WIMAX WITH WI-FI: OPENING NEW FRONTIERS IN EDUCATION

K.R.Santhi[1] and G. Senthil Kumaran[2]
Kigali Institute of Science and Technology (KIST), Kigali, B.P.3900, Rwanda.
[1]Email: santhikr@yahoo.com , +250 08594505,
[2]Email: kumarangs@yahoo.com , +250 03000813

Key words: WiMAX, Wi-Fi, Mesh, broadband, HE

Abstract

Connectivity is vital to any country to usher in economic growth, better education and healthcare and improved entertainment services as it has done elsewhere in the world. And the solution must be wireless, to avoid the overwhelming cost and resources that would be required to deploy countrywide fixed-line broadband Internet infrastructure. Some countries, where there is not an established wired communication network, are investigating the potential of broadband wireless technologies to support learning and teaching in remote areas. In order to widen the participation in Higher Education (HE) there is a need for more flexible delivery and study of courses to satisfy the needs of this wider audience. The lack of physical connectivity or telecommunications infrastructure and the cost and lack of broadband technologies are a big hindrance to more widespread participation of people in HE. Broadband wireless technologies like WiMAX with Wi-Fi are beginning to offer reliable alternatives to fixed-line access, offering the potential for widespread, affordable connectivity to every education institutions viz Schools and Colleges, in the rural areas. This paper addresses the potential uses of wireless and mobile technologies and identifies some recent technical developments. It considers how their use might be developed within existing learning and teaching paradigms and it identifies some new models for providing connectivity to rural Educational Institutions.

1. Introduction

The education sector is being accorded top priority by governments in developing countries,

as a means of building a reservoir of competent leaders and skilled personnel who will guide and sustain the region's current pace of development. As a result, both the government and private sectors are directing huge technological inputs towards improving educational content and delivery systems and in upgrading infrastructure. Wireless is one of the most important technologies of the century, influencing the nature of business, commerce, education, and society for all time to come. WiMAX with Wi-Fi offer new ways to approach emerging learning environments that holds immense potential like lifelong learning, e-learning, distance learning, home learning, virtual classrooms and mobility between different locations of study in campus based learning. This paper will address in detail: (i) Potential uses of broadband wireless technologies like WiMAX and Wi-Fi and identifies some recent educational developments using these technologies in the world. (ii) How their use might enable education empowerment within existing learning and teaching environments (iii) how it supports connectivity to Educational Institutions in rural areas and provides mobility in campus where connectivity is already available and finally (iv) to generate awareness of the many advantages of wireless connectivity and the mobility it brings to the learning environments.

*1 Author for correspondence

2. Technical Overview of Major Wireless technologies

Broadband wireless technology offers a number of concrete benefits over that of wireline. They are as follows [2]:

a. reduced cost as compared to deployment of new wired infrastructure;

b. enhanced operational flexibility, in particular: more freedom in placement of equipment; reduced installation interval; lower barrier to switching or upgrading infrastructure; and ability to move and redeploy equipment as needed with minimal incremental cost.

Moreover, Broadband Wireless technology has built a bridge over some of the education gap.

Let us see the technical overview of some of them.

2.1 Wireless Fidelity (Wi-Fi)

802.11 WLAN often called Wi-Fi (Wireless Fidelity) uses the license-free 2.4 GHz frequency band and has become popular for its capability to provide high-speed Internet access at low cost.. The ease of use and low cost are in turn driven by the adoption of the Wi-Fi standard by equipment manufacturers, thus ensuring interoperability among Wi-Fi devices. Wi-Fi is arguably the most ubiquitous form of broadband Internet access in the world [2].

2.2 Worldwide Interoperability of Microwave Access (WiMAX)

WiMAX is a standards-based wireless technology that provides high-throughput broadband connections over long distances and it operates in a licensed spectrum. This is based on a mesh structure and it is capable of delivering broadband Internet and, extending services beyond the physical building constraints encountered with Wi-Fi. WiMAX offers a fast, affordable, convenient solution to Internet access needs [1]. As WiMAX becomes more widely available it could offer opportunities for educational use with groups interacting wirelessly within a much broader virtual classroom [3].

A key characteristic of this standard is a differentiated approach to the Media Access Control (MAC) layer; in contrast to Wi-Fi, the WiMAX MAC can support a range of physical (PHY) physical layer implementations, thus substantially freeing equipment vendors in developing solutions for different applications and vertical markets.

2.3 Wireless Mesh Networking (WMN)

A WMN is a communications network made up of radio nodes organized in a mesh topology.

Meshed networks self-configure and self-heal by dynamically sharing information, almost in real-time, between all the access points in a wireless network. If a mesh link becomes obstructed in the event of a device failure, client traffic is dynamically re-routed, ensuring uninterrupted communication through the other available access points. In the mesh network,

the core configuration is an array of access points or base stations, all managed by a mesh
routing protocol which determines the optimal path across the network at any given time [2].
The advantages of a mesh topology are route diversity and redundancy, thus maximizing the
performance of the network. Wi-Fi/WiMAX mesh uses such concepts as cellular-equivalent
"picocells" for node proximity and non-line-of-site mesh routing around obstacles.
237

2.4 UltraWideBand (UWB)

Ultra wideband is a wireless technology for transmitting large amounts of digital data over a
wide spectrum of frequency bands with very low power for a short distance. UWB signals are
usually very difficult to detect. The amount of spectrum occupied by a UWB signal, i.e. the
bandwidth of the UWB signal is at least 25% of the center frequency. Thus, a UWB signal
centered at 2 GHz would have a minimum bandwidth of 500 MHz and the minimum
bandwidth of a UWB signal centered at 4 GHz would be 1 GHz. High data rate UWB can
enable wireless monitors, the efficient transfer of data from digital camcorders, wireless
printing of digital pictures from a camera without the need for an intervening personal
computer, and the transfer of files among cell phone handsets and other handheld devices like
personal digital audio and video players. Intel researchers are working on a variety of UWB
technologies, including a platform for next-generation development efforts, and believe it
will be a critical step in enabling advanced communications for a wide range of uses in the
future [7].

2.5 Free Space Optics (FSO)

FSO is a telecommunication technology that uses light propagating in free space to transmit
data between two points. The technology is useful where the physical connection of the
transmit and receive locations is difficult, for example in cities where the laying of fibre optic

cables is expensive. FSO uses lasers to transmit data, but instead of enclosing the data stream in a glass fiber, it is transmitted through the air. Unlike radio and microwave systems, FSO is an optical technology that operates in invisible parts of the optical spectrum at near-infrared wavelengths and no spectrum licensing or frequency coordination with other users is required, interference from or to other systems or equipment is not a concern, and the point-to-point laser signal is extremely difficult to intercept, and therefore secure. Transmission is highly directional making it far more secure than RF technologies but also requiring that the two points to be connected be within line-of-sight of each other.

2.6 Virtual Fiber

Virtual Fiber Connectivity is a line-of-sight technology that uses lasers to provide optical bandwidth connections [9]. This is a point-to-point wireless system using very high radio frequency (71-76 GHz and 81-86 GHz) to transmit up to 2.5 Gbps of data, voice, and video communications. For example a ninety minute movie will download in one second.

3. Impact of Wireless Technologies in Higher Education

The emergence of wireless technologies and various solutions to extend the capability of the wired world to a mobile secured environment in and out of the classroom is rapidly becoming the norm in providing education programs to students of all ages. At the same time, teaching methodologies have also evolved to encompass concepts such as e-learning, distance learning, home learning, and lifelong learning. To support these different types of learning the modern curriculum has been reformed. Such emerging learning environments and the need for flexible hours in learning environment are driving forces to advocate for wireless networking technologies and hence wireless campuses. This will result in some learners moving between school, workplace and home. Mobile and wireless technologies offer new

ways to approach both learning and assessment. They could provide the following: [3]
238
a. both synchronous and asynchronous communication with peers and teachers
b. collaborative features enabling the sharing of material
c. the facility to access resources, including online communities from local and worldwide
repositories via the internet
d. delivery of multimedia content.
The integration of technology in assessment activities has led many universities to use an
online Learning Management System (LMS) to present electronic content and control aspects
of course management relating to assessments and organization etc. that will facilitate online
learning. Wireless is clearly exploding across university campuses as it has in the corporate
and consumer sectors and educational applications, IT services and management solutions are
growing fast in higher education. Below are some scenarios that how higher education must
address the contribution of wireless beyond convenience to its potential impact on teaching,
learning and research.

3.1 Conventional networked Campus

Some of the most mobile and connected people in our society can be found in the education
community. So broadband wireless technology has become the present and the future of
education. It has changed the way instructors teach by relieving them from having to rely on
the book and straight lecture as the only tools. It has made learning much quicker than
looking for a book or something. Wi-Fi solutions within campus allow the possibility to
extend the physical space of the classroom in to other areas while maintaining access to
online resources. Wi-Fi goes from buildings to green spaces to the football stadium and other
athletic facilities.Thus WLAN solutions provide the necessary functionality, simplicity, and
trust to ensure an enriched learning environment.

