Optimizing Internet Bandwidth In Higher Learning Institutions: A Case Of Sokoine University Of Agriculture

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Abstract

Internet connectivity is very crucial for Higher Learning Institutions in order to fulfill their mandates of training, research and consultancy. The Internet connection is important for (i) communication and collaboration (ii) research and consultancy (iii) courses and content delivery i.e. academic management of courses and access to educational resources. One of the challenges facing higher learning institutions in developing countries is the low bandwidth leading to low Internet speed. This situation is aggravated by the fact (i) these countries have poor infrastructure for Information and Communication Technology (ICT) (ii) equipment, software and bandwidth are acquired at very high price in comparison with developed countries (iii) the acquired bandwidth is poorly managed due to limited number of skilled personnel. This paper presents lessons learnt from Sokoine University of Agriculture on how to face the mentioned challenges of poor bandwidth optimization and management (BOM). It also proposes a way forward for management and optimization of bandwidth. The concluding remark is that the use of tools for bandwidth management and optimization from Free and Open Source Software in developing countries is recommended. Furthermore, purchasing more bandwidth for SUA in near future is inevitable.

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General Terms: design, data management
Keywords: Internet, bandwidth, management, optimization, tools, Free and Open Source Software, Higher Learning Institutions in developing countries

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1. BACKGROUND INFORMATION

Sokoine University of Agriculture (SUA) has two campuses, namely: main campus and Solomoni Mahlangu Campus (SMC). Computer Centre was established in 1993 with various functions including coordination of the computerization of the university activities; planning, establishing and maintaining the Information and Communication Technology (ICT) infrastructure and develops manpower responsible for ICT [SIPG, 2002]. Computer Centre has three computer laboratories for more than 8000 students.

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Currently, there are 500 computers connected to the SUA Local Area Network (LAN). The Internet connection is hooked to two Internet Service providers (ISP). One is an International ISP (IISP) called "Constellation Company Limited" and the other local ISP (LISP), is Tanzania Telecom and Communications Company Limited (TTCL). The Internet Connectivity from Constellation Company Limited is shared by 8 institutions. The bandwidth obtained from IISP is 2 mbps for downlink and 256kbps for uplink; while for LISP is 64kbps for downlink and 64kbps for uplink.

The connection for IISP is through shared mode via Very Small Aperture Terminal (VSAT) while for LISP is of dedicated model via leased line. SUA's mail service uses the bandwidth from LISP while the other Internet services (such as Web i.e. WWW or World Wide Web) use the bandwidth from IISP. The problem which SUA experience from shared model is that during peak hours when all organizations are using Internet, the bandwidth becomes saturated. Thus, the available bandwidth at SUA becomes limited. This is has caused some departments to have their own Internet connection via VSAT. Examples of departments which have their own Internet connectivity are Soil and Water Management, Microbiology and Forestry Engineering. The tendency of the departments having their own Internet connection does not solve the problem for long term. Instead those solutions do add more cost for the Institutions and there is mismanagement of bandwidth. The reason for this is that those departments have no skilled staff to manage their network and they are unaware of dangers caused by poor management of bandwidth. Furthermore, when the funding period of the projects supporting the Internet connectivity finishes it will mean even the departments Internet connections must end. Moreover, this trend of individual department being hooked by private Internet connectivity shows that the ICT Policy and Guidelines are not being followed well. The ICT Policy and Guidelines states it categorically that Computer Centre will be responsible for supporting Internet services for the whole university [SIPG, 2002].

2. PROBLEM STATEMENT

When the Internet was first setup at SUA there was no enough qualified staff to design, develop, implement and maintain the LAN. This resulted into poor design, improper development and mismanagement of computer network. Also, there were no proper procedures to handle computer network, Internet connectivity and security related problems. There was no proxy server for caching purposes. Mail servers and routers were poor installed and this lead to misuse of bandwidth because of the peer-to-peer traffic, streaming of audio and video, spam (i.e. junks), computer viruses, computer worms, etc. Peer-to-peer allows file sharing around the world to connect to each other. These problems, among many, caused SUA mail server to be blacklisted. Blacklisting of server happens when the server allows open relay hosts (mail servers that accept connections from anywhere) and open proxies (proxy servers that accept connections from anywhere) [Venter, 2003].This in turn made some Internet services from SUA being unavailable. When the mail server was blacklisted the e-mails bounced when it was send to recipients using yahoo, Gmail and hotmail mail services.

Internet services provided by Computer Centre to the university community are based from the following servers: Network Address Translation (NAT) Servers (RedHat enterprise), Domain Name Server (DNS) (RedHat enterprise), E-mail and Web Servers (Fedora Core 3), Firewall (RedHat enterprise), Gateway (RedHat enterprise) and Dynamic Host Configuration Protocol (DHCP) server. For more clarification about Internet services read the following Table 1:

Internet Services	Comments
Electronic mail	Simple Mail Transfer Protocol (SMTP) to/from the Internet
	Post Office Protocol (POP) access from the Internet
	Internet Message Access Protocol (IMAP) access from the Internet
Web	Access from SUA network to Internet
	Hypertext Transfer Protocol (HTTP) from Internet to web caches
	HTTP from priority websites to web caches
	Hypertext Transfer Protocol Secure (HTTPS) from Internet
DNS	DNS requests and replies
	DNS zone file transfers

Website updates	File Transfer Protocol (FTP) access for upload and download

Table 1: Internet services at SUA

Thus in order to address the above described problems, there is a need of implementing the bandwidth management and optimization (BOM) tools. In addition, the recommendations mentioned by Mawazo and Ruhusa [2009] need to be taken into considerations during the implementation of BOM. The suggestions were to (i) replace core switch (distributors) (ii) install new manageable layer three switches (iii) replace uplink switches (iv) place new manageable layer two switches (v) create virtual LAN infrastructure (vi) purchase commercial firewall with network antivirus (vii) procure more bandwidth for Internet Services (ibid.).

3. METHODS

3.1 Tools used in BMO

As stated early from the situational analysis that we realized the need for BOM then we identified how the implementation will be done. Thus, bandwidth was managed and optimized using Free and Open Source Software (FOSS) tools [Benvenuti, 2009]. One reason why FOSS tools were chosen was to cut cost. The tools were implemented for classification, shaping, scheduling, policing, marking and dropping the traffic of packets as proposed by Wambua [2009].

The FOSS tools which were adopted for BMO implementations were first evaluated. After evaluation tcpdump and Multi router traffic grapher (Mrtg) was adopted (see Table 2).

