2011

E-Health Technologies in Attainment of the Millennium Development Goals for Africa Healthcare System

George E. M. Ditsa
Tshwane University of Technology, Ditsage@tut.ac.za

Sunday O. Ojo
Tshwane University of Technology, Ojoso@tut.ac.za

E-Health Technologies in Attainment of the Millennium Development Goals for Africa Healthcare System

George E. M. Ditsa, PhD and Sunday O. Ojo, PhD
Faculty of Information & Communication Technology
Tshwane University of Technology,
Pretoria, South Africa
Ditsage@tut.ac.za and Ojoso@tut.ac.za

Abstract

The challenge of quality and equitable health services provisioning in Africa is daunting. Advances in e-health technologies hold great potential to revolutionalize health systems in Africa. This paper examines the African health systems challenges and the potential in e-health technologies in enabling the attainment of the African health Millennium Development Goals. An e-health research, innovation and partnership strategy is proposed towards this end. Some implications are posited and conclusion drawn.

Keywords: e-Health Technologies, Millennium Development Goals, African Healthcare System, Innovation and Partnership Strategy, Mobile Health.

INTRODUCTION

There are major developmental challenges facing African countries including economic diversification, poverty and unemployment, quality health for all, and the sustainable use of natural resources. In particular, the healthcare challenges are daunting with negative impact on various aspects of African lives (Adigun et al., 2006), and severe burden of disease in Africa hampers development (WHO African Regional Report, 2005).

The UN Assembly (2000) in its Millennium Development Goals (MDGs) declaration envisions "a world with less poverty, hunger and disease, greater survival prospects for mothers and their infants, better educated children, equal opportunities for women, and a healthier environment". Eight goals (labelled MDG 1 to MDG 8) with 18 targets and 48 indicators were set around this vision. The first three of the eight goals, MDG 1 to MDG 3, respectively focus on eradication of extreme poverty and hunger, education for all, and gender equity and women empowerment. The MDG 4, 5 and 6 are concerned about health for all, while MDG 7 deals with environmental stability. The MDG 8 is a capstone goal advocating for global partnership for development.

Development experts have long recognized health as an important moral and social goal, which is essential to a productive society. Hence, along with education, economic growth and good governance, health is considered a key component of a sound development strategy. Health can drive social progress and pull people out of poverty traps. Hence, the UN MDG project fully endorses the central role of health in development.

Information and Communication Technology (ICT) is globally viewed as a catalyst for social transformation and economic development. The ongoing ICT revolution, most especially, that of the mobile/wireless and Internet technologies, has introduced greater fluidity, allowing virtual and ubiquitous interaction, collaboration and services delivery at will. The indispensable role of ICT in enabling the attainment of the MDGs is well acknowledged (Hajela 2005). The target 18 of the MDG 8 states, "In cooperation with the private sector, make available the benefits of new technologies, especially information and communication technologies". Hence, in the African development strategy, it is imperative that ICT be mainstreamed to effectively contribute to the attainment of the MDGs.

Drawing from the WHO (2006) report in global health, the African health system challenges are characterized by unprecedented reversals in human development index despite the advances in new medicines and technologies, and a collapse of life expectancies to half the level of developed countries. It is also characterized by acute shortage of health workers at all levels which makes it "very unlikely" to achieve the health-related Millennium Development Goals (MDGs). The African Regional WHO Director is of the view that the fragility of Africa's health system represents a great barrier to wider application of solutions recommended to address the health systems challenges.

Undoubtedly, developing countries in general are faced with operational, contextual and strategic constraints in productive exploitation of the potentials of ICT for socio-economic development. Given this reality, it is necessary to evolve a holistic and multi-sectoral framework and partnership approach to more effectively harness the potential of ICT as an enabler of development and enhancer of capacity development at the individual, community, organizational, systemic and societal levels (Hajela, 2005).

This paper presents a scenario of the African healthcare system challenges, examines the opportunities offered by the advances in e-health technologies to address the challenges, and posits a research, innovation and capacity-building agenda for the maximal exploitation of the e-health technologies potentials as an enabler of African healthcare. Multi-stakeholder strategic partnership is stressed as a pillar for a successful implementation of the agenda.

THE AFRICAN HEALTHCARE SYSTEM CHALLENGES

The World Health Report 2006 (WHO 2011) points out that "in this first decade of the 21st century, immense advances in human well-being coexist with extreme deprivation". It further observes that the world community has sufficient financial resources and technologies to tackle most of the healthcare system challenges; yet today many national healthcare systems are weak, unresponsive, inequitable and even unsafe - the African continent being most hard hit, the report further opines.

WHO (2011) observes that in global health, while the benefits of new medicines and technologies are being witnessed, there are unprecedented reversals in human development index. For example, life expectancies have collapsed in some of the poorest countries to half the level of the rich nations. The current ranking on life expectancies in WHO member states shows 52 of the 55 countries at the bottom of the ladder being sub-Sahara African countries having life expectancies ranging between 32.23 and 59.12 years. This is attributable in part to the ravages of HIV/AIDS in parts of sub-Saharan Africa.