3.2 Extended networked Campus

Not only within campus connectivity is needed, but extended campus offers more flexibility.
This supports both synchronous and asynchronous communication and collaboration. We can
build-out an Education Network linking schools and universities with Wi-Fi network. This
Inter-campus Wi-Fi network will facilitate students and educators of K-12 and higher
education campuses to seamlessly log into any other member campus' educational wireless
network. This will allow the educational community to extend their learning experience by
leveraging wireless networks of other schools and universities across the country.
Every member campus will become accessible to students, staff, and faculty via this network.
This single interconnect will allow the institution's IT department to dedicate scarce resources
just once, effectively growing the access available to their students and faculty without
having to dedicate additional IT resources and without changing the existing deployed
architecture[4].

3.3 Connected Rural Schools

Connectivity is important for the rural schools to participate in the extended campus
environment. Some countries where there is not an established wired communication network
must find ways to use cost effective hybrid wireless networks for education to the reach the
unreached sections of the society. This will increase the opportunities for students to do
online learning , to participate in audio/video conferencing, to research by accessing eresources
from other schools and universities etc.. WiMAX plays a major role in providing cost effective access to rural areas.

4. Need for Connectivity and Mobility in Higher Education

In the world today, we have the potential to know and be able to access any kind of
information that has ever existed. While students may not want to have all that information

every minute, they do want to be able to access it whenever they need. So for colleges and universities to attract the Mobile (M)-generation of students, it is mandatory to provide wireless connectivity and mobility with broadband technologies like WiMAX with Wi-Fi.

Connectivity and mobility in Education is a necessity for the following reasons:

(i) Traditional campus based education often reaps the benefits of the proximity of groups of learners. Even then connectivity and mobility are required in the campus to fulfill student expectations to generate self-help groups, opportunities for informal discussion, and support prescribed group work. Wi-Fi access will provide campus educational wireless network.

(ii) Today's educators and students demand an always-connected, everywhere wireless campus environment [4]. WiMAX provides the backhaul for Wi-Fi access points and provides anytime, anywhere connection.

(iii) Internet services provide a means for students to stay connected with their friends in another campus through e-mail, audio or video chat, and to browse the Internet for job and academic opportunities.

(iv) Over 55 percent of all educational documents are electronic at this point [1] and broadband connectivity is very important to access these educational materials.

(v) Schools and libraries in rural or remote areas without wired infrastructure or broadband services can be cost effectively connected to broadband using WiMAX, so that the students in rural areas could videoconference with educators across the country, and use Internet telephony services, like Voice over Internet Protocol (VoIP) [1].

(vi) Lecture classes from urban schools and top universities can be broadcast to rural students, and the students could use the broadband facilities of WiMAX for communicating with teachers and with their remote classmates. This will allow the educational community to extend their learning experience by leveraging wireless networks of other schools and universities across the country.

(vii)Universities providing distance education is increasing its use of online collaborative
activity and content and an online LMS to present electronic content and control aspects of
course management relating to assessments and organization etc. With higher bandwidth and
faster speeds, broadband Internet can make education more accessible by delivering
interactive distance education at a low cost.
(viii) Broadband wireless technologies help to bring our education customers the power of
being linked together. This will allow them to provide new services that give their students
more educational value while keeping operational costs low.

5. Broadband Hybrid Wireless Network (BHWN)

The potential of wireless communications is to break down traditional wired boundaries,
bridge digital divides and stimulate economic growth [2]. Although a range of new
technologies have emerged, including WiMAX, Wi-Fi and WMN, each one addresses a
specific network segment or application, and that no single technology fits all applications,
and also the necessary complementary technologies have differed in terms of stages of
development. So it will be critical to use these technologies in tandem to create truly scalable
broadband wireless networks. One limitation is that many vendors focus on selected

technologies and applications, thus increasing the complexity of evaluating, procuring,
installing, managing and maintaining different parts of the network. However, standards
based broadband wireless technologies particularly Wi-Fi, WiMAX, WMN are interoperable
and have matured to the point of being deployable in a single, connected network, and
furthermore such solutions can now be sourced from a single vendor. This is the concept of a
scalable Broadband Hybrid Wireless Network (BHWN).

6. Proposed BHWN for Connectivity to Rural Schools

Schools and libraries in rural or remote areas without wired infrastructure or broadband

services can be cost effectively connected to broadband by combining several broadband
wireless platforms.
In this proposed hybrid wireless network the traffic from the large fiber optic backbone from
the urban area is carried over the last mile via a high speed point-to-multipoint distribution
system based on the features of WiMAX that is, enhanced data rate and range. In the pointto-
multipoint network, the core configuration is a single access point or base station
communicating with one or more clients, and a larger network can be comprised of several
such separate cells joined by a common backbone. WiMAX serves as a backhaul for Meshed
Wi-Fi Local Area Network. Figure 1 below shows WiMAX connecting to Wi-Fi access
points located in rural school buildings. The access points in turn will serve a mesh array
LAN which is not shown in the figure. With a robust backhaul system in place, coverage of
the network is practically just a function of the number of Wi-Fi access points installed at the
edge. The access points reside in a mesh array, with one radio available for access and a
second radio connecting into the array. In the figure the customer premise equipment (CPE)
serves as the access points.
Thus by combining Wi-Fi mesh and WiMAX could provide the rural population with the
most extensive and complete broadband wireless coverage. Though both technologies are
distinct, each with unique characteristics, they often are deployed in tandem using WiMAX
for backhaul and Wi-Fi mesh to provide access to the growing base of Wi-Fi enabled LANs.
Until now, the only solution was to install two separate units, one WiMAX and one Wi-Fi
mesh but nowadays companies have come with solutions of integrating these technologies in
a single compact outdoor enclosure.

7. Suggestions

(i) National level conferences should be organized to generate awareness of the many

advantages of wireless connectivity and the mobility it brings to the learning environment.
(ii) This concept needs to be promoted from the early stages of school, given its importance in achieving better broadband Internet connectivity, and its role in linking homes to virtual classrooms, libraries, campus networks, and Internet labs and in delivering elearning courses.
(iii)Wireless should not be considered as a replacement for the wired technology, rather it should be considered as a supplement to enhance the effectiveness of the learning environment.
(iv) Research should be done on new methods and new approaches to learning with ICT because ICT is an integrated part of learning process.
(v) Using BHWN with the convergence of multiple wireless services, using different frequencies necessitates the creation of a campus wide spectrum Management group to plan to use any form of wireless and then to work on coordination this with strategic directions of IT, teaching, learning and research.

Figure 1: WiMAX with Wi-Fi mesh on the Customer premise side for rural connectivity

8. Challenges in adapting Wireless Technologies

The challenges to adapt to wireless technologies by educators and students, however, is one of understanding and exploring these resources to support teaching and learning.
(i) The most challenging problem facing higher education systems incorporating wireless devices into their classrooms is technical support. Schools must have an in-house support or outsourcing the support for the effective use of the wireless devices [11].
(ii) Speed plays a factor when there are several students competing for the same website and the broadband width is not enough.
(iii) The use of wireless devices in classroom can be a challenge for faculty trying to get the attention of students to a particular lecture when the students are engaged in the World Wide Web [11].

(iv) IT security is still a reality in only a small minority of schools. This is one of the biggest
challenges of wireless technologies in classroom. With more data and information transmitting frequently through the airwave, makes transmission of data easily accessible
by hackers and intruders.
(v) Allowing outside laptops onto the school network increases the risk of the spread of
computer viruses and hacker attacks. Therefore, there is a need for security software
updates to protect end-users from viruses and hackers.
242

9. Conclusion

In conclusion, the opportunities of wireless technologies greatly outweigh the challenges.
Wireless is important to higher education for some of the same reasons it is important to other
areas of the society. It is believed that using wireless technologies in classrooms not only
improves teaching and learning but provides the accessibility of resources to students and
teachers. From this paper it is clear that convergence is inevitable, whether on a wireless
campus backbone or extended campus connectivity or rural connectivity. Though it is too
early to determine the impact of this converged wireless network concept on teaching and
learning, but this brief paper argues that in many aspects we are already envisioning the
possibility of students' access to information by any device, from anywhere and at any time
has become very important in learning environment. The BHWN suggested combining WiMAX with Wi-Fi and Mesh has the potential to provide the rural Educational Institution
with widespread Internet access that can usher in, better education, economic growth and
health care and improved entertainment services as it has done elsewhere in the world.