Tool	Function	Description
tcpdump	Packet sniffer	Log traffic between hosts
Mrtg	Monitors the traffic load on the network links using SNMP	This tool provide a visual representation of inbound and outbound traffic
ping	Spot check for host connection	It uses ICMP packets to contact a specified host and tells how long it takes to get a response
traceroute	Remote connectivity checker	Used to find the location of problems between different computers and any point on Internet

Table 2: Tools used during implementation of BMO

During evaluation of tools the network traffic were generated and measured using the identified BMO tools. The BMO tools were installed in different servers such as mail server, DNS etc. These servers consist of traffic sources and sinks from a switch, VSAT connections and router devices. The interfaces (see eth0, eth1, eth2, eth3 in Figure 1) of these devices were connected to different servers. Eth0, Eth1, Eth2 and Eth3 stands for Ethernet number 0, 1, 2 and 3 respectively.

3.1.1 How analysis of traffic was done from different interfaces

First, we configured MRTG and setup it to monitor the network and link utilization. Second, we configured the firewall to prevent access to/from remote sites based on Internet Protocol (IP) address ranges, port numbers, and individual sites. In addition, the proxy was configured to filter HTTP traffic forwarded from firewall.

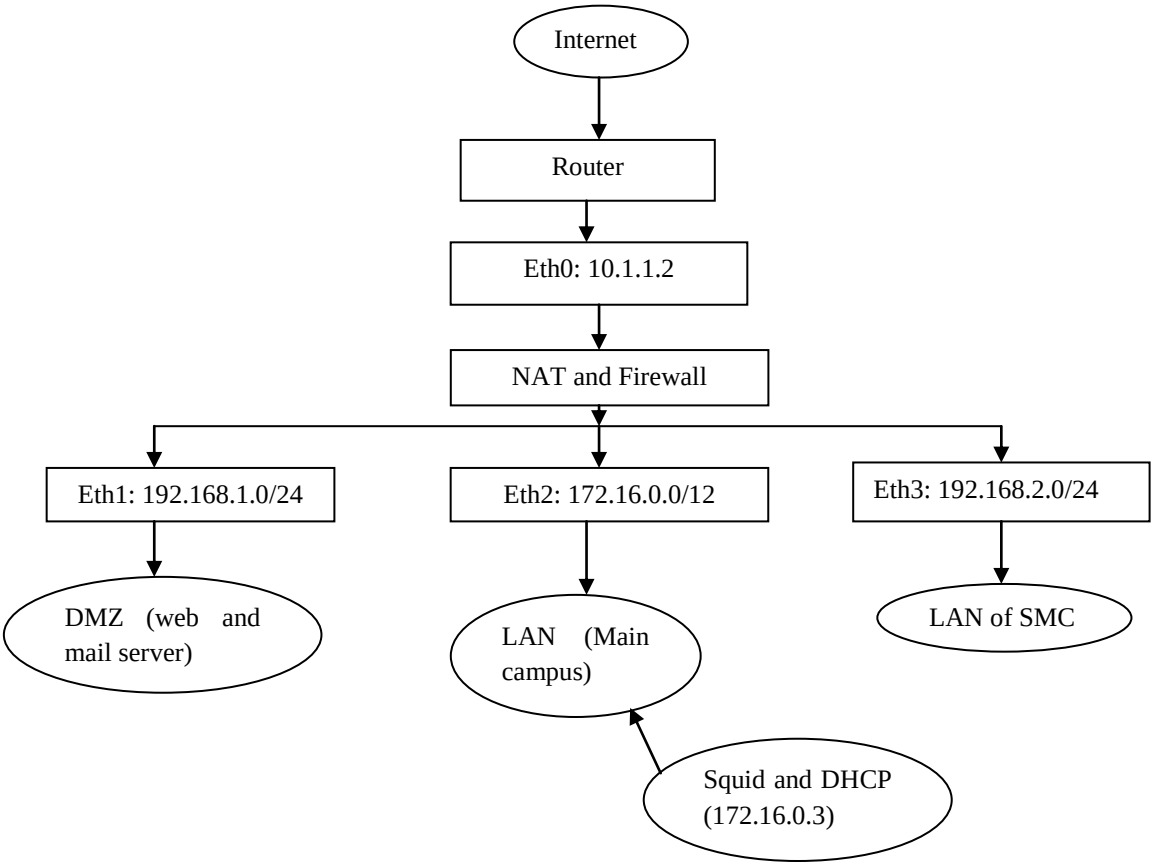

Figure 1: Network architecture of SUA [Adopted from Magesa and Luhusa, 2009].

From Figure 1, our Firewall has four Ethernet interfaces: eth0, with the IP 10.1.1.2, faces the outside; eth1, with the IP 192.168.1.0/24, faces DMZ (consisting of Mail and Web Servers); eth2, with IP 172.16.0.0/12, faces Local Area Network (LAN) of main campus; eth3, with IP 192.168.2.0/24, faces the Solomon Mahlangu Campus (SMC). The link between Main Campus (MC) and SMC is through wireless link.
Therefore, in this case, the example of rules contained in our firewall is as follows:

- Drop packets arriving at eth0 whose source IP is within 192.168.1.0/24 or 192.168.2.0/24 or 172.16.0.0/12

The advantage of the above rule is that it supports anti-IP-spoofing. This means all spoofed IP (forged source IP) addresses can easily be detected. The IP spoofing is a common network attack which pretends to send packet with IP addresses as if they come from the trusted (internal) networks.

In order to identify the cause of the bandwidth misuse the traffic of the Internet connection was analyzed using MRTG and the results, which was obtained from MRTG, (as shown in Appendices) were used as baseline. The cause of slow Internet connection was established from the baseline. The information obtained was used in the implementations of BOM. Furthermore, the problems in the network configurations of the university's servers were identified. In addition, the computer and network security techniques and the software in use were examined. Finally, user awareness training which have already been undertaken by Computer Centre staff to the SUA community were investigated if they meet the current challenges facing Internet connections at SUA.

In a project of Vlaamse Interuniversitaire Raad (VLIR) which involved universities from Southern

of Africa and from north (i.e. Belgium), the capacity building of our three staff was undertaken at MSc. level. In addition, some of our staff participated in 5 workshops which were meant for capacity building in all matters related to BOM [Mantell and Abagi, 2008]. The training and workshops range from theory to practical aspects of BOM. The topics taught were policy formulation for BMO, practical guide to BMO using FOSS, installation of proxy (squid), web server, mail server and DNS. The training conducted by VLIR through International Network for the Availability of Scientific Publications (INASP) helped the Computer Centre staff in network management, monitoring and security administration using FOSS tools [Venter, 2003].

Some of the network management, network monitoring, network security activities which were done at SUA are:

a) Firewall was implemented in our router.
b) Spam filter (using Spamassassin) and blocking some e-mail attachments (using Procmail) was installed at mail server.
c) Anti virus called Sophos Antivirus for the mail server was installed
d) Proxy server using Squid was implemented
e) Traffic shaping was introduced and BMO using FOSS tools was implemented

The results of the implementation of FOSS tools to monitor the SUA network are presented in the Appendix.