BBC (2011) quoting some report on health in Africa, states that "90% of world malaria cases and 60% of people with HIV/AIDS are found in Africa" and mortality rates are increasing. The report further acknowledges the growth of "lifestyle" negative medical conditions such as cardiovascular diseases and stroke, as well as "hidden" diseases such as mental disorder. Summing up, the report concludes that "African countries will not develop economically and socially without substantial improvements in the health of their people". The report therefore recommends that more investment is needed to reduce disease and tackle poverty in Africa.

The challenge of quality healthcare service provisioning has been compounded by the prevalence of HIV/AIDS pandemic. The pandemic has caused reversals in life expectancies, puts strain on the national healthcare systems and decimates human capital in the affected countries. It has also reduced productivity, eroded knowledge and skills, stressed family support systems and put pressure on national budgets, thus, limiting how much investment that can go into the healthcare systems (Adigun et al., 2006).

Compounding the African healthcare system challenges further is the shortage of healthcare workforce. The World Health Report 2006 (WHO 2011) observes that in sub-Saharan Africa, a mere 3% of the world's health workers struggle against all odds to treat 14% of the world's population and combat 24% of global disease burden. The report estimates that the region is suffering from a shortage of more than 0.8 million doctors, nurses and midwives and an overall shortfall of nearly 1.5 million healthcare providers. The funds needed to double the healthcare workforce in sub-Saharan Africa have been put at an additional $2 billion in the first year, and more in ensuing years.

Some of the reasons for the shortage of healthcare workers in Africa have been identified as including HIV/AIDS which is decimating much of the workforce. In one of the countries, it is conservatively estimated that 16% of the existing workforce are HIV+, and in another, the government assumes that 3% of their workforce will be lost in each year to the disease. In addition, there is a lack of sufficient training institutions to produce the number of health workers required; an inability to retain health workers due to poor working conditions and lack of adequate remunerations, sometime due to wage caps imposed by the IMF; and the brain drain of large scale emigration of healthcare workers seeking greener pastures, mostly in the Western countries (Ojo, 2007).

Given the African healthcare system challenges, African countries' quest to attain the MDGs including quality health

for all, have become all the more intractable. In fact, WHO (2011) has identified 57 countries, including 36 in Africa, where the current level of health workers makes it "very unlikely" to achieve health-related Millennium Development Goals (MDG), internationally agreed goals on reversing the spread of HIV/AIDS, malaria and other major diseases, and significantly reducing child and maternal mortality.

In view of the resources limitation in African countries and the various national needs competing for resource allocations, how much financial investment could be afforded for the healthcare sector is obviously inadequate. Luis Gomes Sambo, the African Regional WHO Director is quoted in WHO/AFRO (2011) as saying: "… we also need to recognise that Africa's fragile health systems represent an enormous barrier to wider application of solutions recommended". There is therefore an urgent need for sectoral, national, regional and global strategic partnership to tackle the challenge head on, through a well contextualised exploitation of the potentials of e-health technologies. There is also a need for a deliberate strategy to effectively manage technological investments and allocation of healthcare resources. Health informatics educators and researchers in the Higher Education sector have a critical role to play. In particular, there is the need, in addition to the traditional responsibilities of teaching, research and community engagement, to meaningfully contribute to addressing the socio-economic challenges in the African continent through innovative health informatics education, research and innovation.

THE PROMISES OF E-HEALTH

The WHO Assembly (1997) identified fostering the use of, and innovation in science & technology for health as one of the essential functions of sustainable health system. WHO Assembly (2005) resolution on e-health called on nations to leverage the use of e-health in the pursuit of health-for-all-vision. Though, up to date, the precise definition of the term "ehealth" or "e-health" remains elusive - as many definitions as there are articles in bibliographic databases Oh et al. (2005), SPICH (1999), Eng (2001) and WHO(2004) posit a service-oriented and multi-disciplinary views of e-health. WHO (2004) defines e-health as the use of ICTs "for healthcare delivery including the diagnoses and treatment of disease and ill-health, management, surveillance, health promotion, health education, research & services, health knowledge access and other public health function". SPICH (1999) and (Eng 2001) take a multi-disciplinary view by defining it as encompassing "a range of overlapping disciplines that relate to the application of information, computer and communication technology to healthcare or population health", including "medical informatics, telehealth, telemedicine, consumer health informatics, public health informatics, among others". The combined service-oriented and multi-disciplinary view of e-health crystallizes the diverse views of it being portrayed in the literature.

