

A Proposal to Develop a Sustainable Digital Health Information Systems Infrastructure in Uganda

Dr. Fred Wabwire-Mangan, MD, PhD, Director, Institute of Public Health, Makerere University

Mr. Robert T. Kambic, MSH, Associate Scientist, Johns Hopkins School of Public Health

Dr. Eddie Mukooyo, MD, Ministry of Health, Uganda

October 2000

Table of Contents	Page
Executive Summary	2
Overview	3
Education	3
Health	3
Information Technology and Telecommunications	3
Institutions Participating in the Ugandan Health Information System	4
Statement of Need: How IT can Improve the Health Sector	4
Proposed Digital Health Information System (DHIS)	6
Budget	7
Evaluation	8
Appendix 1	10
Appendix 2	12

Executive Summary

“In the past 20 years, more than 30 new infectious agents that threaten human health have been discovered, including rotavirus, cryptosporidium parvum, legionella pneumophila, hantavirus, and ebola. No region of the world is immune from the onslaught of disease....”¹

“There is a fundamental difference between leadership and unilateralism because leadership implies followership. . . But the principal activity that has become the day-to-day “meat n’ taters” of foreign policy has to be consultations . . . with the other major centers of power in the world. We have to be consulting with them regularly.”²

The purpose of this proposal is: 1) to obtain assistance for necessary hardware, software and training for a Digital Health Information Systems (DHIS) infrastructure in Uganda; and 2) to show the benefits of a (DHIS) in the Uganda health sector. Such benefits include: a reduction in illness and poverty thereby bettering economic and social conditions in Uganda; epidemiological surveillance of diseases important to global interests; improved collaboration and consultation for development; and regional stability.

The world has an interest in Uganda to support its economic growth (6% over the past 12 years) with the aim of promoting regional stability in Africa and opening Africa to import and export market opportunities. Uganda continues to move towards an open economy with free markets and democratic reforms. Uganda has many attractive qualities that make it a focal point for leadership in Africa. Uganda has an excellent University, Makerere, providing education to students throughout Africa. Uganda could become a food exporter to Africa; Uganda contains unique ecosystems critical to the conservation of globally important biological diversity. Uganda has instituted reforms to increase educational opportunity for girls, and finally, Uganda has decentralized its government with 45 newly-created district administrations which give communities direct access to local government policy makers.

Improvement in the health sector is a basic component of development strategy in Uganda. Besides humanitarian efforts to reduce suffering, decreasing the prevalence and impact of infectious and communicable diseases has the pragmatic result of providing more workers, with less time lost to illness, and a longer life span leading to senior leadership expertise. These issues are especially important as knowledge workers become a more important part of the Ugandan economy, mirroring recent changes in northern economies.

Planning for a DHIS has been ongoing for a number of years with numerous participants. This prospectus is the culmination of a number of these efforts which include:

- | | |
|--|---|
| 1. Institute of Public Health (IPH) and the Institute for Statistics and Applied Economics (ISAE) at Makerere University | 8. The Bill and Melinda Gates Foundation |
| 2. Ugandan Ministry of Health (MOH) | 9. The Mellon Foundation |
| 3. Johns Hopkins University School of Public Health (JHSPH) | 10. The Rockefeller Foundation |
| 4. The Rakai Project | 11. George Mason University (ICASIT) |
| 5. The US Agency for International Development (USAID) | 12. Uganda Online |
| 6. The Ugandan Virus Research Institute | 13. The University of Oregon Network Startup Resource Center (NSRC) |
| 7. The Italian Government Ugandan Cooperative Mission | 14. The Regional Center for Quality of Health Care at IPH (RCQHC) |
| | 15. The Johns Hopkins Program of International Education in Gynecology and Obstetrics (JHPIEGO) |

Overview

Uganda is a sub-Saharan Africa country in Eastern Africa on the shores of Lake Victoria. In area, it is about 92,000 square miles or slightly smaller than Oregon and topographically is a central plateau with a rim of mountains that are as high as 15,000 feet in the west. Uganda enjoys natural resources of copper, cobalt, hydro-electric power, limestone, salt and fertile land with good rainfall. It has great bio-diversity from deserts to high mountains and the marine life of Lake Victoria and other smaller lakes. The high mountain areas include mountain gorilla reserves. Agriculture is the most important sector of the economy, employing 80% of the work force. Coffee is a major export crop.

Based upon a recent plebiscite the political system is a one party system, with a legal system based on English common law in a unicameral national assembly. The government has been decentralized and decision making placed at district levels. English is the official national language, taught in grade schools, used in courts of law by most newspapers and radio broadcasts and there are several other languages.