4. RESULTS AND DISCUSSION

The introduction of firewall and proxy server at SUA resulted to better Internet speed. This was reported from staff and students. User satisfaction probing was done by using open ended questions through staff mailing lists. The response from different stakeholders was they realized that before implementation the situation was worse (in terms of Internet speed) and after implementation, the Internet services improved.

The implementation of Procmail and Spamassassin helped to control the problem of spam (or junks e-mail) and thus, the IP address of our mail server which was blacklisted was removed from those servers showing blacklisted mail servers. Procmail and Spamassassin were configured to check incoming and outgoing mail viruses, spam and suspicise e-mail attachment (example those with .exe, sex.* file extensions). As results the viruses and spam/junks were no longer being transmitted in larger number consequently, the uplink traffic of SUA was no longer clogged. Hence, the overall Internet speed improved.

The implementation of the traffic analysis tools such as MRTG helped to optimize the use of our bandwidth. By using such tools the peer to peer traffic was under control and therefore, this improved the browsing behavior of our users since HTTP was setup to have high priority. One of the problems that we are still facing is that during peak hours of Internet utilization MRTG shows that the bandwidth at peak consumption is below the bandwidth bought from IISP (127.6 kb/s (49.9%). The reason for this is due to the shared link thus sometimes other 7 institutions connected in the same link are utilizing more than the purchased bandwidth (see Figure 1 up to Figure 9 in an appendix).

Figure 2 and Figure 3 in the appendix reveal that there is too much traffic during mid night at SUA Internet link; this signals virus activities, spam/junk e-mails as well as malicious codes. Also graph in Figure 2 shows that SUA internet link has more download traffics than upload traffics; this also signals lack of local content inside SUA network for outsiders to download from SUA. This in turn shows why we opted to implement cache server to resolve the issue of not having enough local contents.

Figure 6 in the appendix shows SUA Internet link saturate very quickly from 09:00 a.m. up to 23:00 p.m., this emphasis need for improved Bandwidth Management and Optimization as well as need to increase more Internet bandwidth.

Figure 8 in the appendix reveals that there are peer-to-peer connection using SUA Internet link, this signals that there are users with download managers software in their computers. These software enable heavy down loaders congest internet connection restricting internet access to other users and servers that need global accessibility.

Websites accessed by each user of our network was identified. We found that bulk of Internet traffic is peer to peer access and downloads of music, video and Anti-virus updates and access of free e-mail services (See Figure 11 in the appendix). Although, we acknowledge that peer to peer access and download of music, video and Anti-virus updates and free e-mail services might be important for academic

institutions (such as SUA) but, they fall under low priority in low bandwidth environment. This shows the importance of contextulising the solution of the problems related to BOM. Thus, the SUA management through Computer Centre established a policy which allowed our system administrators to block all websites which were not of SUA priority during peak hours. The website listed were: facebook, blogs, chatting applications, applications supporting peer to peer file sharing, gaming, pornography and video streaming.

Our results from this paper presents the experience of bandwidth management and optimisation problems and solutions from SUA which is similar to those reported from Addis Ababa University, Ethiopia; Malawi College of Medicine; the Multilateral Initiative on Malaria network (MIMCOM); University of Zululand, South Africa; University of Moratuwa, Sri Lanka, University of Dar es Salaam, Tanzania; Makerere University, Uganda; and the University of Bristol, UK [Venter, 2003].

5. CONCLUSIONS

Many universities in developing country which have low bandwidth are forced to adopt BOM tools from FOSS [Venter, 2003]. Gwynn [2006] identified that 59% of higher learning institutions in Africa do not monitor or manage bandwidth at all. This is an alarming situation and thus, calls for more researches related to BOM aspects. We have presented, in this paper, the experience of SUA's Computer Centre. We did explain the network related issues and how to implement the BMO using FOSS tools.

According to Weerawarana and Weeratunga [2004], FOSS is better suitable to be adopted in Africa environment for BOM since: (i) FOSS can cost less to acquire and run than proprietary software (ii) FOSS can ease the burden of software license management (iii) FOSS can be robust and secure (iv) FOSS can help discourage software piracy which is one of the major problems in Africa's software industry and (v) FOSS can be a useful teaching and learning tool in ways proprietary software can't match. Thus, the use of FOSS in university of developing countries has economic, social and culture advantages. Economic advantages arise from reducing the cost of procuring the software, reducing foreigner currency to buy the software outside the country and retaining the money by supporting local company involved in providing FOSS training. Social advantage arise from the software development methodology of FOSS where by software is produced for the people and by the people of different communities in the world. Thus the end product is owned by the whole communities. Culture advantage arises from the fact that any FOSS tools allow customization and localization as per culture values of the concerned society. Additional potential advantages includes increasing choice and competition among the stakeholders of software industry, positioning software as public good, increasing technological self reliance, reducing vendor lock-in, minimizing security risks, and cost savings.

Internet services access at SUA has emerged to be developing fast, and bandwidth management and optimization (BMO) appears to get due attention. With the large numbers of computers that are being added to SUA's Local Area Network (LAN), and the fact that the Internet bandwidth is already fully utilised, it would not be surprising if more bandwidth is purchased in the near future. This is in turn will necessitate future study to be conducted to investigate how we can migrate to a better Internet Service Provider (ISP) with affordable cost (i.e. within our budget).

6. REFERENCES

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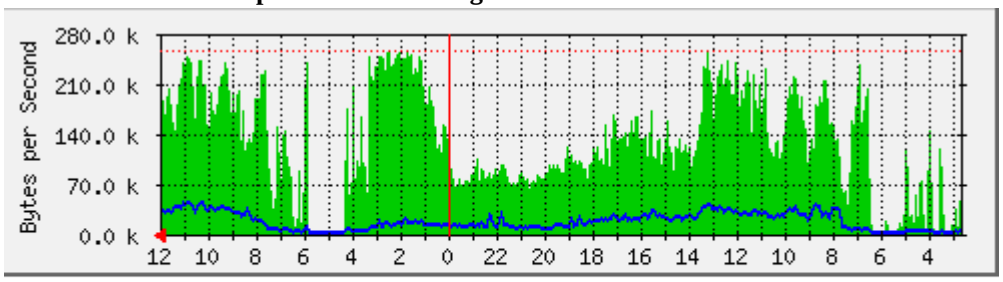
7. APPENDIX