As to the promises of e-health, Eysenbach (2001) sums these up as including efficacy, enhanced quality healthcare, evidenced-based healthcare interventions, empowerment of healthcare service consumers and encouragement of partnership between the patient and health professional. Kirigia et al. (2005), from the healthcare provider view point, see e-health as an enabler of promotion of economies of scale in healthcare resources utilization, offering time flexibility and responsiveness on the part of healthcare service providers – pharmacists, nurses, doctors, administrators and health care managers. Ginter et al. (1998) view e-health as enabling "seamless connectivity to all components of a health delivery system … with significant potential for cost reduction and improved quality of care". In general, e-health has the promise of making health services more efficient and improving access to healthcare, especially in remote areas, for people with disabilities and for the elderly through higher quality of care and health promotion; affecting the cost of care by reducing redundancy and duplication of examinations and making possible economies of scale (Ojo et al., 2007).

It can be adduced that e-health holds great promises for both low- and high-income countries, and some are already realizing the benefits. These benefits apply not only to healthcare services delivery, but also to public health governance, finance, education, research, and health-related economic activities. However, for many the benefits expected of e-health have not yet materialized, and it is difficult to predict the rate and extent to which ICT will affect diverse healthcare systems. Efforts are needed to tackle the undue burden of ill-health borne by vulnerable and marginalized groups. It is essential to invest in development of infrastructure for e-Healthcare, and to ensure equitable, affordable, and universal access to the benefits (WHO 2005).

In spite of the enabling potential and role, ICT is yet to be widely mainstreamed to assist developing countries in addressing traditional development problems with innovative solutions and approaches that are both effective and more easily scalable and replicable. After years of e-health advocacy, more recently, WHO (2011) seeks to find out how real are these promises. Kirigia et al. (2005) have established a correlation between the levels of ICT and related human infrastructural provisioning in Africa and the capacity to appropriate these benefits. According to them, "the

implementation of the 58th World Health Assembly resolution on e-Health poses a major challenge for the African region due to lack of ICT and mass Internet connectivity, compounded by a paucity of ICT-related knowledge and skills". Notwithstanding, Brewer et al. (2005) optimistically posit that if researchers can find a suitable and appropriate healthcare management solution for developing regions, then technology and specifically ICT can play enabling roles in disease control, telemedicine, improving doctor's efficiency, offering low cost diagnostics, improving data collection and providing patient management tools.

EXPLOITING THE PROMISES OF E-HEALTH IN AFRICA HEALTHACRE SYSTEMS

The central question arising from the forgoing is how can the promises of the e-health technologies be exploited to address the African healthcare system challenges towards attaining the Africa's healthcare MDGs? Following this question is "what are the key issues to be addressed in exploiting the e-health promises?

Towards answering the first question, drawing from the earlier joint works of this authors with others (Adigun et al, 2006; Emuoyibofarhe et al, 2007; Ojo, 2007, Ojo et al, 2007; Olugbara et al, 2007a; 2007b) and those of other researchers in the field of e-health (Healthgrid, 2004; Iakovidis, 2005; Konstantas, 2002; Wac et al., 2006; Zimmerma, 1999), this paper takes a recourse to exploiting the combination of the advances in mobile and wireless communications technologies, grid and service-oriented computing, as well as intelligent sensors network, as providing a plausible technological platform for e-health in African Healthcare Systems. In this endeavor, it is appropriate to take heed of the admonition in the target 18 of the MDG 8 which advances strategic partnership in making the promise of ICT available to society. Hence, a research, innovation and partnership agenda for e-health in African Healthcare Systems is being advocated in this paper.

Towards answering the second question, with regard to the e-health solution provisioning, the issues of aappropriateness, affordability, sustainability, security, integrity and confidentiality, socio-economic returns on investment and, community ownership and empowerment need be given paramount consideration. In addition, of paramount importance is addressing the issues of appropriate connectivity, appropriate user interfaces, low cost devices, intermittent power and power failure recovery, health divide, paucity of healthcare workers, as well as e-health readiness.

MOBILE HEALTH

African countries are witnessing considerable investments in mobile communication technologies with diffusion growing at exponential rate. Quibria et al. (2002) state "the migration of the Internet and Internet applications into mobile phone systems will have tremendous technological implications for e-Health practices in developing countries".

Kirigia et al. (2005) state, "the advent of the cellular phone presents an important opportunity for the practice of e-health in the African region", exploiting its important attributes. With the advances in wireless technology, new applications become possible in the healthcare sector.