References

[1] "WiMAX in India: Opening New Frontiers through Broadband Connectivity", Technology@Intel
Magazine, November 2004
[2] Amit Malhotra, "Scalable Broadband wireless networks", Proxim Wireless Corporation, PTC

Proceedings, 2006.
[3] Diane Evans, "Potential uses of wireless and mobile Learning", Landscape study in Wireless and
mobile Learning in the post-16 sector, The Open University, UK, April 2005.
[4] Robert Hoskins, Broadband Wireless exchange Magazine, "Wi-Fi Industry Leaders Launch Nation's First Coast-to-Coast Inter-Campus Network To Link Schools and Universities", May 2005,
[5] Sumit Kumar, "USRobotics to showcase latest wireless technology products for regional
education sector at GETEX Dubai", DIT. Net online Magazine, Technology News, April 2006
[6] Erick Galindo, "Technology not necessarily a boon for all students", Digital communications
online Magazine, October 2006.
[7] Rafael Kolic, "Ultra Wideband -- the Next-Generation Wireless Connection", DeviceForge.com,
February, 2004, [Online]. Available:
http://www.deviceforge.com/articles/AT8171287040.html
[8] SonaBeam Series, "Free Space Optics (FSO): An Introduction", [Online]. Available:
http://www.free-space-optics.org/
[9] Virtual Fiber Connectivity, Network Infrastructure Magazine, [Online]. Available:
http://www.dtsi.com.ph/ni_vfc.htm
[10] EDUCAUSE , "Wireless: Coming Next to a Handset Near You", White paper, September 2005,
[Online]. Available: http://whitepapers.techrepublic.com.com/abstract.aspx?docid=164731
[11] Ngozi Oriaku , "The Challenges And Opportunities Of Wireless Technologies In The
Classroom: Related Standards And Regulations" , College Teaching Methods & Styles
Journal, Volume 4, Number 4, April 2008
[12] William Pritchard , "Wireless Networks: Opportunities and Challenges for Foothill
College", A White Paper, Foothill - De Anza Community College District, August 25, 2004.

ENHANCING PUBLIC AND PRIVATE SECTOR DELIVERY THROUGH RWANDAN NATIONAL SMART CARD INITIATIVE.

Sashi Kumar Sivam
ıSenior Consultant
MSC Technology Centre, Cyberjaya, Malaysia
sashi@msctc.com.my

Key words: Smart Card, National ID, Enhancement of Public sector delivery, Rwandan National ID and Smart Card , GMPC, MyKad, Malaysian Smart Card Initiative

Abstract

This study is based on the ongoing Rwandan National Smart Card Initiative. Drawing

parallelism from The Malaysian Smart Card Initiative and similar Global Smart Card Initiatives, the study intends to evaluate the role of smart card technology in enhancing public and private sector delivery. Based on review, the enhancement in public and private sector delivery could potentially be the key to the increment of National productivity and competitiveness. Strategically, the elevation of National productivity and competitiveness has been a strong catalyst for economic development and similarly poverty reduction. In view of the above, the low level of productivity and competiveness are among the factors contributing to the high poverty rate in the low income level nations. Therefore, the study intends to provide a comprehensive overview on common global best practices and methodologies which has led to the enhancement of public and private sector delivery. Strategically, it also evaluates potential economy gains arising from the enhancement of public and private sector delivery. Based on review and analysis, the study provides strategic recommendation and global best practices that could be adopted during the Rwandan National Smart Card program.

INTRODUCTION

Following the success of the National ID program, The Rwandan Government is optimistic in launching the second stage of The National ID and Smart Card program. The second stage is expected to commence as early as August 2008[1] and will involve the introduction of 500,000 smart cards to prospective Rwandan citizens.

A unique feature of the second stage will be the incorporation of a 64 Kb smart chip. Unlike the 2D barcode that has limited data retention capacity and processing capability, the 64 Kb smart chips is designed to incorporate vast amount of data and applications. Initial review suggests that among the application that promises to be incorporated in the National ID and

Smart Card scheme are National Registry Information, Driver's License, Immigration and
Passport Information, Health Information, Social Security Information, Banking and ATM
pin codes and Rwanda Revenue Authority Information [2].
Based on review, the stakeholders are optimistic with the potential success of this initiative.
Many stakeholders believe that the Rwandan Smart Card initiative would enhance their
quality of service delivery while reducing the lengthy turnaround time [3].Ultimately it could be
a catalyst to revolutionize The Rwandan public and private service delivery. In the near
future, the entire Rwandan citizen might be carrying a smart card in their pockets or in their
wallets.

Overview on Smart Card

Smart Card is a plastic card that contains an embedded integrated circuit, which can process
data. This implies that it can receive input which is processed - by way of the ICC
applications - and delivered as an output. [4b, 4c,]
Historically it is recorded as a French invention and was first introduced to the European
consumers in 1982 in the form of serial memory phone cards. The first commercial
manufacturing of smart card dates back to 1977, when 3 commercial manufacturers, Bull
CP8, SGS Thomson, and Schlumberger get together to develop an IC based smartcard. The
first commercial success of smart card indicates to Motorola with the success of the first
secure single chip microcontroller for use in French Banks in 1979 [4a]. The First large-scale
smart card application implementation was in the United States in 1987 with the U.S.
Department of Agriculture's Nationwide introducing Peanut Marketing Card.
Ever since then, The National Smart Card initiative involving smart cards gained much
popularity throughout the world. In 1994, Germany launched the largest Smart Card initiative
with the issuance of 80 million serial memory chip cards in the form of National Health

Cards. Currently, there are more than 60 Nations reverting to some form of National Smart Card initiative and the number is expected to grow with time. [4]

Overview of Malaysian Government Multipurpose Card - MyKad

Due to cost and complexity factor, all smart cards initiatives have been for a single purpose but all that changed in 1997, when The Malaysian Government introduced the very first Multipurpose Smart Card [5]. The notion of the Malaysian Government is best described by the former Malaysian Prime Minister, Tun Dr. Mahathir Mohammed. In his own words the former premier indicated that "The Malaysian Government is proud to lead the new wave of technology application for a better tomorrow. The transformation of public service and Government machinery is the ultimate achievement for the nation, which is pro-investment and growth-driven. The engine of growth can be propelled further with the world's first Multi-Application Smart Card as we travel into the cyberspace where a growing segment of the economic pie is taking place." [6]

In a nutshell, The Malaysian Government Multipurpose Smart Card or better known as GMPC MyKad is an integration of 9 core public and private service applications under a single technology platform. Among the applications incorporated in the GMPC scheme are identity card, passport information, basic medical data, frequent traveler card, public key infrastructure, ATM application, electronic cash and transit or travel card. Among its primary objectives are to improve The Malaysian public service delivery with the use of technology vis-a-vis to create a pleasant experience for citizen while interacting with Government service providers .To date some 20 Million GMPC cards have been distributed to potential citizens.

The large scale roll out operation was segmented into three distinct phases: [6a]

· Phase 1 (1997-2000) - National Population Registration System
· Phase 2 (2000-2002) - Pilot Roll out of 2 Million Cards to Klang Valley and MSC Area.
· Phase 3 (2003-2007) - National Roll out of 18 Million Cards covering all states

Phase I primarily involves the conversion of the National Registry Database to the new GMPC format. A significant amount of digitization and automation exercises was carried out during the first Phase. Among them includes the introduction of the new Automated Finger Identification System (AFIS) and automation of 183 National Registration Department (NRD) branches.

245

During Phase II, some 2 Million Smart Cards were rolled out to eligible Malaysian citizens in the Klang Valley and Multimedia Super Corridor (MSC) Area. Phase II also witnessed the development of core GMPC Mykad applications. The pilot enabled the Malaysian Government to evaluate and understand the impact and benefit of multipurpose smart card before embarking on the more ambitious Nationwide National Roll Out.

Phase III, some 18 Million cards were rolled out to eligible Malaysian citizens throughout West and East Malaysia. The seven years roll out period not only elevated the service level delivery among public and private sectors but also created the platform for the emergence of Smart card industry in Malaysia. To date, Malaysian Smart Card companies has a global foothold in Card production (Iris), Chip Manufactures (My-MS), Smart Card Application Development (Iris, Heitech). Smart Card Device Manufactures (Tricubes).

Impact and Benefit of The Malaysian Mykad Scheme.

In reference to the following illustration, The Malaysian Mykad Initiative underwent an extensive integration exercise by incorporating nine (9) applications under a single smart card platform. [8]

Figure 1a: Integration Model of Malaysian Mykad Initiative.

In doing so, The Malaysian Government advertently integrated the following public and private entities[7]:

· Six (6) Government agencies / ministries - NRD, RTD, Immigration, Police, Ministry of Finance, Ministry of Health.