Education

Uganda has a number of institutes of higher education including universities, teacher colleges, business colleges and technical colleges. The most important of these is Makerere University (<http://imul.com/muk/>) located in the capitol, Kampala. Makerere is a large modern university with a faculty of arts, sciences, public health, medical, nursing and library science. Makerere provides education to students from all of Central Africa. Under a previous despotic Ugandan government in the 1970s, the University libraries languished and have been unable to restock with current books and journals. The libraries seek Web access as a solution.

Health

Health conditions in Uganda reflect those of a poor country in the tropics with limited resources to spend on both preventive and curative medicine. The population of Uganda is about 23.3 million and is growing at the rate of 2.7% per year with a total fertility rate (number of births per woman) of almost 7. The infant mortality rate is 93 deaths per thousand live births. Life expectancy is about 43 years at birth. Communicable diseases are the most important health problems in Uganda. The most common causes of death and illness are Malaria, Cholera, Measles, Meningitis, AIDS, and Sexually Transmitted Diseases (STDs). Considered epidemic are Cholera, Measles, and Yellow Fever. Non communicable diseases, such as diabetes, hypertension and cancer are becoming a more important causes of morbidity and mortality in the country. A significant proportion of the adult population is infected with HIV and Uganda may have one of the lowest life expectancies in the world as a result of AIDS. In response to this, Uganda has promoted an aggressive effort to reduce the spread of AIDS through awareness and prevention. These campaigns have resulted in significant decreases in new infections especially in the young adult population. There are both public and private health services in Uganda. The government health service is active in each of the 45 districts of the country with a medical director, at least one hospital and several medical clinics.

Information Technology and Telecommunications

Uganda has one of the lowest penetrations of telephone service in the world. In 1995 Uganda Telephone Company had just under 70,000 lines and 42,000 subscribers with an estimated 80,000 potential subscribers were waiting to be served. Because of the inadequacy and unreliability of the wired system, wireless telephone service has made major inroads in Uganda.

Computer and computer networking are growing at a rapid rate. Uganda was one of the first countries in sub-Saharan Africa to obtain full, but limited, internet connections. Currently internet service providers usually use radio lines of site services, and high frequency radio bandwidth for long distance e-mail. There are four active internet service providers which had about 4,000 accounts (about 2,500 users) in January 2000. One of the most prominent internet service providers is Uganda Online (<http://www.uol.co.ug/>), whose company owner, Charles Musisi, is the domain administrator for the top level domain in Uganda and a key participant in this proposal.

The Uganda Global Distance Learning Center (UGDLC) in Kampala, is supported by the World Bank and has cutting edge technology to allow this site to participate in meetings and short courses held around the world. In the conference-lecture room are 40 Dell desktop computers and the front wall contains two large (two meter by three meter) screens that project images of local and international participants. A command module sends videos, slides, and other documents to the web. Faxing is also possible. Two way communications use a large dish at the facility, uplinked to a satellite and then to the World Bank in Washington DC and from there to be redistributed. In addition to the conference room, the facility has two computer labs with Dell computers that can be used for IT training purposes.

Institutions Participating in the Ugandan Health Information System

There are six participating institutions in this proposal, each with an important part to play. They stand alone but combined provide a synergistic pilot program where the sum of the parts is greater than the whole.

The institutions are:

1. The Institute for Public Health (IPH) at Makerere University. IPH trains public health professionals for Uganda and other African countries, it provides research and consultation to the Ministry and other health providers in Uganda
2. The Institute for Statistics and Applied Economics (ISAE) at Makerere University. ISAE was established in 1969 to train statisticians, demographers, and population experts for English speaking countries in Africa.
3. The Regional Center for Quality of Health Care (RCQHC) at Makerere funded by USAID to train health care providers for the sub-Saharan African Region; the RCQHC is attached to the IPH.
4. Two Rakai Project centers consisting of offices in the Uganda Virus Research Institute (UVRI) in Entebbe and the Rakai project for HIV control in the Rakai District
5. The Ministry of Health (MOH).

The MOH is the policy making agency for health in Uganda. For about ten years, the MOH has had a paper-based Health Information System which provides comprehensive reports from the district to the central office in Kampala. The academic agencies provide education, training, research, and consultation on issues related to health in Uganda. The Rakai project is closely associated with Johns Hopkins University. Its two sites provide the opportunity to test the network over longer distances and to immediately begin to make use of Web connectivity to international libraries for research.

Computers have been making inroads into public health and related areas more rapidly than into the curative medicine side. The IPH and the ISAE have used stand alone computers for data analysis and more recently e-mail. The UVRI and Uganda health district offices use computers primarily for data analysis, and word processing. The MOH headquarters building in Kampala has individual computers with some network capability, but overall there is little computer networking available within the health service community in Uganda. The medical school has a computer laboratory in which none of the computers are networked.