Mobile Health (m-health) removes the restrictions imposed by wires and cables and enables patients to benefit from increased mobility. M-health (Konstantas, Jones and Bult, 2002) introduces innovative value-added mobile healthcare services based on public broadband 2.5G (GPRS) and 3G (UMTS) wireless networks for continuous monitoring and transmission of vital signals. This was achieved with the integration of smart sensors to a wireless generic Body Area Network (BAN) (Burkow and Bakkevoll, 2005). The BAN is a wireless health monitoring system that consists of sensors, actuators, communication and processing facilities and integrates wearable devices for connecting different sensors. The BAN sensors are responsible for data acquisition, measurement and transmission processes ensuring that a physical phenomenon, such as patient movement, muscle activity or blood flow is converted to an electrical signal. The signal is amplified and internally communicated within the BAN through intra-BAN communication process. The gateway that facilitates extra-BAN communication of vital signals to healthcare providers or brokers is the Mobile Base Unit (MBU) (Wac 2006), which can be a PDA or a smart phone. This way, the network facilitates time and location independent monitoring of a patient's health conditions (Olugbara et al., 2007b). M-health enables ambulant patients to be attended to without confinement to a health center even when they require regular health monitoring, as it becomes possible for them to be home-based with the attendant comfort. Such an application not only improves the patient's quality of life, but also benefits healthcare insurers when it comes to disease and care related costs. A healthcare center can save on its expenses on food and housing, and the pressure on the healthcare facilities is reduced.

UTILITY HEALTHGRID

A grid is a flexible, distributed, information technology environment that enables multiple services to be created with a significant degree of independence from the specific attributes of underlying support infrastructure (Travostino, Mambretti and Edwards 2006). It integrates web services, traditional enterprise software and high performance computing and peer-to-peer systems to provide the information technology, e-Infrastructure. Its architecture has been specifically designed to enable it to be used to create many different types of services. In the order of their historical emergences, such services include Computational services, Data services, Application services, Interaction services, and Knowledge services. Grids can be classified according to the functionality they offer and the applications supported. Commonly used grids and their applications to healthcare management are described below.

Utility grids are distributed enterprise grids that provide all the grid services to the consumer as utilities on a subscription basis. Utility grids support a pool of computers to be assigned on-demand to take-up extra requirement that can defy the potential of human expertise. They provide the infrastructure necessary for negotiation of the required Quality of Service (QoS), management of contracts and allocation of resources to meet competing demands from multiple consumers and applications.

A HealthGrid is an innovative use of emerging SET of computing to support broad access to rapid, cost-effective and high quality healthcare. A HealthGrid is an environment where healthcare data are stored, processed and made available to users on demand. As such, HealthGrids are an emerging aspect of e-Healthcare. It is an innovative use of emerging information technology to support broad access to rapid, cost effective and high quality healthcare services. HealthGrid (HealthGrid-A, 2004) becomes relevant due to the slow take up of grid technology, which is as a result of (i) lack of adequate infrastructure, (ii) lack of users' confidence and (iii) shortage of applications. To facilitate easy accessibility to HealthGrid resources, there is the essential need for flexible user profile management tools.

The HealthGrid community is presently focusing on the use of grid in healthcare management, looking into the needs for grid in both research and medical practice. The potential areas of healthcare service provisioning and research that have benefited from grid technology include: (i) image processing; (ii) human body modeling; (iii) epidemiological studies; (iv) pharmaceutical research and development; and (v) genomic research. In all these areas, grid technology can significantly reduce the cost and time to produce results. Just as the World Wide Web transformed the way we exchange information, the Grid concept takes parallel and distributed computing to the next level - providing a unified, resilient, and transparent infrastructure, available on demand - in order to solve increasingly complex problems. There are some significant hurdles to overcome before HealthGrid applications become commonplace – including ethical, confidentiality and working practice issues that are extremely challenging (Olugbara et al., 2007a).

THE CONVERGENCE: INTELLIGENT UTILITY HEALTHGRID

One known operational principle of technology evolution is that technology is cumulative and combinational. The process of technological development gains momentum from the ability to combine, recombine, and modify existing technology (DeGrigori 1985). Historical enquiry into the evolution of the science and technology of computing reveals the validity of this principle. For example, the ICT idea emerged from the combination (or convergence) of the computing and telecommunications technologies. Figure 1 schematically depicts the Intelligent Utility HealthGrid (IUHG) Computing concept as a convergence of ideas.