· Twelve (12) Malaysian Banks and One (1) Micro - electronic payment systems (

financial gateway) provider - MEPS
· Two (2) Digital Certificate providers - MSCTrustgate, DigiCert
· One (1) Transit application provider - Touch' n Go
These technology centered integrations elevated the Malaysian public service delivery into a
new spectrum. The followings section will briefly explain some of the key Business Process
Improvements introduced throughout the implementation of Malaysian Mykad scheme: 246
Adoption of New Database Format:- The new database format brought a new level of sophistication where it now allows the branches to retrieve more comprehensive informations
within a shorter time frame. As a result of this, the yield and the productivity of the branches
improved and more business transactions are processed in a day.
Digital Thumbprint:-. The biometric minutiae stored on the cards is an excellent mean of
citizen authentication Digital matching of the thumbprints are less prone to errors compared
to ink based thumbprints. Due to its nature, it suggests to be a popular adoption in the
financial world where it allows faster turnaround time on common financial transactions e.g.
opening on account, money transfer, mortgage and loan processing while providing the
required security and reliability
The integration coupled with the above mentioned business process improvement revolutionized both the service offering and delivery of public and private sectors. Although
there were no empirical evidences indicating the success the Malaysian GMPC initiative but
through a series of observations it becomes clear that the initiative has resulted in the
following benefits [7a, 7b]:
· The production and delivery of National IDs to citizens have significantly reduced
from a few months to a single day.
· Capturing and retrieval of National Registration data could be carried out from any
remote and mobile locations thus allowing citizens greater mobility and flexibility.
· Issuance and renewal of driving license have significantly reduced from three days to

less than an hour. Similarly, the operation can be carried out throughout nationwide
National Registration Departments (NRDs)
· Drivers information together with his/her traffic offences could be verified immediately by traffic police from any remote location through GSM network
· Electronic issuance of traffic summons and payment collection through e-portals,
provided the citizens greater flexibility and wider customer interaction points (touch-points).
· The introduction of Auto gate by Malaysian Immigration at the nation’s entry and exit
succeeded in eliminating the long queue at these points and subsequently reducing the wait time to an approximate three minutes.
· Patient Registration at selected hospitals is carried out by reading the information
stored in Mykad thus significantly reducing the amount of time required for manual
entry.
· Opening of accounts and customer verification are carried out by reading the information and biometric minutiae thus significantly reducing the time required for data entry and customer verification.
· Automated Fare collection through the Touch’n go application stored in Mykad has
significantly reduced traffic queues at toll booths.
· Automated Fare collection through the Touch’n go application stored in Mykad has
streamlined passenger movement at both light rail transit (LRT) and public buses.
· Incorporation of Public Key Infrastructure (PKIs) on Mykad has provided the necessary security needed for electronic filling of income taxes. The PKI together
247
with electronic filling resulted in greater flexibility on tax filing for Inland Revenue
Authority’s (IRA) customers.
In a nutshell, the Malaysian GMPC- Mykad not only revolutionized the Malaysian public
service delivery but it also provided the necessary cataclysm to enhance the productivity and
competiveness of Malaysian public sectors. Malaysia is not the only example where the
Government has enhanced the public and private sector delivery through National ID and

Smart Card Initiative. Similar achievements could be also credited to the Hong Kong
Government Initiative on “Octopus Smart Card” and Finland on “Fin-ID” initiative.

Parallelism between Malaysian MyKad Initiative with Rwandan National ID and Smart Card Program

Therefore and by virtue of parallelism to other global initiatives, one should expect that an
efficient implementation of Rwandan National ID and Smart Scheme would harvest similar
impact and benefits.

Review suggests that the Rwandan Smart card Scheme is already progressing through similar
tracks. Among the first agencies to be integrated are the Police Departments which are to be
integrated with financial institutions and the National Registry. The following illustration
depicts of the proposed integration model. [9]

Figure 2a: Suggested Integration of Rwandan National Smart Card Scheme

Subsequently the scheme intends to integrate the National Health Services, Financial
Institutions, Social Security, Medical Insurance and Immigration Services. The immediate
benefits expected for the implementation of the Rwandan National Smart Card program are:

· Establishment of a Central National Registry; which will act as an official reference
point thus reducing the amount of time and processes required to authenticate and verify citizen related information.

· Retention of data on digital media e.g. on Smart Chip and database would eliminate
the need of paper records thus reducing the cost involved in generating and maintaining paper records.

· Retrieval of stored user data from Smart Card will minimize the need to capture them
through human data entry. Potentially, it could reduce the time required for data capture and minimize the errors resulting from human data entry.

· The ability to rewrite or update digital records on smart chip could potentially reduce
the need to reproduce new ID cards whenever a change on user record occurs

· The ability to store multiple applications and data in a single smart card reduces the

need for users to carry multiple cards.

· The biometric minutiae stored on the card are an excellent mean of customer authentication. Enabling, the banks and micro financiers a reliable means to authenticate and verify potential customers.

· Integration of Government agencies and financial institutions is among the key requirements of this phase. Based on review, integration could potentially enhance information flow and automate the common business processes and workflows. Therefore, reducing the time required to process common business transactions.

In view of the above Rwandan National ID and Smart Card initiative is poised to revolutionize both public and private service delivery and similarly to catalyze Rwanda's National productivity and competitiveness.

Conclusion

A comprehensive overview of The Malaysian and other Global National Smart Card initiative does indeed suggest that the project has a potential to enhance public and private service delivery. By drawing parallelism, to the Malaysian GMPC - MyKad initiative it becomes evident that the Rwandan National ID and Smart Card Initiative could indeed be an efficient vehicle to revolutionize both the public and private service delivery. In view of the above, the Rwandan National ID and Smart Card Scheme are in the right path to evaluate the Government entities and components to be integrated. The Malaysian and Global best experience, case studies and best practices are indeed valuable tools to under see the success of this initiative. Modernization of Government through the use of technology could ultimately result in the enhancement of Rwanda's National productivity and competitiveness.

Acknowledgements

The author would like to acknowledge the assistance of The Malaysian GMPC unit for the valuable experience in implementing the Malaysian Mykad initiative, Mr. Zulranee, Mr. Meor Fadzil, Mr. Ng Chee Wai and other fellow colleagues and consultants at MSCTC for the patience guidance of Smart Card Technology, Mr. Pascal Nyamurinda, Mr. Jacques

Kayisire, Mr. Justin, Mr. Innocenece,Mr. Claude and other friends and colleagues from the
Rwandan National ID and Smart Card Uniit for letting me to be an advisor to the National
initiave, Mr. Patrick Nyirishema and Mr. Herbert for the assistance from RITA and last but
not least to my immediate family members and my lovely wife for being patience throughout
my assignment in Rwanda.

REFERENCES

[1]Interview with Mr. Pascal Nyamurinda, Rwanda National ID Coordinator on 24th April
2008 by Sashi Kumar Sivam.
249
[2]Adopted from the Presentation to National ID Steering Committee on 2nd May 2008,
Document source: Presentation to National ID Steering Committee 2-May-08 v2.4.ppt
[3]Interview with Stakeholders by Sashi Kumar Sivam on 28th April 2008.
[4]Adopted from card Cardswerk and SchlumbergerSema
[4a]Adopted from card Cardswerk and SchlumbergerSema
[4b]Adopted from Wikipedia on Smart card :
http://en.wikipedia.org/wiki/Smart_card
[4c]Rankl, W.; W. Effing (1997). Smart Card Handbook. John Wiley & Sons. ISBN 0-471-
96720-3.
[5]Adopted from Malaysian National Registration Presentation titled The Malaysian Government Multipurpose Smartcard (MyKad) -The Malaysian Experience
[6]Adopted from Tun. Dr Mahathir's speech during the launch of MSC Malaysia on 1st
August 1996.
[6a]Adopted from New Applications Workgroup - Cards Applications (Reduced), GMPC Consulting Team, September 2003
[7]Adopted from The Malaysian Government Multipurpose Smartcard (Mykad) - The Malaysian Experience presentation .
[7a]Adopted from Unisys & The Government of Malaysia : Malaysia Smart Card Delivering
Citizen Services Faster;
http://www.unisys.com/public_sector/clients/featured__case__studies/malaysia__smartcard_
_.htm
[7b]Unisys Case Study: Visible Breakthrough: Malaysia Smart Card Delivering Citizen
Services Faster : http://www.securityunleashed.com/pdf/Malaysia_Smart_Card_CS.pdf

[8]Adopted from Malaysian National Registration Presentation titled The Malaysian Government Multipurpose Smartcard (MyKad) -The Malaysian Experience
[9]Adopted from Malaysian National Registration Presentation titled The Malaysian Government Multipurpose Smartcard (MyKad) -The Malaysian Experience
250