The paucity of internet access for public health providers to the cornucopia of resources available on the internet results in poor information flow both into and out of Uganda. The data drought keeps Uganda researchers from developing and writing the most up-to-date reports, and having access to the most up-to-date research information available throughout the world on the net.

Statement of Need: How Information Technologies Can Improve the Health Sector in Uganda

Improvement in the public health sector is a critical component of development strategy in countries with transitional economies. Infectious and communicable diseases destroy lives, initiative and creativity in the population; they are burdens on the health system and remove productivity from the economy. Resources dedicated to public health, to prevention of these diseases and conditions can show multiplicative benefits in the economy. Healthy people not only forgo curative health services, thus saving those resources, but also produce more goods and services over a longer period of time. Uganda has demonstrated that public health programs can make a difference by a focused effort to

reduce the incidence of HIV through education and intervention programs.

Health Information Systems (HIS) are a necessary part of any nation's effort to maintain and improve citizen health. HIS includes patient records, the aggregating of individual information into data and reports that take the pulse of the country's population, births, deaths, old, and new cases of illness, logistics, manpower, and budgets. All of this information has to be communicated to those knowledgeable enough to interpret it and with the authority to act as warranted. The Digital HIS (DHIS) will be a network of pipelines for communication and access to the latest data, research results, and health information. Necessary to the DHIS are management and support for the hardware, software, transmitters, Web, and data systems that make up the DHIS. In the USA, until the advent of computers, HIS were paper-based and took over 150 years to develop. Through the past 30 years with the burgeoning of computers and networks the USA today has a DHIS that contributes to an increasing healthy and productive life span.

In Uganda, as in much of Africa, HIS have been under development for a short time and have been paper-based. With the advent of computers and telecommunications in Africa, and as Uganda increasingly becomes a part of the global economic and health network, HIS must become digital. Uganda has a singular benefit in this project: because there is a lag time between DHIS development in Uganda and in the USA where DHIS is a mature technology, DHIS development in Uganda can look to the USA for expert guidance on how to proceed and thus get an DHIS that will be right the first time.

There have been a number of projects, meetings and consultations (shown in Appendix 1) with the objective of identifying goals and addressing specific needs for the DHIS in Uganda. These assessments have identified the following currently existing staff and infrastructure at participating institutions.:

1. Trained and motivated IT staff in key posts;
2. International level computing and telecommunications expertise at Uganda Online (Mr. Musisi);
3. Some hardware, software, network and Web access at each institution (shown in Table 1);

Table 1. Hardware and software currently in place for Digital Health Information System in Uganda					
Institution and size		Computers	Printers	Network Systems#	Software
Name	Number of users*	Have	Have	Have	Have
IPH	30 Faculty 50 Student	30	6	2	30
RCQHC	10 Faculty 5 Student	15	4	2	15
ISAE	40 Faculty 450 Student	70	4	0	10
UVRI	15 Senior staff	6	2	0	6
Rakai	20 Senior staff	15	2	0	4
MOH**	300	280	100	2	280
Total	920	416	118	6	345

* Faculty includes faculty and their supporting staff, secretaries, IT specialists, etc.

** The MOH will obtain the majority of the necessary functions outside of this proposal.

Hubs, servers, cable, and radio transceivers

The numbers of computers and printers in Table 1 and Table 2 below are straightforward as they are related to the numbers of users. The items labeled "Network Infrastructure Systems" and "Software" require explanation. The Network System components are described in Appendix 1 and 2. Software includes: productivity software (e.g. MS Office), statistical and analytical software (e.g. SPSS, Stata), and email and web software (e.g. Netscape, pine).

The assessments (Appendix 1) have identified five goals and six functional needs of a Ugandan DHIS. The goals are:

1. To increase the health of the public by reducing the incidence and prevalence of infectious disease;
2. To expand knowledge and skills of faculty, students and health providers;
3. To improve access to and quality of health services;
4. To promote public health by improved health communications;
5. To have a model system that would be a pilot for other countries in the region.

The six functional needs were identified as:

1. Makerere University (IPH and ISAE) and Ministry of Health (MOH) to have email and Web access including access to JHSPH for online learning;
2. To provide email and Web access to specific Health Districts and select sites (Rakai, UVRI) as a pilot test;
3. To provide access for IPH, MOH, and researchers at district sites to international centers of excellence such as SPH and the USA National Library of Medicine;
4. To have a digital health library accessible to IPH, MOH, and ISAE;
5. To develop Web sites for participating institutions;
6. To access data stored on local servers.