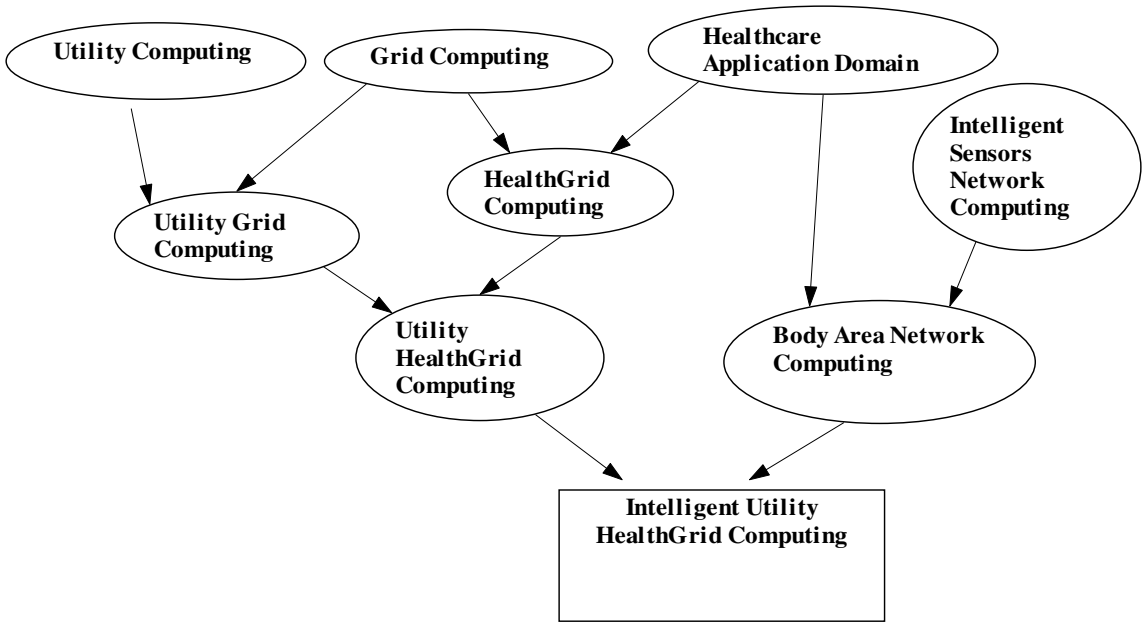

Figure 1: The Intelligent Utility HealthGrid Computing Concept

The IUHG Computing idea has the potential to revolutionalize healthcare systems in Africa. In particular, the emergence of Utility HealthGrid (UHG) computing and Intelligent Wireless Sensors Network computing provide unique opportunities in this regard. Body Area Network (BAN) computing emerging from the convergence of Computing Science and Sensors Network enables the use of innovative smart biomedical Sensors Networks for remote diagnosis, treatment and continuous monitoring of patients' health conditions. However, there are challenges such as low bandwidth, limited computational power and limited functionality for communication with wireless sensors networks. On the other hand, UHG computing which is rich in functionality can be used to provide access to appropriate computational services and can give high-bandwidth to a large collection of distributed time-varying resources. The incorporation of medical image databases and Content-Based Image Retrieval functionality into the UHG services provides a robust environment for disease diagnosis and treatment. An integrated BAN-UHG technology provides an enabling platform for ubiquitous and quality healthcare service provisioning towards attaining the Millennium Development Goal of health for all (Olugbara, Adigun, Ojo and Mudali 2007).

HEALTHCARE UTILITY-SERVICE BROKER (HSB)

Earlier (Olugbara, et al., 2007) we proposed the integrated UGC-BAN technology that gives rise to new healthcare services and applications that can provide remote diagnosis and treatment capabilities. Using this integrated technology, healthcare practitioners and patients will have access to resources that cannot be provided by BAN only. For example, a patient health record could be moved around and a healthcare practitioner would be able to collaborate with colleagues from other locations and make informed diagnosis and decisions anytime by sharing resources. The vital signals that are measured and transmitted to a software broker could be adequately analyzed using the discovered grid resources. The result of the analysis could be effectively delivered to the user in real-time. Thus, enabling remote management of patient conditions and quick detection of health emergencies whilst maximizing patient mobility and minimizing healthcare costs. The consideration of BAN for several e-Healthcare applications raises some entirely new requirements for utility grid-based infrastructure. These requirements can be met by a new type of Grid Resource Broker (GRB), a Healthcare utility-Service Broker (HSB) (Olugbara, Ojo and Adigun 2007b). The HSB acts as a mediator between the user and the network resources to perform various tasks such as patient health status monitoring, diagnosis and treatment, using sensors and the discovered grid services. Fig. 2 depicts the on-demand assemblage of healthcare services using the HSB technology.