A SYSTEMS APPROACH TO DETERMINING CRITICAL INFRASTRUCTURES & APPROPRIATE TECHNOLOGY

Andrew Nyamvumba §§, Dr Christopher M. Kumile2, Dr. John Trimble

1 Industrial Engineering Department, Tshwane University of Technology, South Africa, E-mail2andrewn@gmail.com, P.o Box 2596, Kigali, Rwanda

2 Manufacturing Department, Tshwane University of Technology, South Africa, E-mail: kumilecm@tut.ac.za

3 Systems and Computer Science Department, Howard University, Washington DC, USA, Email: jtrimble@howard.edu

Key Words: Simulation, supply chain, productivity, competitive advantage, systems thinking, critical infrastructures

ABSTRACT

The Systems thinking approach to problem solving has been used to address strategic questions in determining process choice and supporting infrastructures, including optimisation of resources and project management. This study is based on the need for an approach to determine critical infrastructures and appropriate technologies to be deployed in underdeveloped and developing countries and focuses on the dairy industry. The study is informed by our current work of developing a productivity model for knowledge- based systems to be applied in the dairy industry in Rwanda. The benefits of systems thinking approach in deriving a supply chain model is examined against the constraints and goals of an individual organisation in the supply chain attempting to maximise profit. This paper provides an approach that uses a discrete simulation method at the factory level and systems dynamics for simulation of the supply chain in determining alternative choices, and links key characteristics of system dynamics and modeling to process choice for organisational excellence and competitiveness. We close with some guidance on factors to consider when selecting an analysis approach that is appropriate to the problem under study.

INTRODUCTION

The major constraints facing the dairy industry in Rwanda are the low level of productivity, seasonal fluctuations in supply and demand, and inadequate infrastructures to support the competitiveness of the industry. The lack of important services compounded by the relatively high interest rates impact gravely not only on the competitiveness but also on the sustainability of the industry. This paper suggests how these industry challenges can be analyzed by using systems dynamics and discrete simulation models. The purpose of the modelling is to gain insights into supply chain factors that contribute to the low productivity and to explore strategies to minimise these effects. Changes to infrastructures are recommended to support the process choice.

§§ Author for correspondence

LITERATURE REVIEW

Society is a complex system with many interacting constituents that influence each other. These constituents include critical infrastructures whose availability and reliability determine to a considerable extent the productivity, and hence the well being, of the particular society. This is because for goal attainment, a process choice is made and the process choice has to be supported by critical infrastructures.

A current definition of a “critical infrastructure” is a large scale infrastructure which if degraded, disrupted or destroyed, would have a serious impact on the health, safety, security or well-being of citizens or the effective functioning of the government and/or the economy [2]. These infrastructures can be divided into physical and soft infrastructures. Examples of physical (tangible) infrastructures include transportation networks, telecommunication systems, and energy supply systems while the soft (intangible) infrastructures include trade credit procedures and policies, regulatory systems, skills availability, and the easiness of the

business environment. It is deduced that an increase in availability of critical infrastructures
positively impacts productivity.
However, researchers have extensively highlighted the impact of knowledge on growth and productivity during the last two decades. This discussion has put in focus the
importance of knowledge-based productivity and important measurement problems. It also
highlights potentially important conceptual challenges in the conventional ways of measuring
growth and productivity in the knowledge-driven society [9].
Ilka Tuomi [9] argues that these challenges are particularly visible in developing
countries as they try to increase competitiveness in the face of globalisation but that they also
require new approaches for understanding productivity and growth. The famous "Solow
paradox" can be interpreted as an indication of a need for a new productivity paradigm [9]. A
conceptualization of productivity that would allow substantial analysis of the impact of
knowledge seems [9] to require reconsideration of the links between growth and development
to innovation, creativity and the degree of openness of the system as well as its degree of
stability.
Within the supply chain, knowledge-based systems consist of hardware, software, skills, systems integration, operational support, and infrastructure that support decision
making. They are what may be considered decision support technologies chosen from existing ICTs and combined with research, modelling and optimisation applications.
However, a multidimensional and holistic conceptualization of application of knowledge
bases in a supply chain allows the researchers to address the different complementary
elements that are needed to make decisions affecting choices of appropriate infrastructures to
support total productivity goals.
Supply chains in rural areas are the next big issue for businesses in the dairy industry
in developing countries. The reasons are simple: the urban areas are congested with markets,

and more than 70% of Rwanda's population lives in rural areas. Thus, there is a need for
transforming rural areas into a group of sophisticated vibrant activity centers. Innovations in
every layer - products, processes, business models, and service models are fundamental for
this transformation process to happen. Businesses need to be reinvented with appropriate
technology tools that can provide employment and services for millions of rural dwellers at
an affordable cost. Increased productivity of supply chains is needed.
252

WHY DOES PRODUCTIVITY MATTER?

The main purpose of improving productivity would be to improve service delivery and increase availability of basic infrastructural facilities. It would also improve quality and
quantity of goods and services, increase both the quality and quantity of employment
opportunities, reduce poverty, increase self reliance and develop a well motivated, dynamic
and productive workforce.
Whereas policymakers use productivity outcomes to plan how productivity and economic growth could be increased [9], managers relate productivity to increased operational efficiency and reduced waste. If productivity increases, other things equal,
aggregate economic welfare increases. In the dairy industry, this means reducing losses and
increasing gains per invested input (labour, capital, information, energy, and raw materials).
Productivity measurement is also important for monetary and fiscal policy. Productivity trends are used to forecast potential economic growth and, for example, tax
revenues. If labour income grows faster than labour productivity, the expected result is
inflation. Productivity measurement, therefore, is used in the difficult act of balancing
unemployment and inflation. Long-term productivity growth is commonly viewed as the
speed limit for sustainable economic growth [9].

A SYSTEMS APPROACH TO SUPPLY CHAIN PROCESSES

The different firms in the supply chain should not work individually to achieve an

optimum, as the goal is not to achieve local optimums but to achieve the highest global performance level. Therefore an organisation should take a systems approach to designing a supply chain or making decisions in the organisation [16]. In a supply chain, business processes can be considered the basic units of organisations. Thus, they are the means by which an organisation, whatever the economic sector, survives and thrives by processing products or services for a customer.

Due to specialisation in the dairy industry and the fact that factories [in Rwanda] tend to structure themselves around tasks, there is a tendency to design and operate business processes within a specific department or group of internal departments. This leads the company not employing a systems (global) approach to carrying out operations. Today’s need for specialisation stems from the rapidly growing body of knowledge and information [15]. Specialisation should not be blamed, nor is it wrong to specialise in a specific field.

Specialists can still play an important role in any organisation, but the organisations ought to structure themselves around outcomes [7]. Processes generate outcomes by linking functions across the entire organisation (systems approach).

The same holds true for the entire supply chain. Specialist organisations still play an important role within the supply chain, but organisations ought to structure the processes so that the entire supply chain can achieve an optimum.

How are business processes designed to achieve global optimums for the entire supply chain? There are no specific steps for this purpose, but business processes should be designed so that each link in the supply chain would share in the risk of the entire chain [8].

THE IMPORTANCE OF THE PROBLEM

Improving the productivity of knowledge work is a significant societal problem. Peter Drucker identified that:

To make knowledge work productive will be the great management task of this century, just as to make manual work productive was the great management task of the last century. [14]
He argued that unless managers undertake serious and effective approaches to improving the
productivity of knowledge workers, now the fastest growing sector in industrial societies,
nothing like the gains in prosperity of the 20th century will materialize in this century [13].
The significance of Drucker's observation is that if non-trivial gains could be made in the
productivity of knowledge work [if integrated in a supply chain] the value to the economy
could be dramatic [especially for developing countries that lack both the knowledge and
organized supply chains].

APPROACH TO THE PROBLEM

A Lean Supply Chain could be of greatest importance in determining appropriate technologies and infrastructures. A lean supply chain is characterized by as a set of
organizations and processes that are linked in a continuous flow of products and services,
finances and information, and that interact collaboratively to reduce cost and waste.
Knowledge [of opportunities to continual improvement] gives the competitive edge.
If a lean approach to managing the supply chain is to succeed, the entire organization has to
focus on removing waste and adding value. The organisation has to focus beyond its
boundaries and adapt change to focus on the entire chain.

- Product value has to be defined from the customer's point of view, not the company's; to eliminating waste caused by making the wrong product (one that nobody wants), making the product at an unsuitable quality level, making too much or too little of it, or delivering it too slowly or through the wrong channel.
- Avoiding delays and discontinuities in the supply chain process is the second principle. The supply chain should flow continuously, and so should the information
that supports it.
- Product should be pulled by the customer, not pushed by the company.
- Finally, continual improvement is critical, concentrating on the elimination of waste
and the addition of value in all of its supply chain processes.