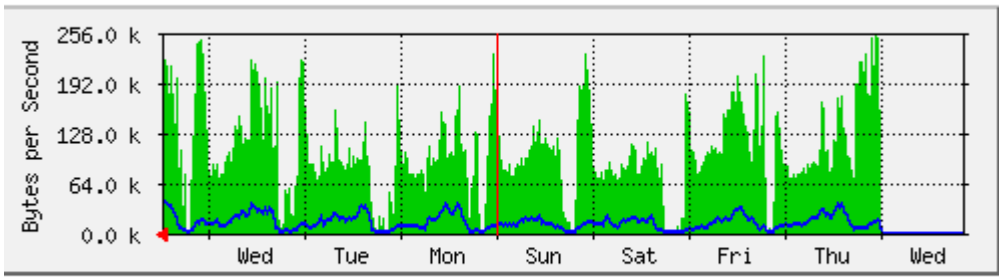
Results from BMO implementations using FOSS



	Max	Average	Current
In	254.7 kB/s (99.5%)	127.6 kB/s (49.9%)	222.2 kB/s (86.8%)
Out	44.1 kB/s (17.2%)	17.0 kB/s (6.7%)	33.7 kB/s (13.1%)

Figure 2: Traffic analysis using MRTG at 22 April 2010

'Weekly' Graph (30 Minute Average)



	Max	Average	Current
In	254.2 kB/s (99.3%)	106.6 kB/s (41.6%)	190.9 kB/s (74.6%)