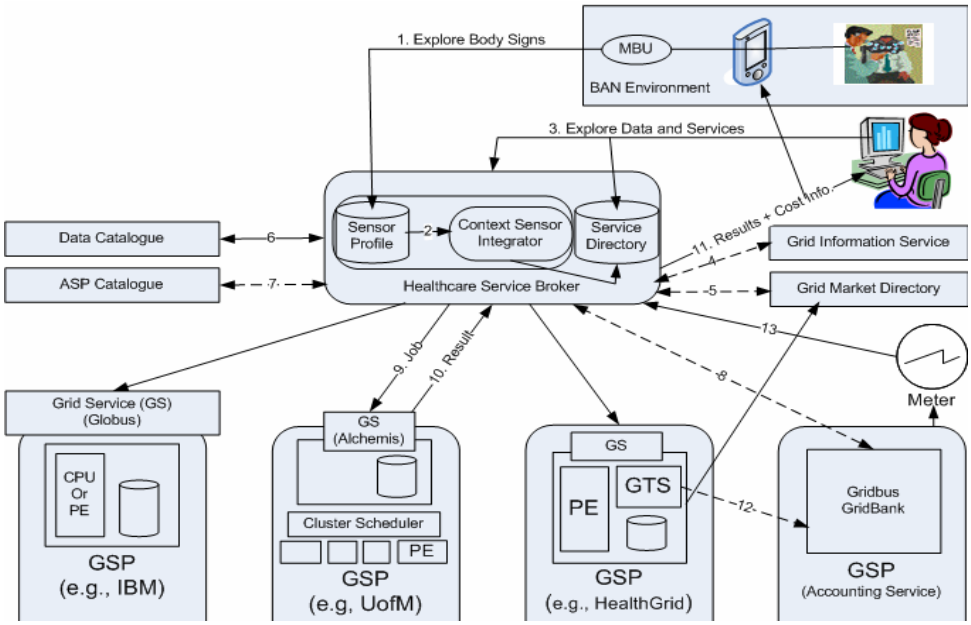

Figure 2: On-demand Healthcare Service Provisioning in Utility Grid (Source: Olugbara, et al., 2007b)

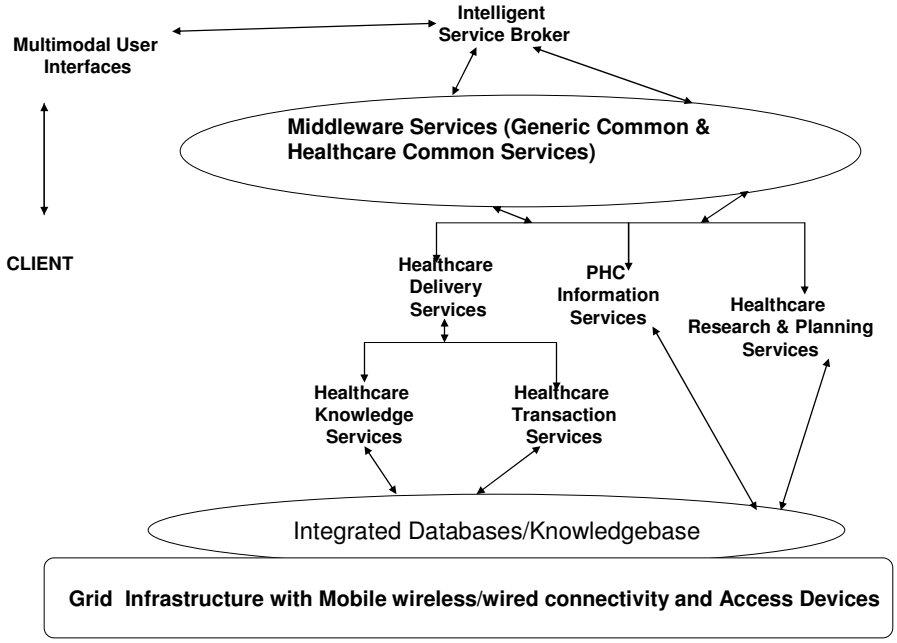

Figure 3: A Reference Model forE-Health Services Infrastructure

RESEARCH, INNOVATION AND PARTNERSHIP AGENDA FOR E-HEALTH IN AFRICA HEALTHCARE SYSTEMS

Relevant research, innovation and partnership (RIP) is key to maximal exploitation of e-health in Africa Healthcare Systems towards attaining the MDGs. Figures 3 shows our grid-enabled framework and reference model for e-health research and innovation, while Figure 4 shows a partnership framework being proposed.