THE MODELS

In choosing the appropriate model, it is recognized that business operations can be formally described in business process models that capture activities, information, and flow embedded in business operation. System dynamics modeling enables business process designers to build computer simulations of complex business process behaviors. System dynamics (SD) models provide an accurate description of system behavior along the time dimension. It gives a convenient tool to conduct what if analysis though dynamics points of view. The SD model in figure I below illustrates how 'infrastructure quality'; 'farming practices & extension services quality' and 'milk products demand' drive the productivity in the Dairy Supply chain.

The individual organisations in the supply chain will have a value chain as demonstrated in Figure II [12]. Primary activities are those involved in the physical creation of the product or service - its marketing and delivery to buyers, and support and servicing after sale. Supporting activities provide the input and infrastructure that allow the primary activities to take place. Each activity in the organisational value chain employs purchased input products, human resources and a combination of technologies. The organisation's infrastructure, such as legal work, accounting and general management, supports the whole chain [12]. A **competitive advantage** is gained when all activities (primary and supporting) in the chain are improved or managed on system principles [14]

cows
births deaths
birth rate
f arming practices &
extension serv ices
quality
milk at
collection
center
milk at
f actory
transport
f rom milk
center
milk products

at distribution
points
transport
f rom
f actory
milk products
consumed
milk
produced
milk
production
rate
losss at
collection
center
loss at
f actory
loss at
distribution
points
death rate
inf rastructure quality
infrastructure quality
milk
product
demand
Figure I: An SD model for the supply chain

255

Figure II: Value chain of an organisation

Porter [12] shows the importance of linkages within the value chain as a competitive advantage and its valuable role in designing organisational structure and Goldratt &Cox [5], [6] indicate how the same applies for the supply chain [16]. If a supply chain is considered as a network of individual organisations, an individual organisation can be regarded as a constraint that limits the output of the whole supply chain. A constraint within the individual organisation limits the throughput of the organisation and has to be improved. The process of continuous improvement by improving the constraint organisation within the supply chain increases the throughput of the entire value chain [16]. Therefore, in order to improve the output of the whole supply chain the *constraint organisation* has to improve. This means that the other organisations in the supply chain have to work according to the *constraint organisation*. In this way the entire chain will reach its full potential [4].

Supply chain lead-time is the time it takes information to travel from the market to the raw material supplier (total supply chain information lead-time) plus the time it takes *a single* product to travel through the different transformation processes (total supply chain production lead-time) back to the market. By shortening the lead-time, sales will be made more often. If more sales are made, more money is generated for the supply chain. To shorten the total supply chain lead-time, the inventory levels have to be reduced [6] and/or additional capacity be created within the system [5]

The effective flow of information, from a knowledge base, through a supply chain plays a crucial role in ensuring that all organisations have the necessary information to make global decisions regarding the productivity of the whole supply chain.

Some Factors to Consider When Selecting an Analysis approach

While this discussion has focused on Systems Dynamics, there are other approaches, including the use of spreadsheets, discrete simulation, and various types of optimization algorithms, that are often a better choice for addressing particular types of transport, supply chain and logistics issues [10] [3]. Selecting the right approach or collection of approaches will be guided by the problem to be solved [1] [3].

One example is provided by to use the SD model to link the quality of farming practices, extension services and infrastructure to production through the supply chain. This will be used to assist in the design of operations. The application of optimization techniques

Inbound
logistics
Operations Outbound
logistics
Marketing Service
Procurement
Technology
Human resources
Infrastructure
M
A
R

G
I
N
PRIMARY ACTIVITIES
SUPPORTING
ACTIVITIES
256
to identify the ideal mix of infrastructure (number of sites, locations, functions, links between
these, etc.), use of a discrete event simulation model to test and develop the operational rules
that will govern the new operations (e.g. replenishment rules, production priorities, transport
policies, etc.), and creation of a spreadsheet model to combine and present the modeling
results in financial terms (e.g. calculate total costs and analyze cash flow, etc.) are also key
components. It is observed that in practice, using a mix of models is an iterative process
whereby results from one model may inform the inputs to another and vice versa [3] [1]. In
using systems approach to determine critical infrastructures and appropriate technology
utilizing systems dynamics and other approaches use of major assumptions that inform
models like perfect competition in which sellers are price takers and the quantities sold are
driven by supply and demand regulate the appropriate allocation of resources and push for
productivity improvement in the supply chain.
Collaboration in the supply chain is driven by information technology infrastructure
(interface/presentation devices, communications, Databases, and system architecture) as well
as applications like ERP (enterprise resource planning) ability to support SOA (serviceoriented
architecture) and BPM (business process management) technology [17]. However, the same factors associated with analysis of productivity, from considering the overall system
cost and perfect competition as a baseline, expands beyond the scope of this paper but
highlights the basis of analysis. The challenge of what information to share and what not to

share given the advantage of sharing information weighed against the competition challenge
remains the discretion of the organisation within the supply chain and is beyond the scope of
this paper.

CONCLUSION

In this paper, it has been highlighted that it is feasible for a process to strive to achieve
a global optimum in the enterprise instead of a local optimum for an organization if all parts
of the organization touched by the process can be taken into consideration as a whole. This
requires a systems approach to supply chain optimization. That in turn generates choices of
infrastructures that lead to global results that increase total productivity. A SD model allows
the impact of these choices to be modeled. This is combined with the use of other tools like
discrete event simulation, spreadsheets and optimization are employed using a systems
thinking approach.

REFERENCES

[1] An, L., and J.J. Jeng. On Developing System Dynamics Model for Business Process
Simulation, *2005 Winter Simulation Conference*, *pp. 2072,* 2005.

[2] Dirk, H., Lomor, I., Lammer, S., and Rosato, V. Managing Complexity: insights,
concepts, applications: Critical Infrastructures Vulnerability: The highway networks,
Berlin Heidelberg, Sringer-Verlag, *pp.219*, 2008

[3] Dong, Jin, Hongwei Ding, Changrui Ren, and Wei Wang. 2006. IBM SmartSCOR - a SCOR based supply chain transformation platform through simulation and optimization
techniques. *Proceedings of the 2006 WinterSimulation Conference*, accepted.

[4] Goldratt, E.M. *Necessary but not sufficient*. New York: North River Press, *pp.222-223*,
2000.

[5]. Goldratt, E.M. & Cox, J. *The goal*. New York: North River Press, *pp p.151*,
1986.

[6]. Goldratt, E.M. & Fox, R.E. *The race*. New York: North River Press. *pp.28-29*,
1986.

257

[7] HAMMER, M. Re-engineering work: don’t automate, obliterate. *Harvard business*

review, 1990, Vol.68, No.4, 104-114, 1990.
[8] HOLT, J.R. & BUTTON, S.D. Integrating strategy and tactics across multiple business
units: The supply chain solution. *Society of automotive engineers*, *2000-01-1767,* 2000.
[9] Ilka, Toumi. Economic productivity in the Knowledge society: A critical review of
productivity theory and the impacts of ICT (online). Available via <http://www.firstmonday.org/issues/issue97/tuomi/index.html> [accessed 12 March 2008]
[10] Mayo, *D. D.* and K. E. Wichmann. *2003.* Tutorial on business and market modeling to
aid strategic decision making: system dynamics in perspective and selecting appropriate
analysis approaches. *Proceedings of the 2003 Winter Simulation Conference, eds.* S. Chick,
P. J. Sanchez, D. Ferrin, and D. J. Morrice. *1569-1577.*
[11] P. F. Drucker. Knowledge worker productivity: The biggest challenge. *California*
Management Review,Vol.1 No. 2, pp. 79-94, 1999.
[12] Porter, M.E. *Competitive advantage: creating and sustaining a competitive superior*
performance. New York: The Free Press. *pp.33-61,* 1985 reprinted 1998.
[13] Peter Drucker. *The Age of Discontinuity*. Harper & Row, New York, 1969.
[14] P. F. Drucker. Knowledge worker productivity: The biggest challenge. *California*
Management Review,Vol.1 No. 2, pp. 79-94, 1999.
[15] TOFFLER, A. *Powershift*. New York: Bantam Books, 1991.
[16] Tshwane University of Technology, Btech Industrial Engineering, Production Technology IV; process improvement, *section 1.3*, 2007, Unpublished
[17] Simchi-Levi D, Kaminsky P, Simchi-Levi E., 2008, *Designing and managing the Supply*
Chain: Concepts, strategies and case studies. McGrawHill Irwin, 3rd Ed, pp.438-439

258

A National Framework for Infusing Information Technology in the Decision Support Process

Dr. John Trimble[1] and Andrew Nyamvumba[2]
[1]Systems and Computer Science Department
Howard University, Washington DC, usa, jtrimble@howard.edu
[2]Tshwane University of Technology, South Africa

Key Words: Knowledge management, decision support systems, e-governance, web portals, ICT educational strategy

ABSTRACT

This study is based on an examination of the decision support needs of underdeveloped and developing countries and draws largely on our current work in Rwanda. This effort centers on a comprehensive framework for an information technology based decision support system (ITDSS). It addresses decision support at the national and local levels. The strategies and benefits of informed decision making at the central level are contrasted with the strategies and benefits of involving the broader population in decentralized decision making. Particular detail is provided on the strategy to infuse the necessary training and education in the national education process. The focus of this education strategy is on the tertiary level, but extends to recommendations to K-12 and community based education. The intent of this work is to draw on previous studies, as well as an examination of current conditions to detail a framework for IT-based decision support that national policymakers can consider as a guideline for developing, enhancing and assessing their knowledge-based decision support process.