Figure 3: Traffic analysis using MRTG at 22 April 2010

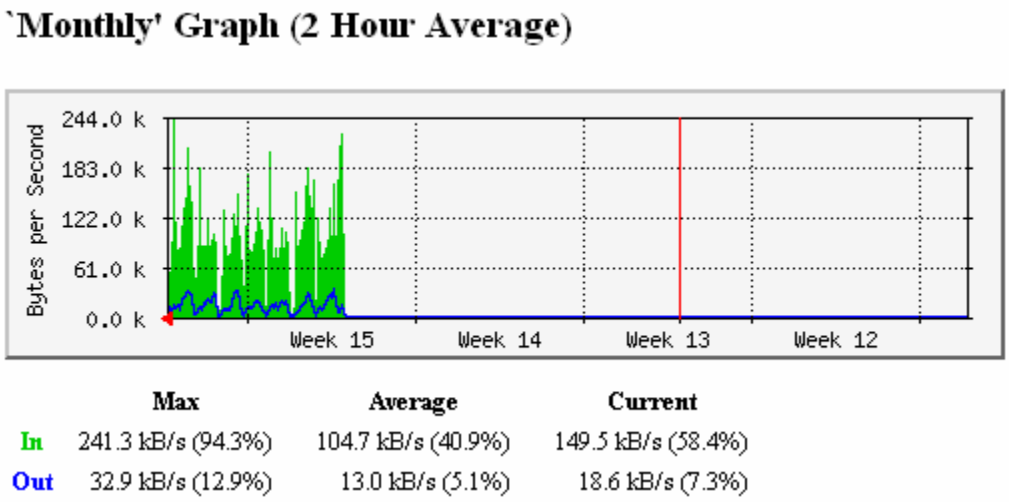


Figure 4: Traffic analysis using MRTG at 22 April 2010

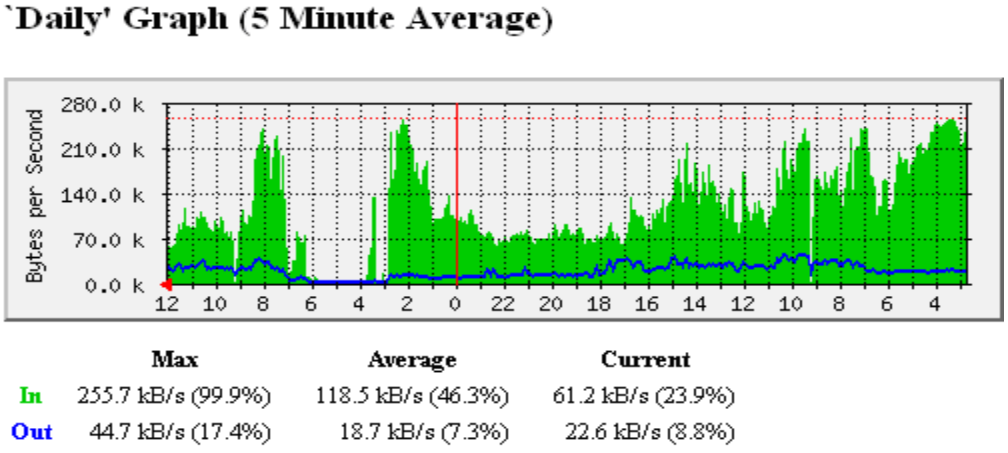


Figure 5: Traffic analysis using MRTG at 22 April 2010

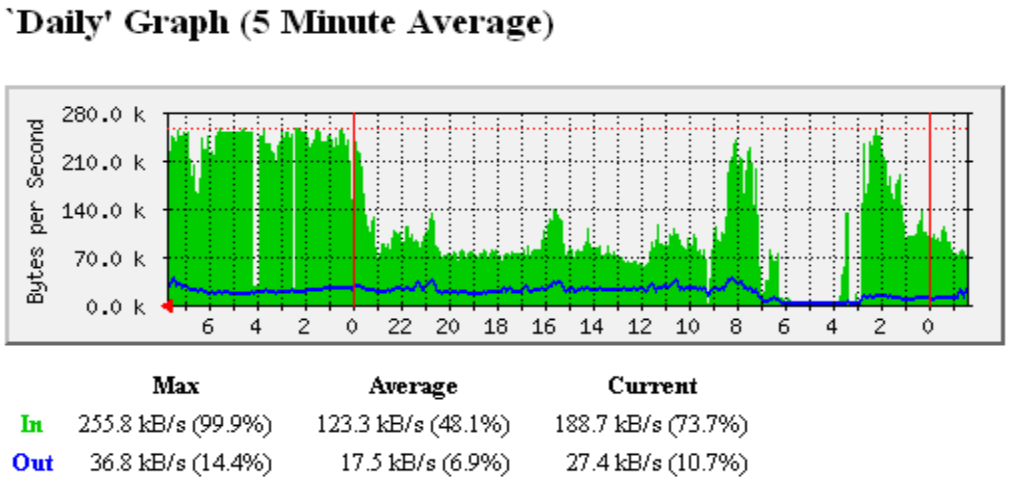


Figure 6: Traffic analysis using MRTG at 24 March 2010

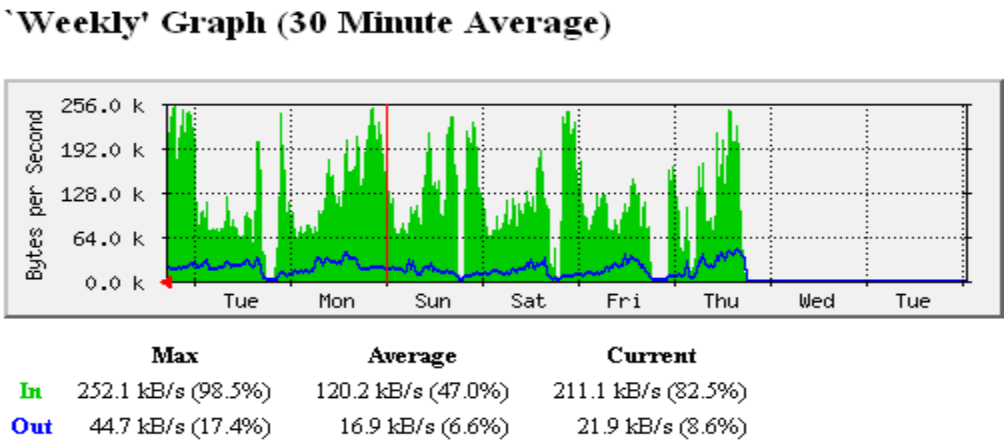


Figure 7: Traffic analysis using MRTG at 24 March 2010

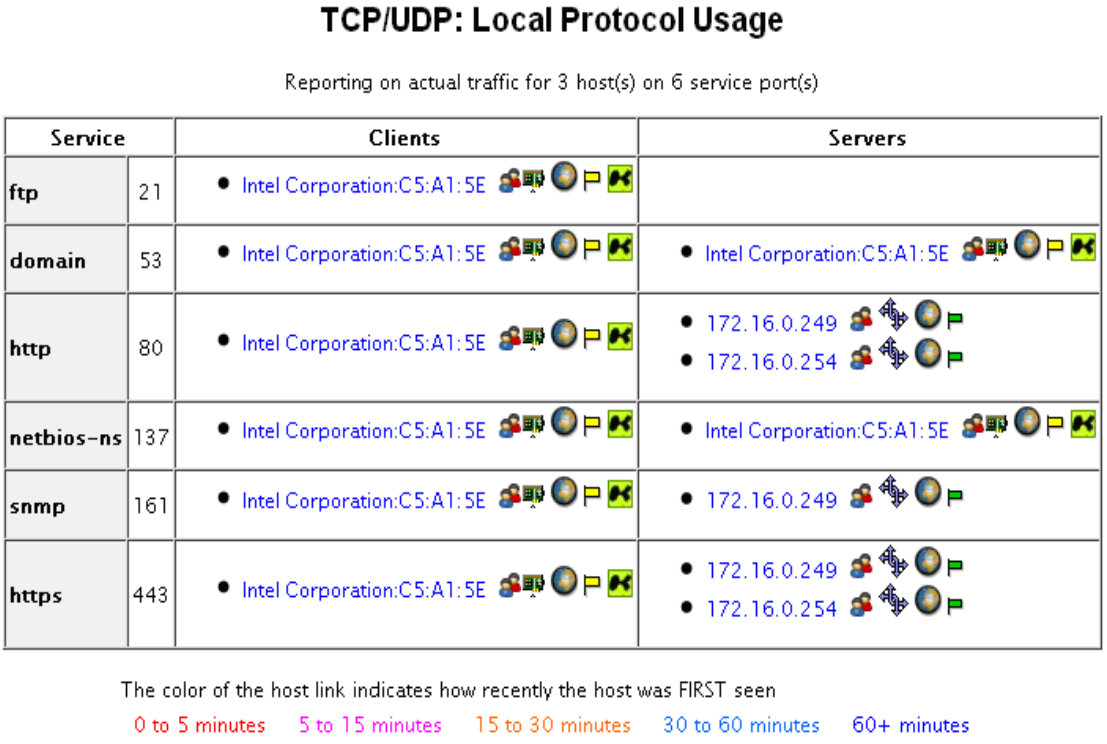


Figure 8: Local Protocol Usage

Active TCP/UDP Sessions

Client	Server	Data Sent	Data Rcvd
Intel Corporation:C5:A1:5E :36065	173-17-112-190.client.mchsi.com :https	23.8 KBytes	14.9 KBytes
Intel Corporation:C5:A1:5E :60147	d.yimg.com :http	1.0 KBytes	80
Intel Corporation:C5:A1:5E :36772	httpcs104p2.msg.ac4.yahoo.com :http	1.1 KBytes	160
Intel Corporation:C5:A1:5E :38144	us.mg2.mail.yahoo.com :http	1.3 KBytes	80
172.16.3.229 :61925	Intel Corporation:C5:A1:5E :squid	23.4 KBytes	0
Intel Corporation:C5:A1:5E :60842	d.yimg.com :http	3.1 KBytes	82.1 KBytes
172.16.3.35 :62568	Intel Corporation:C5:A1:5E :squid	1.8 KBytes	0
172.16.3.35 :62590	Intel Corporation:C5:A1:5E :squid	1006	0
172.16.3.35 :62628	Intel Corporation:C5:A1:5E :squid	754	0
172.16.3.35 :62632	Intel Corporation:C5:A1:5E :squid	639	0
172.16.3.35 :62636	Intel Corporation:C5:A1:5E :squid	639	0
172.16.3.35 :62655	Intel Corporation:C5:A1:5E :squid	634	0
172.16.3.35 :62661	Intel Corporation:C5:A1:5E :squid	519	0
172.16.3.35 :62663	Intel Corporation:C5:A1:5E :squid	519	0
172.16.3.35 :62681	Intel Corporation:C5:A1:5E :squid	372	0