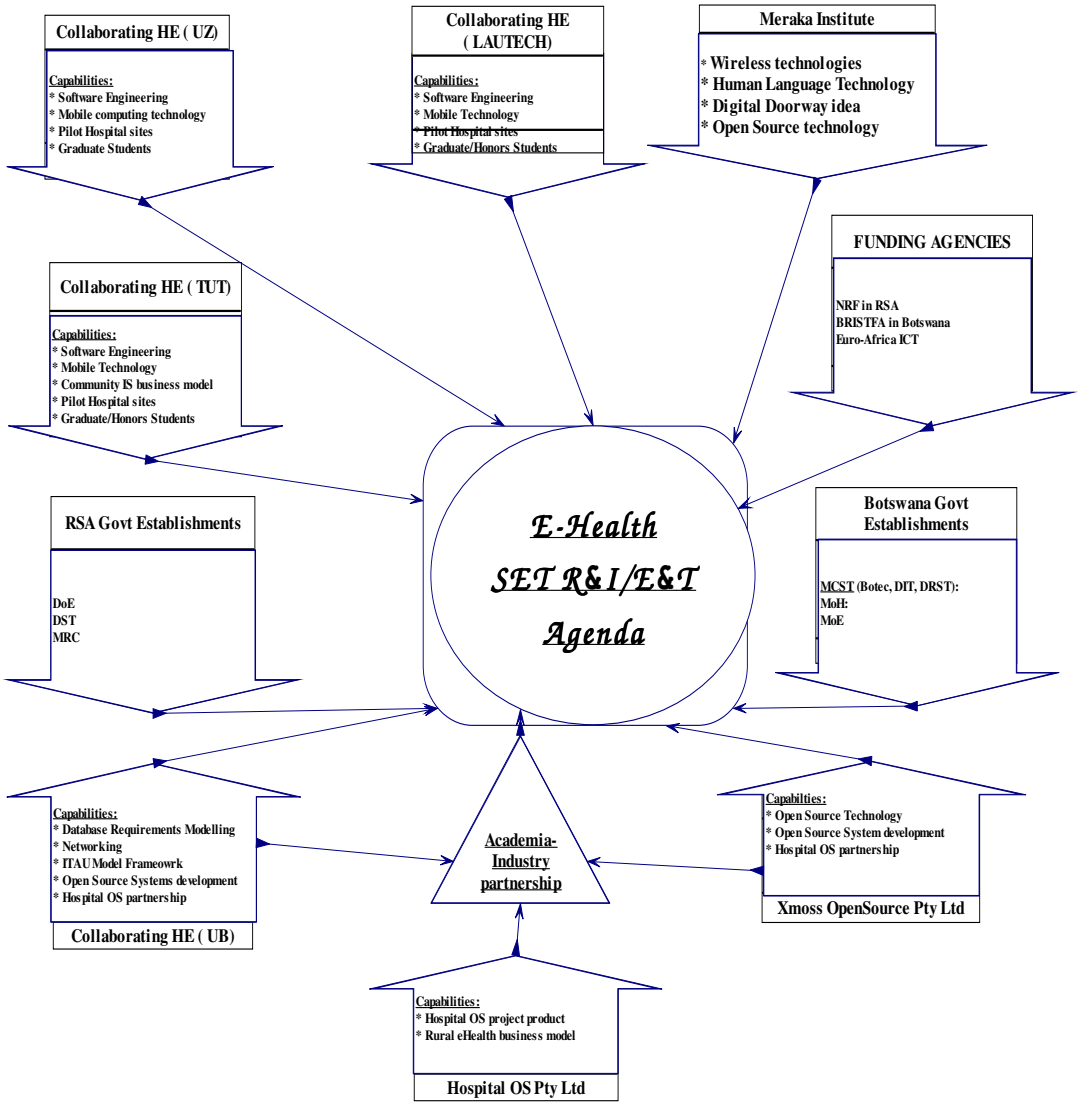

Figure 4: E-Health Research & Innovation Partnership Framework

The thrust of the RIP strategy should be to exploit the complimentary strengths of the partners from the industry, academia and relevant government agencies. Elements of the RIP strategy should include the need for expanding e-health access and participation, leveraging the potential for e-health uptake (e.g., through mainstreaming in relevant education and training programs) engagement and entrepreneurship, extending research and innovation, scholarship and graduate studies, enhancing capabilities, and exploiting the Utility Grid enabled approach to complimentary resources provisioning and sharing.

IMPLICATIONS

The implications of the e-health in Africa Healthcare Systems can be viewed from three dimensional investment angles, namely: Operational, Contextual, and Strategic investment dimensions. The operational investment dimension deals with the resources related investments requirements that would enable translating the potential benefits into

reality. These include investments in appropriate human resources, adequate funding and conducive supporting infrastructure. Investments in appropriate healthcare workforce able to effectively function in an e-healthcare system environment, computing practitioners able to appropriately contextualize technological solutions, multi-disciplinary researchers with home-grown innovative research ideas and solutions needed to guide the direction of e-health in Africa Healthcare Systems are the needed changes required. Finally, investments in continuous workforce capacity building and retention are necessary.

Contextual investment deals with prioritizing home grown initiatives directed at well contextualized e-health solutions for healthcare. Research-driven Open Source based e-healthcare initiatives are worthy candidates from such investments.

Strategic investment deals with appropriate strategy adoption for e-health in Africa Healthcare Systems. These include strategic investments in appropriate policy/strategy formulation; strategic win-win partnership at institutional, sectoral, national, regional and global levels in continuous capacity building, research-based solutions; appropriate Higher Education Health Sciences and Computing Science, Engineering and Technology curricula development and implementation.

CONCLUSION

E-health in Africa Healthcare Systems holds great promise for turning things around for better. The combination of e-health areas of HealthhGrid computing and Intelligent Computing in particular, holds good potential in this regard. The combination is an enabler for a future, where cost effective healthcare services will be provided in ubiquitous clinics to patients in rural communities who cannot afford expensive healthcare. In order to provide ubiquitous healthcare services, efficient infrastructure is highly desirable. A technology that combines the advantages of both Grid Computing and Intelligent Computing for the e-Healthcare service provisioning is necessary. The dynamic behavior of the virtual organizations, service provisioning power and smart sensor advantages are well suited for healthcare service provisioning for collaborative support, resource sharing, interoperable solution, reduced time for treatment, remote diagnosis, point of care treatment and remote monitoring (Olugbara, et al., 2007).