INTRODUCTION

Every day the world becomes more globally connected. As a result our daily economic and social lives are becoming more and more knowledge-driven. The challenge is for individuals, organizations and nations to plan for more effective knowledge management to aid in decision making at all levels. Computing researchers and academics will play a role in the organization and development of decision support software and techniques to facilitate all levels of decision-making. E-governance and e-government have unique roles in this knowledge management decision support system partnership. They have the ability to contribute significantly to more effective governmental administration on all levels and more effective efforts by governments to empower the people. Academics have a particular task to

further curriculum development at all levels to better prepare future participants in this scenario of: knowledge management - computer based decision support systems - more effective e-governance. The collaborative, distributed nature of this scenario makes using content management systems to develop web portal based Knowledge and decision support systems a meaningful alternative.

METHODOLOGY

This effort starts by clarifying what is knowledge, knowledge management and a decision support system (DSS), based on current work. This follows with a close 259 examination of DSS' s role in e-governance. Based on the work and future plans of Information Decision support Centers (IDSCs) in Egypt and Rwanda we propose 1) a framework for DSS development to enhance e-governance and 2) an educational strategy to complement that framework.

KNOWLEDGE

In projecting the role of knowledge management, a concise definition of knowledge must be forwarded. This definition must distinguish knowledge from information and data. These three terms are often used interchangeably and in many instances inconsistently and contradictorily. "Knowledge is understanding gained through experience or study. It is "know-how" or a familiarity with the way to do something that enables a person to perform a task. It may also be an accumulation of facts, procedural rules, or heuristics." [1] This broader definition of knowledge includes 'facts' which in many instances are classified as information. "Knowledge is a more subjective way of knowing and is typically based on experiential or individual values, perceptions, and experience." [2] This narrow definition of knowledge excludes much of what is classified as explicit knowledge. A middle ground is more appropriate.

Knowledge is 'information about information'. Knowledge can be concisely defined as rules, guidelines, decisions, algorithms or processes that act on information. Knowledge is

distinguished from information in that knowledge implies real or potential action. In contrast
data is a string of signals with no assigned meaning. Information is data with an assigned
meaning. Information can be simple facts such as my weight = 180 pounds or more complex
information structures such as a database of student information that includes names,
addresses, id numbers, courses, grades, etc..
Part of the confusion on distinguishing information and knowledge is the fact that
most information implies knowledge. For example the 'class average = 74.5' implies the
knowledge on how to calculate the mean from a set of individual grades. The equations and
the action of the calculations represent the knowledge and the practice of the knowledge.
However the individual grades and the class average are simply information.

KNOWLEDGE STRUCTURES

Knowledge can be captured in a wide range of knowledge structures. Knowledge
structures can be placed in four broad categories: graphical representations, logic, prose, and
mixed approaches. Examples of graphical representations are decision trees, causal
diagrams, semantic networks and 'stock and flow diagrams'. Logic knowledge structures are
grounded in proposition logic and predicate calculus. The most widely used logic knowledge
structures are 'rule based systems' popularized by expert system development. Prose is by
far the most widely used category of knowledge structures used in knowledge management
systems. Prose structures can take many forms such as: scripts, recipes, scenarios, cases,
guidelines and reports. These prose structures follow particular formatting rules that
facilitate their utilization.

KNOWLEDGE MANAGEMENT (KM)

The definitions of knowledge management range from the simple and straightforward
"doing what is needed to get the most out of knowledge resources" [3] to Dalkir's set of
contextual definitions captured in table 1 below.

Business Perspective	Cognitive Science Perspective	Process/technology perspective
KM is a business activity with 2 primary aspects: treating the knowledge component of business activities as an explicit concern of business and making a direct connection between an organization's intellectual assets and positive business results.	Managing Knowledge (the insights, understandings and practical know-how), the fundamental resource that allows us to function intelligently. Knowledge is one, if not THE, principal factor that makes personal, organizational, and societal intelligent behavior possible	KM is the concept under which information is turned into actionable knowledge and made available effortlessly in a usable form to the people who can apply it. A virtual repository for relevant information critical to tasks performed daily.

Table 1 Contextual Definitions of Knowledge Management (adapted from Dalkir)

As the world becomes more globally connected our daily economic and social lives are becoming more and more knowledge-driven. Individuals, organizations and nations must be more conscious of this and plan for effective knowledge management. The task of knowledge engineering practitioners and researchers is to advance the science and art of knowledge management to keep pace with advances in information and communication technology (ICT). The definition and intent of knowledge management may vary given the

context. However, all knowledge management systems must be concerned with best practices, rare expertise and complex knowledge practice.

LINKING KNOWLEDGE TO DECISION SUPPORT

Generally a knowledge management system is based on a particular 'domain of knowledge'. This domain can reflect a scientific discipline such as Botany or an organizational structure such as Umutara Polytechnic University. Knowledge outside of the
principal domain can be used to manipulate the domain knowledge to assist in the decision
making process. This assisting knowledge is classified as 'decision support techniques' and
decision support software'. The relationship is evident in figure 1 below.

Figure 1 "Linking Knowledge to Decision Support"

261

DECISION SUPPORT SYSTEMS

A Decision support system combines intellectual resources (information and knowledge) of individuals and organizations with computing and communication technology
to improve the quality and timeliness of decisions. It uses a computer-based system to
support decision-making. Early decision support computing environments were isolated
dedicated systems.

The most recent wikipedia definition of DSS "A properly-designed DSS is an interactive software-based system intended to help decision makers compile useful information from raw data, documents, personal knowledge, and/or business models to
identify and solve problems and make decisions" [4] shows the shift to interactive
collaborative decision making.

The decision support process should cover 1) approaches to decision-making, 2) techniques for decision-making and 3) technologies for decision-making. In addressing
approaches to decision making the concerns are philosophical and ideological perspectives,
critical, scientific and system thinking, and the role of collective decision-making versus
individual decision-making. There is a wide range of decision-making techniques that can be
considered such as: group meeting where consensus is required, individual and group ranking
techniques and the nominal group technique.

Decision support technologies automate communication and management techniques

where relations of production are key. Decision making technologies are built using a variety
of software approaches such as 1) intelligent systems (software agents, particularly search
agents; expert systems; case-based reasoning); 2) Operation research / Decision Science -
(math programming, inventory theory and supply chain mgmt, discrete simulation (grounded
in queueing theory and Markov decision processes)); and 3) system dynamics (based on
continuous simulation, grounded in closed feedback loop).

DECISION SUPPORT AND E-GOVERNANCE

"e-Governance is a growing phenomenon within public sector institutions around the
world and is emerging as a significant discipline within the field of public administration and
management in general. … The concept of e-Governance is evolving and efforts to stabilize
and clarify its operational implications must be made." [5] The combination of knowledge
repositories and decision support tools and techniques combined under a e-governance
agenda can provide a powerful environment for empowering the public in the governance
process.

However "the debate regarding e-Governance is most often polarized between those who feel that ICTs will enhance the participation of citizens in the government policy
decision-making process, and those who feel that it will simply be business as usual via a
new medium." [5] Government, ICT practitioners, and academics all have a role in assuring
that it is not 'business as usual' by working to assure that the design and implementation of egovernance
is 'appropriate technology'. "The National Center for Digital Government seeks to apply and extend the social sciences in research at the intersection of governance,
institutions and information technologies." [6] This effort should promote a people centered
e-governance development.

The public awareness, in general, of the potentials of the advances in ICT has led to

increased expectations of government efficiency and access. This will serve to increase pressure on policy makers to make e-governance more people-centered. “Recent advances in information and communication technologies (ICTs) have redefined citizens’ expectations of the government and its services”.[7] Punia focuses on communication and coordination between departments in the workflow and concludes “To facilitate coordination between independent and autonomous government departments, public private process structure with an independent third party monitoring may provide a feasible solution.” [7] Misuraca examines the implementation of e-governance strategies in Ghana, Senegal, South Africa and Uganda; and concludes “there is no single way of introducing ICTs ” in the governance process. Their study recognizes that “local languages and illiteracy constitute a barrier to access of information as well as lack of available skills to operate and maintain the physical infrastructure, as well as develop and maintain software”.[5] Our personal experience in Rwanda confirms this reality. Most of Africa lacks the ICT personnel to develop and maintain an ICT-based governance process. One solution is orienting the educational process to address this shortage and developing a national ‘information, knowledge and decision support center’ to implement a long-range national and continental strategy of e-governance.

