clearly evident (Figure 7):

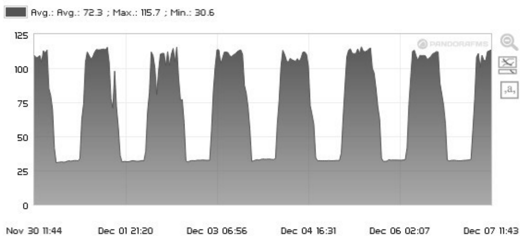

Figure 7: Solar panel output voltage over a 1-week period

It must be emphasised that the visualisations require informed (human) analysis in order to establish an accurate picture of this element of usage behaviour. In the same vein, ticket creation and assignment requires some level of human intervention by an operator familiar with the site history. This will eliminate unnecessary ticket creation of incidents requiring attention and allows the operator to input additional details relevant to the ticket assignee. There is a synergy between automatic processing and manual intervention with the combination being greater than the sum of the parts. What is required is appropriate technology for the task, not over-automation [2].

6. Conclusion and Recommendations

This paper has discussed some of the challenges, tools and approaches to monitoring and supporting ICT installations in remote rural communities. We have emphasised the importance of distilling large amounts of near real-time data into meaningful and accessible visualisations. The role of a support desk has been discussed, and how a combination of automated technical feedback from site and telephonic and messaging communications may be combined to provide a clearer understanding of the reality on the ground.

We surmise that installation projects in rural areas of the African continent will only be successful in the long-term if the right tools, support, maintenance and funding are in place and there is sufficient community engagement and involvement, including active community administrators on site. The open source tools described in this paper are freely available and could be customised and utilised by infrastructure maintainers in other developing countries.

Recommendations for ICT projects of a similar nature are listed below:

- Train and deploy local site administrators, including clear instructions regarding their provision of timeous and relevant feedback
- Establish a competent help desk with access to the necessary monitoring and communication tools
- Train help desk personnel to provide first line support to site administrators
- Factor in adequate budget for ongoing support and maintenance. This should be done before the project commences
- Ensure that funders understand the need for support and maintenance
- Incorporate the necessary monitoring technologies and scripts from the outset
- Ensure reliably connectivity at the site to enable real-time monitoring
- Ensure adequate communications channels exist between local administrators and support desk
- Establish clear processes for dealing with equipment failure, ongoing maintenance and champion turnover
- Ensure that the tool-set used in the project is adequate for the tasks at hand
- Customise visualisation tools in such a way that only the most relevant information is displayed

Future work in this area aims to research appropriate technological interventions to motivate champions in their site involvement. This could include an automated reporting tool utilising a messaging service or mobile application notifications to alert champions and others of issues requiring attention.

References

[1] Begoli, E., & Horey, J. (2012). Design principles for effective knowledge discovery from big data. Paper presented at the Software Architecture (WICSA) and European Conference on Software Architecture (ECSA), 2012 Joint Working IEEE/IFIP Conference on, 215-218.

[2] Clegg, C. (1988). Appropriate technology for manufacturing: Some management issues. Applied Ergonomics, 19(1), 25-34.

[3] Colvin, D. (2014). What motivates community health workers? Designing programs that incentivize community health worker performance and retention. Developing and Strengthening Community Health Worker Programs at Scale: A Reference Guide for Program Managers and Policy Makers.Washington, DC: USAID/Maternal and Child Health Integrated Project (MCHIP).

[4] Foko, T., Thulare, T., Legare, L. And Maremi, K. (2017). Information and Communication Technology Platforms Deployment: Technology Access Reaches South African Rural Areas.

[5] Hart, A., Northmore, S., Gerhardt, C., & Rodriguez, P. (2009). Developing access between universities and local community groups: A university helpdesk in action. Journal of Higher Education Outreach and Engagement, 13(3), 45-59.

[6] Miller, H. G., & Mork, P. (2013). From data to decisions: A value chain for big data. IT Professional, 15(1), 57-59.

[7] Pade, C., Mallinson, B., & Sewry, D. (2009). An exploration of the critical success factors for the sustainability of rural ICT projects–The dwesa case study. Information systems development (pp. 339-352) Springer.

[8] Powell, J., Michelson-Thiery, M., Bryant, L., Koltay, Z., & Patterson, M. (2007). Integrating an engineering library's public services desk: Multiple perspectives. Issues in Science and Technology Librarianship, 49(2).

[9] Viswanathan, B. (2016). Understanding The Different Levels of Help Desk Support, https://project-management.com/understanding-the-different-levels-of-help-desk-support. Accessed 01 Dec 2017