Constraints for Information and Communications Technologies implementation in rural Zambia

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Abstract. Introduction and use of Information and Communication Technologies in rural sub-Saharan Africa face a particular array of challenges. Often, challenges interrelate with context, tradition and culture. This poster presentation identifies constraints during sensitisation, introduction and operations of ICT in rural Zambia. Although quantitative engineering aspects play a role, a multitude of qualitative constraints feature prominently. These involve environmental, skills, and cultural ingredients. Research, planning and evaluation has to be sensitive to these challenges if all rural areas are to receive proper inclusion and benefit from the growing penetration of the Internet worldwide.

Key words: ICT for development, Rural area wireless networks, Technology and Society, Research methodology, Internet adoption constraints

1 Introduction

The role of Information and Communication Technologies (ICT) in advancing economic growth in the least developed countries is a growing topic of research and debate [1][2][1][3][4][5][6]. Attention focuses on the plight of the least connected. Institutes and nations urge collaboration on addressing the needs in rural areas. Most ICT research approaches from a quantitative, technological perspective, using conventional wisdom [7]. Work often lacks long term contextual evidence [8]. This poster presents an array of challenges that surface during

the process of local adoption of ICT, based upon observations and experience with ICT at a rural African community level in seven rural communities in Zambia. These challenges are:

1. **environmental constraints** determined by environmental challenges specific to rural areas such as unreliable electricity or supply chain logistics. Rural inhabitants have little control over these challenges.
2. **skills constraints** caused by the lack of availability of trained ICT practitioners as well as the process of training and equipping these practitioners in ICT.
3. **cultural constraints** that deal with the complexity of using, installing, and maintaining ICTs in the context of African culture. Examples: perceptions of time and resources, roles and authority and the role of oral tradition versus written tradition.

2 Background

In Zambia, a typical rural community pivots around health and/or education institutions. Traditional leadership structures govern daily activities. In several locations, church-administered mission stations provide the nucleus of activities. The co-operative organisation, Macha Works, is a rural social enterprise. It resides in the rural community of Macha, Zambia. It operates with a holistic approach, aiming for holistic development of services and facilities at a village level. Macha Works strives to inspire people in rural communities to reach their collective and individual potential and operates according to the Macha Works model [9]. It teams up with national institutes like University of Zambia, and international organisations in a collaborative approach [10].

3 Methodology

The approach to this investigation uses mixed methods of research to address multi-disciplinary research questions, within a single-case study methodology. The method of data collection is one of critical ethnography over a period of nine years. Embedded studies involved positive analysis of quantitative, longitudinal usage data derived from the ICT network in Macha, based upon:

1. a network traffic monitoring system on the village network gateway capturing 14 days of traffic from midnight, Sunday 31 January to midnight Sunday 14 February in 2010, two months of network traffic in February, March and April 2011, involving approximately 450 GB of packets to assess the use and locality of traffic [11][12]
2. survey of Internet usage and attitudes towards ICT, private, one-on-one, on-site interviews in Macha in July/August 2010 (23 interviews)
3. follow up through 44 online interviews of Internet users in Macha, June/July 2011, investigating the use of Web 2.0 applications and services [12].

3.1 Environmental constraints in Macha

Geographical constraints. Distances between towns are far, with the surface of Zambia (752,600 km) equalling the size of Turkey (783,600 km) or Texas (696,200 km). Oneway travel typically spans a number of days. Sensitive ICT equipment can easily be broken in transport. *Dust* is common in Zambia year around. Further there are periods of *extreme heat* and periods of rain, *lightening and strong winds*.

Infrastructural constraints. *Electricity* is a vital constraint in rural areas. National electricity supply is either unavailable or unreliable, with power failures and voltage surges or brown-outs being common (dirty power). In practice, there are many *standards* of equipment arriving in rural areas. Standard Uninterrupted Power Supplies (UPS), meant to protect equipment from energy disruptions get easily damaged as first line of defence. In practice, *solar* equipment proves difficult to source. Battery replacement require specialist efforts.

The constraints on providing for *housing or offices* in rural areas are severe. Sources of funding for building activities are sparse.

Most Zambians conduct their activities in accordance with customary law. Customary tenure of *land* and the position of traditional chiefs are respected [13].

Political and legal constraints. The regulatory frameworks for ICT are not necessarily conducive to widespread scale up of ICT in rural areas. Universal Service Fund (USF) collection is part of the work of regulators in many African countries [14]. Processes take several years and require many regular visits to monitor and encourage progress, without assurance of success. Property issues and access to physical infrastructure create significant constraints. Different perceptions of time, power distance between all participants, or mundane issues of transport, all serve to compound the challenges in practice.

Deterministic constraints. Windows users in Macha were experiencing poorer performance in the Linknet network than their Linux or Mac OS counterparts. There was a perception that LinkNet unfairly disadvantages Windows users.