INFORMATION DECISION SUPPORT CENTERS

As part of their ICT plan 2005-2010, Rwanda intends to establish a National Information, Knowledge and Decision support center.[8] They indicate the purpose of the center will be to provide “valid and robust information for use in decision-making by key central authorities.” I will focus on the analysis of data and information required by such agencies as the Presidency, the Cabinet, the Parliament, various Ministries and Agencies.

Rwanda identified Egypt's IDSC as a model. Egypt's IDSC Center identified five national projects categories that are to reflect their objectives listed in table 2 below: 1) decision support in strategic issues; 2) technological infrastructure; 3) information provision; 4) human resources development and 5) development of the administrative environment.[9]

Egypt's 'Information and Decision Support Center (IDSC) Objectives

To Strategically identify opportunities and challenges confronting the Egyptian Government in implementing its programs.

To Support implementation of public policies and decisions through carrying out state-of-the-art policy research leading to solutions to the reform and development challenges facing Egypt.

To disseminate our findings and views through a regular flow of publications and public events.

To develop regional and international networks/ partnerships, to exchange know-how and research, which will result in the integration of international best practices in government

Table 2 IDSC Objectives

ROLE OF WEB PORTAL DEVELOPMENT

Web portals provide a Content Management Framework System that also 1) Builds connections with outside resources; 2) Brings many tools to one convenient Location and 3) Supports Dynamic Customization and Personalization. The private sector has seen extensive use of web portal development. In recent years non-profit and government organizations have begun to build sites using portal development tools. Kastel identifies four

layers of an Enterprise Portal, from top to bottom: business layer, functional layer, administration layer and portal platform layer. Key components of the functional layer are single sign-on, workflow and collaboration. Much of our concern in constructing an egovernance portal lies with the administrative layer that handles: user management, content management and document management.[10] The importance of content management is apparent in that many of the portal development tools are classified as 'content management

systems’. While major computing companies, such as IBM Microsoft, Oracle and SAP are
portal vendors, the open source community has developed several high quality content
management systems that can be used to develop and maintain a substantial web portal.
Bonfeld compares the three leading open source contenders: Joomla, Drupal and Plone. The
article concludes “For simpler requirements or lower budgets, Joomla, or possibly Drupal,
should suit your needs. If you need something powerful and proven, and are willing to
commit the resources to make it happen, Plone is likely to meet your need, but Drupal is also
worth a look”.[11] Look for the open source portal tool set to continue to develop. New tool
features and additional support (online videos, user groups, books and conferences) will make
it even easier to quickly develop and maintain decision support portals.

FRAMEWORK FOR IT BASED NATIONAL DSS

“While organizational leaders and managers must manage as knowledge leaders, they
must be aware of the relationship between knowledge and those who possess it. Obtaining
individual cooperation and motivation to be part of teams and groups is essential in making
knowledge sharing the core of effective knowledge management.” [12] Not only do all
government workers possess and use knowledge, but all citizens possess and use knowledge.
A comprehensive framework for decision support development must address knowledge
development and sharing from the highest leadership to the common citizen. The table below
serves as a starting framework for this process.

PARTICIPANTS TOOLS / STRATEGIES BENEFITS

National leadership:
President, Prime Minister,
Cabinet, etc.
-Operation Research Models,
-Simulation,
-System Dynamics,
-Statistical analysis
-Better central planning

-Better national assessment
-Better international linkage
Local leadership and
technical workers:
Secretary generals, sector,
district and provisional
leaders
-Collaboration tools,
-Operation Research models,
-E-learning tools,
-Document sharing on portal
-Decentralized work plans
-Larger segment of trained
e-ready government workers
-More collaboration across
organizations and regions
Citizens -Regular update of content
-Diverse 'how to do' content
-Elicit citizen inputs (i.e.
surveys, petitions)
-Increase democracy
-More satisfied population
-Channel more creativity
-EMPOWER THE PEOPLE

Table 3: Framework for Decision Support Processes

The implementation of this framework requires governmental support at all levels. However, it requires a strong commitment on the part of central or national government
leaders to involve the general citizenry and commit to the necessary training to make egovernance
a reality.

ADDRESSING EDUCATIONAL NEEDS

The implementation of any effective e-governance strategy requires the trained personnel. In the case of most of Africa, the extreme shortage of personnel capable of
implementing and maintaining information and knowledge-based systems requires a comprehensive, aggressive educational strategy.

The educational strategy is divided into two parts. The first addresses the general
needs - preparation at secondary school level, general education at university level for all

students, and community based education. Table 4 below addresses these needs. The 2nd part
deals with training ICT students at the university level to play a leading role in the future of
knowledge-based decision support systems. This curriculum is contained in Table 5. It
assumes a student has completed the secondary curriculum and general university curriculum
listed in Table 4.

SECONDARY UNIVERSITY COMMUNITY

-Critical thinking
-Computer skills
-Student centered learning
-Scientific inquiry
-Introduction to systems
-Computer Skills
-Development Studies
-Web utilization
-Appropriate Technology
-Critical Thinking
-Computer Skills
-Web utilization
-Introduction to Systems
-Appropriate Technology
-Critical Thinking
-Development Studies

Table 4: General Educational needs for Knowledge society

ICT CORE COURSES ADVANCED COURSES

-Problem solving and programming
-Web development
-Introduction to modeling and simulation
-Database design
-Data structures and algorithms
-Data communications and networks
-Probability and Statistics
-Operation Research
-Statistical analysis and data mining
-System Dynamics
-Knowledge management
-AI and expert systems
-Web services
-Portal development

Table 5: Curriculum for university degree in Knowledge systems.

CONCLUSIONS

A national strategy to achieve more effective use of computer-based decision support processes should start with clarification on what knowledge is. A knowledge management system that focuses on decision support is not only a knowledge repository of a given domain knowledge, but must include techniques and technologies that assist in decision-making. The inclusion of this decision-making component in an e-governance strategy requires 1) a comprehensive evolving national decision support system strategy and 2) and aggressive educational strategy. The educational strategy must be all inclusive - addressing students at secondary and tertiary level as well as community members that are not students. The decision support strategy must address training and tools for the highest administration (national leadership) to the general citizen.

A comprehensive strategy of this type will serve to set and monitor a strong national development agenda, as well as channeling the creativity of the broad citizenry. Most importantly it will empower the people, thereby contributing to appropriate technology.

265

ACKNOWLEDGEMENTS

We must acknowledge are colleagues at RITA and Umutara Polytechnic University for their assistance. We must also acknowledge Howard University for giving the primary author a leave of absence between 2006-2008 making much of this work possible

REFERENCES

[1] Awad, E (1996) *Building Expert Systems Principles, Procedures, and Applications*, West Publishing Company, St. Paul, MN

[2] Dalkir, K (2005) *Knowledge Management in Theory and Practice*, Elsevier, Oxford

[3] Becerra-Fernandez, A. Gonzalez, R. Sabherwal (2004) *Knowledge Management Challenges, Solutions, and Technologies*, Pearson/Prentice Hall, Upper Saddle River, NJ

[4] definition of decision support systems, (last visit in September 2008) http://en.wikipedia.org/wiki/Decision_support_system

[5] Misuraca, G (2006) "e-Governance in Africa, from theory to action: a practical-oriented
research and case studies on ICTs for Local Governance" *Proceedings of 2006 International
Conference on Digital government research,* San Diego CA
[6] Fountain, J and D. Lazer (2005) "The National Center for Digital Government Integrating
Information and Institutions" *Proceeding of National Conference on Digital Government
research*, Atlanta GA
[7] Punia, D and K. Saxena (2004) "Managing Inter-organisational Workflows in eGovernment Services" *Proceedings 6th International Conference on Electronic Commerce*
[8] Government of Rwanda (2006) "An Integrated ICT-led Socio-Economic Development
Plan for Rwanda 2006-2010", http://www.rita.gov.rw/IMG/pdf/NICIfinal.pdf
[9] Egypt's Information Portal (last visit September 2008)
http://www.idsc.gov.eg/
[10] Kastel, B (2003) *Enterprise Portals For the Business & IT Professional*. Competitive
Edge International. Sarasota, FL
[11] Bonfeld, B and L. Quinn (2008) "Comparing Open Source CWSes: Joomla, Drupal, and
Plone" http://www.idealware.org/articles/joomla_drupal_plone.php
[12] *Mcfarlane,* D. (2008). *Effectively Managing The 21st Century Knowledge Worker*. Journal of Knowledge Management Practice, Vol. 9, No. 1, March 2008