Figure 9: Active TCP / UDP sessions

Network Throughput: All Hosts - Data Sent+Received

Hosts: All

Data: All

Host	Location	Data			Packets		
		Current	Avg	Peak	Current	Avg	Peak
Intel Corporation:C5:A1:5E		2.4 Mbit/s	1.0 Mbit/s	25.1 Mbit/s	836.8 Pkt/s	273.6 Pkt/s	2785.2 Pkt/s
a248.e.akamai.net		127.7 Kbit/s	2.0 Kbit/s	1.1 Mbit/s	21.9 Pkt/s	0.3 Pkt/s	133.1 Pkt/s
d.yimg.com		70.4 Kbit/s	1.9 Kbit/s	208.7 Kbit/s	17.1 Pkt/s	0.4 Pkt/s	50.0 Pkt/s
172.16.3.5		58.7 Kbit/s	7.2 Kbit/s	514.2 Kbit/s	45.1 Pkt/s	4.5 Pkt/s	245.0 Pkt/s
mail.yimg.com		55.9 Kbit/s	1.4 Kbit/s	771.0 Kbit/s	13.0 Pkt/s	0.3 Pkt/s	102.8 Pkt/s
us.i1.yimg.com		39.8 Kbit/s	371.9 bit/s	170.4 Kbit/s	8.0 Pkt/s	0.1 Pkt/s	31.8 Pkt/s
172.16.2.158		37.3 Kbit/s	421.0 bit/s	124.6 Kbit/s	11.1 Pkt/s	0.1 Pkt/s	37.3 Pkt/s
ads.yimg.com		37.3 Kbit/s	594.0 bit/s	114.3 Kbit/s	10.8 Pkt/s	0.1 Pkt/s	33.8 Pkt/s
west.thomson.com		30.8 Kbit/s	8.4 bit/s	30.8 Kbit/s	6.6 Pkt/s	0.0 Pkt/s	6.6 Pkt/s
attach.mail.vip.ukl.yahoo.com		29.1 Kbit/s	90.3 bit/s	65.5 Kbit/s	8.5 Pkt/s	0.0 Pkt/s	12.6 Pkt/s
www.yahoo.com		26.8 Kbit/s	244.1 bit/s	68.7 Kbit/s	4.9 Pkt/s	0.1 Pkt/s	12.0 Pkt/s
safebrowsing-cache.google.com		24.4 Kbit/s	10.8 bit/s	26.7 Kbit/s	4.6 Pkt/s	0.0 Pkt/s	5.1 Pkt/s

Figure 11: Network Throughput

ICT Driven E-Governance Public Service Delivery Mechanism in Rural Areas: A Case of Rural Digital Services (Nemmadi) Project in Karnataka, India

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Abstract

Information and Communication Technologies (ICTs) are playing a vital role in day-to-day public services. In the realm of machinery of Government, the ICTs application areas are promising to enhance the service delivery and improve the process and management of Governmental functionaries. This paper traces the current round of discussions on the appropriate roles and scales of Government with respect to ICTs driven e-governance application for enhancing service delivery in rural areas.

The paper reviews the efficacy of the policy framework in context of service providers and enhancement in delivery of goods and services to the rural society. The main issues related to service delivery are the role and multiplicity of organization, the coverage of services, and actual deliveries of goods and services. This is largely dictated by the preparedness of the service provider and as well as the extent of innovative technology used.

Karnataka is one of the pioneering States in India with respect to adopting innovative information technologies. The author has chosen to review on ICT driven e-governance Rural Digital Services (Nemmadi) project in Karnataka. It works at taluk level, covering about 38 citizen-centric services to the rural citizens. The vision of Rural Digital Services (Nemmadi) project is to empower the rural citizens, provide direct access of government services to the citizens and bring government services to the doorstep of the citizens thereby bridging the digital divide in Karnataka.

Key Words: E-governance, Public Service Delivery, Machinery of Government, Rural Digital Services, Citizen-Centric Service

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1. INTRODUCTION

Information Technology (IT) is emerging as a major instrument for shepherd in administrative reforms. The information technology that have changed ways of public services delivery system and promising efficient and enhanced service delivery to citizens. The current trend in Information and Communication

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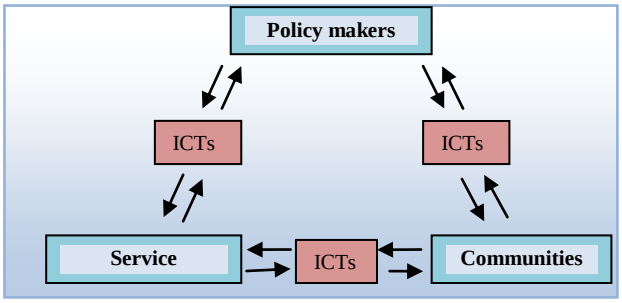
Technology (ICT) has brought a phenomenon which can be termed a "fourth revolution" in information technology. The first revolution comprised of films, radio, television and satellite broadcasting, while the second comprised telecommunications and microcomputers [Paisley, 1985]*. The third revolution what is called as Information Technology was said to promise not only a more productive person, a problem-solver and a lifelong learner, but also a better informed, rational and participative citizen, a modern 'renaissance' person, living in the web and network of a worldwide electronic community [Papagiannis et al, 1987] †. At present we have "fourth revolution" called as applications of Information and Communication Technology. ICT presents many avenues for improving governance. It has opened up new opportunities for governments to manage things differently and in a more efficient manner by utilizing information effectively and re-engineering processes. ICT tools are emerging as important instruments towards the goal of "good governance".

2. ROLE OF SERVICE DELIVERY PROVIDER

In India, according to 2001 census about 72 percent of population living in rural areas and majority of them are poor without access to basic services such as potable drinking water, sanitation, basic health care services, access to primary education etc. There are no institutionalised standards for the delivery of public services. Therefore, there always appears to be an unending struggle between the governmental systems, its capability to deliver and the actual needs of the citizens. For several decades public services have unfortunately been provided with the primary focus on convenience of service providers rather than on service receivers. Various factors like complex regulations, complicated forms, lack of information, absence of performance standards, lack of accountability, corruption and incompetence have left recipients of public services, or ordinary citizens, helpless, dissatisfied and frustrated. In many cases, the lack of implementation and absorptive capacity of government agencies and citizens respectively are problems that hamper efficient service delivery.

The delivery of services requires strong relationships of accountability between the actors in the service delivery chain. The main actors involved in service delivery sequence are central policy makers, state policy makers, service provider and general public. There is a need for accountability between Central and Local Policy makers and service providers. As depicted in Figure 1, new information and communication technologies (ICTs)‡, and e-governance applications can provide essential tools and mechanisms for poor communities to hold both policy makers and service providers accountable for a sustained supply of services. Therefore, e-governance would be mechanism for enabling transactions of governments which aid in governing a state or a community.



* W. Paisley, **Children, new media and microcomputers: continuities of research.** *Children and microcomputers: Research on the Newest Medium, 1985.*

† Papagiannis, G.J., Douglas, C., Williamson, N. and Le Mon, R., **Information technology and education-Implications for theory, research and practice.** IDRC, Canada, 1987.

‡ UNDP, **Pro-Poor Public Service Delivery with ICTs Making local e-governance work towards achieving the Millennium Development Goals,** APDIP e-Note 11 / 2007

Figure 1: Enhancing accountability, transparency and efficiency with e-governance

The ongoing challenge for government is that there are more people to serve, more services to provide, and greater investment is needed in "government preparedness." At the same time, most government organizations are being asked "to do more with less," and that places even more pressure on them to creatively and effectively leverage available technologies. The National e-Governance plan envisages the setting up of a state data centers (SDC) across the country and share infrastructure, allowing departments to access information easily and also cut costs in the process. The key interests of the main stakeholders are:

- **Government** - ensure the delivery of government services in effective and efficient manner;
- **Private partner** - growth opportunities through expansion of the domain and profitability; and
- **Citizens** - quality delivery of public service.