Thorough network analysis of satellite Internet traffic captured over 2 months in early 2011 revealed a large disparity in performance between Windows and Linux/Mac users. Aggregate traffic was broken into hourly bins and then normalized to throughput per IP address per hour. Windows users were separated from Linux/Mac users using the Time to Live (TTL) field in the TCP header. Windows uses a TTL of 64 and Linux/MAC uses a TTL of 128. Table 3.1 shows the results.

During this measurement period, there were almost double the number of Windows users compared to Linux/Mac users logged in on average. However, Windows outgoing normalized aggregate traffic was three times worse than Linux/Mac during the phase of slow satellite connectivity. Incoming Windows normalized traffic was only marginally worse than Linux.

Satellite connectivity phase 2011/01/28 to 2011/04/09	
Linux/Mac avg MB/IP/hour in	5.53
Linux/Mac avg MB/IP/hour out	1.55
Linux/Mac avg IPs/hour	9.75
Windows avg MB/IP/hour in	4.19
Windows avg MB/IP/hour out	0.55
Windows avg IPs/hour	19.24
E1 2Mbps line connectivity phase 2011/04/09 to 2011/05/19	
Linux/Mac avg MB/IP/hour in	6.33
Linux/Mac avg MB/IP/hour out	1.50
Linux/Mac avg IPs/hour	10.07
Windows avg MB/IP/hour in	7.93
Windows avg MB/IP/hour out	1.00
Windows avg IPs/hour	17.12

Table 1. Windows vs Linux/Mac normalized incoming and outgoing throughput.

Further, to confirm that this scenario could be replicated in a lab environment, a Linux and Windows 7 machine were connected to a Linux server over a 1Mbps line and an artificial delay of between 10ms and 1s was introduced to see the effect of increasing the delay on these operating systems. Table **??** shows the results of this simulation. The simulation confirms the significant negative effect of delay on Windows machines. It also confirms that Windows is unfairly disadvantaged when there is a mix of Windows and Linux flows present. Although there was a sound technical reason for the difference in performance between Windows and Linux, it is challenging to share these findings with frustrated users. Users remained convinced that the performance issue was due to a poorly designed network or, worse, that Windows users are being deliberately disadvantaged.

Economic constraints. With the majority of the Zambian economy being in the informal, unregulated sector [15], publicly available, quantitative data needs appropriate interpretation. Most data describes realities in urban areas exclusively.

Providing ICT in landlocked Zambia is costly due to the high monthly *connectivity costs*, plus the costs involved in the procurement of equipment and its installation. Prices for satellite connectivity have changed little since 2004, depending on one's assumptions, satellite pricing have gone up 55% [16].

3.2 Skill constraints

300 People possessed graduate qualification in ICTs in Zambia in 2008 [17]. Uneven distribution of the workforce compounds the shortage of engineers. Although the majority of the population lives in rural areas, most engineers live in urban areas. The shortage is particularly acute for ICT as computers enter

rural areas, especially in health and education, while all support staff reside in urban areas [18][19].

In contrast with efforts in health and education, there are no national programmes, nor public private partnerships, specifically designed for training of engineers for rural areas. Except for Macha Works' LITA [20], there are no vocational training centres located in rural areas, and training is mostly left to the unregulated, commercial markets in major towns.

3.3 Cultural constraints

In Southern Africa, Ubuntu culture centres on diversity and sharing. It values trust and lays a moral foundation for interactions and empowerment. Its outward presentation involves the decentralisation of power and spread of decision-making authority to lower-level leaders [21]. Indigenous cultural heritage expresses itself through *oral tradition* and presentations [22][23]. Most researchers are ignorant of the *indigenous system* that help hold the rural community together [24]. Ubuntu culture and Western cultural expressions differ as antonyms [25].

The understanding of the economic choice in rural areas involves broader conceptions of its constitution, restraints and motivations [26]. African systems work well in doing what they are designed to do. However, when coming from other systems, and other historical conditions, outsiders find interactions often incomprehensible [27][28].

When young persons have a professional connection, or link with expatriate persons, they are expected to fend for themselves. This includes: providing for their own shelter, providing for their own essentials of life (food and soap), contributing to the upkeep of parents, and contributing to or providing for the school fees and upkeep for extended family members.

Contextual ingredients define and influence sustainability. The rural communities judge activities 'sustainable' when they are welcomed by all, are comprehended and can be vocalised by all members of the community, and when all persons are included and have a sense of partaking in the development. As such, the strength of 'rhythm', the tuning into the local culture, sustains the balance an African community strives for [29].

4 Conclusion

Based upon findings during nine years of longitudinal activity in implementing ICT in rural Zambia, this poster shows practical constraints to the ICT inclusion in rural Zambia. These constraints are broken down into environmental constraints, skill constraints, and cultural constraints. They are part of a large picture of ethical, conceptual and pragmatic issues. Constraints heavily influence practice and effect all efforts and activities in rural Zambia.

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