To maximally exploit the potentials, there is a need for Higher Education led RIP agenda giving attention to viz: Creating value-adding functionalities to existing ICT infrastructure; e-health education initiatives for patients; Socio-economic impacts of e-health; and e-Health ethical issues. Attention should also be paid to emerging entrepreneurial opportunities emerging from broad diffusion of e-health technologies, health divide issues, policy and legal frameworks, as well as e-Health readiness assessment.

In general there is potential for enhancing quality of service, the bridging of healthcare service quality divide between different social groups and dealing with the healthcare workforce shortage towards achieving the MDG of quality healthcare for all. To this end it is necessary to provide for operational, contextual and strategic investments as discussed.

REFERENCES

Adigun M.O., Ojo S.O., Emuoyibofarhe O.J., and Dehinbo J. (2006). E-Health Management: A Partnership and Collaboration Model in Developing Countries. In Proceedings 1st All Africa Technology Diffusion Conference, Johannesburg, 12-14 June, pp.68-78

BBC (2011). African health 'needs investment'. Accessed July 2011 from http://news.bbc.co.uk/2/hi/africa/6166246.stm BBC News 20 November.

Burkow T.M., and Bakkevoll P.A., The grid as an enabler for home based healthcare services. Connecting medical informatics and bio-informatics, ENMI, 2005, 1305-1310

DeGregori T.R (1985). A Theory of Technology - Continuity and Change in Human Development. EWP New Delhi, 1985, pp35-66).

Emuoyibofarhe O.J., Adigun M.O., Ojo S.O. and Ademola A.H. (2007) An enterprise view of e-health care services provisioning via the World Wide Web. In P.A. van Brakel (ed), Proceedings of the 9th Annual Conf on WWW Applications. Johannesburg, September 5-7. http://www.zaw3.co.za. ISBN: 978-0-620-39837-4

Hajela Shailendra K(2005). Use of ICT for achieving MDGs, Presentation at the South & Southwest Asia Conference on the follow up to WSIS Kathmandu, 1-3 March 2005

Iakovidis Ilias (2005). European Activities in eHealth. Presentation at Workshop on Semantic Interoperability, February.

HealthGrid-A (2004) Summary, A joint white paper from the Healthgrid Association and Ciscosystems, http://whitepaper.healthgrid.org/WhitePaperdraft_v3_20040922.pdf

Konstantas D., Jones V., and Bult R., MobiHealth-innovative 2.5/3G mobile services and applications for healthcare. Proceedings of the eleven information society technologie 2002

Olugbara O.O., Adigun M.O., Ojo S.O. and Mudali P. (2007a). Utility Grid Computing and Body Area Network as Enabler for Ubiquitous Rural e-Healthcare Service Provisioning. In Proceedings IEEE/Healthcom 2007: Ubiquitous Healthcare in Ageing Societies. , 9th International Conference on Networking, Application & Services, 119-22 June 2007, Taipei, Taiwan..pp.202-207.

Olugbara O.O. Ojo S.O., and Adigun M.O.[2007b], Requirements Engineering Framework for Information Utility Infrastructure for Rural e-Healthcare Service Provisioning. In Proceedings of IRMA 2007 international conference, Canada

Ojo S.O., Olugbara O.O., Ditsa G., Adigun M. O. and Xulu S.S (2007). Formal Model for e-Healthcare Readiness Assessment in Developing Country Context. In Proceedings of the 4th International Conference on Innovations in Information technology, Dubai, November 18020, 2007. IEEE Catalog Number: CFP0745B-CDR.

Ojo S. O. (2007). Science, Engineering and Technology of Computing in African Healthcare Systems: Opportunities and Implications, a Keynote paper presented at the Conference of the Vice Chancellors and Deans of Science, Engineering & Technology (COVIDSET 2007), Midrand, South Africa, August.

Travostino F., Mambretti J., and Edwards G.K., Grids networks: enabling grids with advanced communication technology, John Wiley, 2006

Wac, K. Bults, D. Konstantas, A. Halteren V., Jones V., Widy I., and Herzo R., Mobile healthcare over 3G networks: The MobileHealth pilot system and service. Mobile Information Systems, vol. 2, no. 2-3, 2006, 151 - 167

WHO (2005). Fifty-Eighth World Health Assembly- eHealth: Report by the Secretariat April 7.

WHO (2011). Working together for health: The World Health report 2006. Accessed July 2011 from: http://www.who.int/whr/2006/06_overview_en.pdf

WHO/AFRO (2011). Press Release. The African Regional Health Report – Africa is developing solutions for fight disease and improving health, new WHO report finds. November 20. Accessed on July 2011 from http://www.afro.who.int/press/2006/pr20061120.html

Zimmerma I.G., Wireless networked devices: A new paradigm for computing and communication. IBM systems journal, vol. 38, no. 4, 1999