3. MACHINERY OF GOVERNMENT IN INDIA

The new Oxford English Dictionary defined as **'**Government is the sum total of the systems by which a state or community is governed'. The machinery of government in India comprising of three tier system; Union Government work at country level, State Governments work at State level and Local Self-Governments work at local level. Further local self governments are divided into Urban Local Bodies and Rural Local Bodies. When comes to Rural Local Bodies, the Karnataka Panchayat Raj Act, 1993 provided for a three-tier structure of local government with the Zilla Panchayat (ZP) at the district level, Taluk Panchayat (TP) at the middle level and Grama Panchayat (GP) at the grassroots level. The Zilla Panchayat (ZP) stands at the apex of Panchayat Raj System; the Taluk Panchayat is the middle tier and the Gram Panchayat, the lowest tier. The state of Karnataka was one of the very few states which took important steps to usher in decentralised governance, much before Panchayat Raj as a form of decentralised governance was acknowledged and institutionalised through constitutional amendments.

4. A CASE OF RURAL DIGITAL SERVICES (NEMMADI)[*] PROJECT IN KARNATAKA

Karnataka had a population of about 52.73 millions according to 2001 census, out of which about 66 percent of State population live in rural areas, about 56,682 rural habitats including 27,683 revenue villages. At present, there are 30 Zilla Panchayats, 176 Taluk Panchayats and 5,653 Grama Panchayats in the State. Karnataka State was at the forefront of India's ICT revolution and its capital, Bangalore, was the centre of the country's ICT industry. It is the home of new IT legends like Infosys Technologies and Wipro. Software exports from the state have been growing in dollar terms in the last ten years. A large number of IT startups have come up, and the state has been written about in business magazines around the world.

The Government of Karnataka was introduced 'one-stop -shop' Citizen Service Centres, which allowed members of the public to use a range of services electronically. *The Rural Digital Services (Nemmadi)* initiated in 2007, were originally intended to use Information and Communication Technology (ICT) to simplify procedures, ensuring transparency and improving the quality of the government's relationship with citizens as well improving overall citizen satisfaction. The Karnataka Government was justifiably proud of its United Nations award winning land registration and records system, *Bhoomi*[†]. All levels of the revenue department from the village accountant to the Deputy Commissioners (District Collectors) had been exposed to a very successful implementation of an e-governance program. Because of the bhoomi program, the computing infrastructure for deployment of an e-governance program like servers and connectivity to a central database was available at the taluka office of the revenue department. *The RDS (Nemmadi)*, through a network of 800 telecenters at the *Hobli* (group of villages) level, is an IT

[*] Meaning ***'hassle free'*** in the local language Kannada

[†] The *Bhoomi* (meaning 'land') project of online delivery of land records in Karnataka

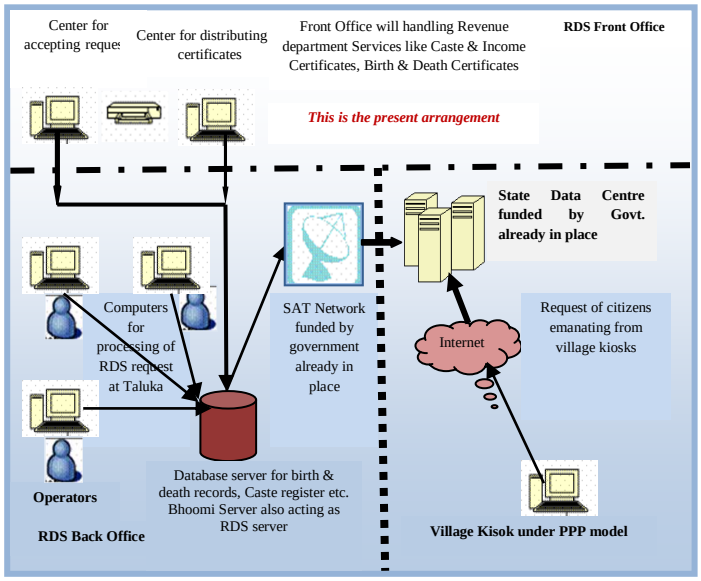
enabled rural initiative to deliver Government services at the citizen's doorstep. Through *Nemmadi* rural citizens can avail of Rural Digital Services (certificates issued by the Revenue department) as well as other services*.

5. BUSINESS MODEL

The RDS (Nemmadi) project was bagged by a consortium of IT firms – M/s Comat Technologies, 3i InfoTech, and n-Logue technologies. The initiative involves the deployment of 800 telecenters to supplement the 177 existing land record service (Bhoomi) kiosks that operate sustainably at the sub district level. The state government owns the project. As part of the build-operate-transfer (BOT) model, M/s Comat build, deploys, and maintains the kiosks for an initial five years. M/s Comat and its partners expect to recover their investment in equipment, infrastructure, and human resources within that five-year period. Services delivered through the RDS, comprising more than 38 government processes, include copies of land records, approval of old age pension for senior citizens, issue of caste certificates, issue of income certificates, birth & death certificates, land holding certificates etc. A fixed transaction charge of Rs. 15 is levied for each service and the private partner is paid a part of the transaction charges.

6. COMPONENTS OF RDS (NEMMADI) PROJECT

The RDS comprises of the following components: a) State Data Centre- Karnataka has been one of the first states to create a State Data Centre for both hosting all e-governance applications of the state and acting as a disaster recovery centre. The State data center is service delivery channels to departmental servers were directly connected to the internet; b) Wide Area Network- The current delivery of RDS services, the State government has set up a network of VSATs linking each of taluka servers to the State Data Center; and c) Delivery Channels - Taluk servers are both local repository of data and additionally data updation. Village Telecenters are another channel for the citizen to make requests and access. In most cases these Village telecenters comprises of one or two computers with associated peripheral devices such as printers, scanners, web cameras and they connect to the internet through various dialup technologies.



* Electricity bill collection and other services such as education through *Sarva Shiksha Abhiyaan*, collection of panchayat taxes, data entry for various departments and data updation of hand held devices.

Figure 2: Diagrams of RDS components in Revenue department Source: Reproduction from RDS (Nemmadi), Government of Karnataka

The various components of RDS (*Nemmadi)* are shown in Figure 2. The village level telecenters are the channels of delivery of various G2C services to rural citizens. The requests received at the kiosks are processed at the taluka back offices, which is connected to the government offices. *Nemmadi* and *Bhoomi* projects use the same database at the taluka levels, which is updated constantly. The consolidated database of land records of the entire state is maintained at the State Data Center (SDC). Requests for the *Nemmadi* services are transferred to the taluka servers through the SDC. Subsequent to receiving the electronic request from the Telecenters through the SDC, the request is processed by appropriate authority (*Tehsildar)*[*] for verification and validation. On receiving the comments of such appropriate authority, the final certificate is generated and is digitally signed by the competent signatory, which is then downloaded at the village telecenter and issued to the applicant see Figure 3.

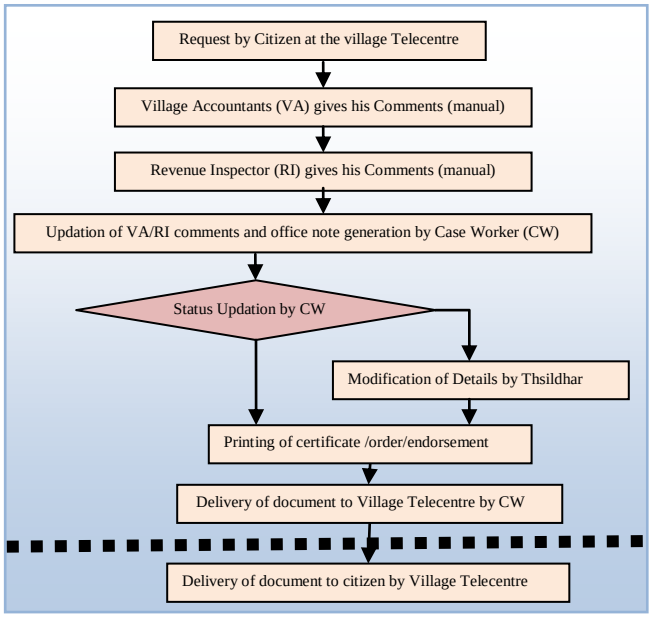


Figure 3: a typical workflow process for delivery of service at taluka that was computerized through the Rural Digital Services

7. SOFTWARE FOR RDS SERVICES

The software for delivery of RDS services was developed on the Microsoft Platform and uses MS SQL Server. It has several innovative features like multiple modes of delivery of services. Some of the software features are given below:

- Reports - Use of RDS software allows one to track the delivery of certificates and also to monitor and thereafter rectify the delays in processing of the citizen service requests.

[*] A tehsildar is revenue administrative officer in Pakistan and India in-charge of obtaining taxation from a tehsil, meaning tax collector. (http://en.wikipedia.org/wiki/Tehsildar) (Accessed on 7th July, 2009).

- Offline functionality - The RDS software has been built on a rich client model with the master data being stored in the local machine also. This allows the application to deliver both online and offline functionality, i.e. service requests of the citizens at the village telecentre can be saved in the local telecentre machine even when connectivity to the SDC is not available. The advantage of this functionality is that citizen can make the service request even when internet connectivity is not available.
- Use of digital signature - The RDS software has a feature of digital signature by the issuing authority. The RDS software generates an XML of this digitally signed certificate and displays it as a 2 D bar code. This feature can help both in checking the authenticity of the certificate and can be later used to dispense with the physical signature of the official on the certificate.
- Smart update facility - Since the RDS client is a rich client application, there is a need for constant updates for incorporating new functionalities. However, since the village telecentres will be located in remote places, the smart update facility will help in maintaining uniformity of the software application across all delivery points.
- Biometric authentication - Finger print authentication for login and updation is used for non-repudiation by the government officials.
- Unicode - Unicode is being used to store data in the local language. The software can be customized to allow multi-language user interfaces. Currently Kannada and English languages are supported.

8. PERFORMANCE EVALUATION OF RDS (NEMMADI) PROJECT*

The performance evaluation analysis was done by Indian Institute of Management, Bangalore during June-July, 2008. The study covered 300 service users from 4 villages were selected in two districts of Karnataka viz., Ramanagara and Chamarajanagara were interviewed. The citizen survey and opinion about efficiency of service delivery data reveals that that service provisioning through these centers have significantly reduced the time taken to obtain RTC, Land holding certificates etc. The level of citizens' satisfaction of various attributes of services at RDS (*Nemmadi)* centers, data reveals that citizens are highly satisfied with the new delivery process, speed and responsiveness of staff, while accuracy of services and records as well as facilities at the centers were satisfactory in both the districts. Whereas in the pre - RDS (Nemmadi) days, where citizens had to wait for the visit of village accountant to initiate the process of obtaining certificate.

The RDS (Nemmadi) project bags the National Award for e-governance - Silver Award for 2007 - 2008, Microsoft e-governance leadership Award for 2007 and Government Technology Award for e-governance, 2007

9. CONCLUSION

In the wake of increasing challenges to deliver quality of public services in developing counties like India, ICT driven e-governance applications making the citizens happier with timely and cost savings in availing services and improvement in the reliability of services. Special emphasis is needed in working out revenue models, ensuring the full implementations through appropriate tenure appointments of project champions, ensuring effective monitoring and maintenance of systems. It is important to understand the 'whys', 'which' and the 'how's' of public service delivery. It is very difficult to define this term. We do not have any comprehensive definition or understanding of what really is public service delivery. Briefly put, it is the inter-relationship between the government functionaries and the citizens to whom the services of the government are addressed to, and the manner in which the services reach those for whom they were intended. Any effective public service delivery mechanism must ultimately lead to good governance. The

* Gopal Naik, K .P. Basavarajappa, Nageena Sultana and Prasanna Rashmi K K, **Public Value Creation through Private Partnership: Lessons from Public Service Delivery in Karnataka,** IIMB, June- July, 2008.

governments generally utilise one or the other of a variety of mechanisms for delivering services to the citizens. There is no limit to the scale of such composite applications. Once the structure is in place, governments can more easily get down to the business of public services.

The RDS (Nemmadi) project is different from most models that currently exists is that its services are based on volume rather than the high-up front costs that other models have difficulties supporting. For example, 20 million land records divided by 176 taluk offices results in 113, 636 records per back office. Priced at Rs. 15 (US$0.32) per RTC certificate, this average to Rs. 1, 704, 545 (US$ 36, 823) per office revenue per year. This is sufficient to cover operating costs, provide a modest return to State revenues, ensure good service levels and result in profit making proposition for private investors such as M/s Comat Technologies and its partners. For other services, such as issues of birth and death certificates, Caste certificate etc. yields supplementary revenue to the Service provider. A key challenge for public service delivery is in designing and implementing a system that holds service providers accountable for the services delivered. Even if the clients are able to reach the policy makers, this does not necessarily lead to improved services because the policy makers cannot ensure that the public service provider (whether public, private or civil society) will deliver the services due to an equally long route of accountability between the policy makers and the service providers[*].

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