Proposed Digital Health Information System

To address the goals and functional needs there are three necessary components:

1. Hardware, software, and network infrastructure (detailed in Appendix 2 and Tables 2-4)
2. Technical training for the support staff and users
3. Sustainability and growth once the system is installed and operational

Table 2 identifies the specific equipment requirements of each institution to meet its functional needs. The hardware, software and network infrastructure items were identified by Mr. Kambic during his trip to Uganda in summer of 2000. They were made in consultation with the key IT faculty, staff, and personnel of the individual institutions and with Mr. Charles Musisi. The assessment shows a need for 124 computers, 25 printers, 7 network systems including routers, gateways, and radio transceivers, and 139 computers (including the 124 new ones) needing software. We note that these numbers describe a basic level of functionality and do not exhaust the needs for IT of the individual institutions.

Table 2. Hardware and software needs for Digital Health Information System in Uganda					
Institution and size		Computers	Printers	Network Systems#	Software
Name	Number of users*	<i>Need</i>	<i>Need</i>	<i>Need</i>	<i>Need</i>
IPH	30 Faculty 50 Student	30	10	1	30
RCQHC	10 Faculty 5 Student	0	0	1	5
ISAE	40 Faculty 450 Student	60	10	2	70
UVRI	15 Senior staff	9	2	1	9
Rakai	20 Senior staff	5	3	1	5
MOH**	300	20	0	1	20
Total	920	124	25	7	139

* Faculty includes faculty and their supporting staff, secretaries, IT specialists, etc.

** The MOH will obtain the majority of the necessary functions outside of this proposal.

Hubs, servers, cable, and radio transceivers

The components are broken down by institution for several reasons. Each institution is autonomous but contributes in several ways to the overall health information infrastructure of the country. Each institution's IT architecture can stand alone. In other words, each is an individual project that if funded and established will improve communication, research, collaboration, and public health in Uganda. However, it is by bringing the agencies together digitally, in a collaborative effort that a Digital Health Information System will be established in a synergistic way that will enable the whole to be more than the sum of its parts.

Budget

Table 3 shows the one time (non recurring or capital) costs for hardware and software related to this proposal. The amounts are based on the cost multiplied by the needed number shown in Table 2.

Table 3. Non recurring (Capital) costs for hardware and software related to Digital Health Information System in Uganda. Cost is in thousands of US Dollars.						
Institution and size		Computers @ \$1500	Printers @ \$300	Network Systems @ \$15,000	Software @ \$500	Total Cost Per Institution
Name	Number of users*	Cost USD	Cost USD	Cost USD	Cost USD	
IPH	30 Faculty 50 Student	\$45,000	\$3,000	\$15,000	\$15,000	\$78,000
RCQHC	10 Faculty 5 Student	\$0	\$0	\$15,000	\$2,500	\$17,500
ISAE	40 Faculty 450 Student	\$90,000	\$3,000	\$30,000	\$35,000	\$158,000
UVRI	15 Senior staff	\$14,500	\$900	\$15,000	\$4,500	\$34,900
Rakai	20 Senior staff	\$7,500	\$1,200	\$15,000	\$2,500	\$26,200
MOH**	300	\$30,000		\$15,000	\$10,000	\$55,000
Total	920	\$187,000	\$8,100	\$105,000	\$69,500	\$369,600

* Faculty includes faculty and their supporting staff, secretaries, IT specialists, etc.

** The MOH will obtain the majority of the necessary functions outside of this proposal.

*** Hubs, servers, cable, and radio transceivers

Table 3 justification.

Computer costs Are averaged between high end workstations and lower end email and word processing machines. Pentium with 128 Ram, 10 Gig disk, CD rom drive, and network card are minimum requirements.

Printers Are laser printers with a network card.

Network systems Are two servers, gateway, and radio transceiver with all associated software and cabling.

Software Includes MS Office suite, statistical packages, email, Netscape, Real, and other productivity tools.

Table 4 shows recurring costs each year for hardware and software maintenance, supplies, training, use, and staff related to Digital Health Information System in Uganda. These estimates are based on Gartner Group data from the USA where, what Gartner calls Total Cost of Ownership (TOC) is \$8,000 to \$12,000 per year for each computer in Table 1 and/or Table 2. Included in the TOC are the printing and software costs because these two items are integral to computer use; therefore the recurring cost for printing and software is shown as \$0 here. These estimates have been adjusted for the differential in personnel costs in Uganda. The total is \$97,500 dollars in yearly recurring costs spread over six participating institutions.

Table 4. Recurring costs (total cost of ownership) each year for hardware and software maintenance, supplies, training, and staff related to Digital Health Information System in Uganda. Cost is in thousands of US Dollars.						
Institution and size		Computers @ \$500	Printer costs included with computers	Network*** Systems Including Line and ISP Fees @ \$4000	Software costs included with computers	Total Cost Per Institution
Name	Number of users*	Cost USD	Cost USD	Cost USD	Cost USD	
IPH	30 Faculty 50 Student	\$15,000		\$4,000		\$19,000
RCQHC	10 Faculty 5 Student	\$7,500		\$4,000		\$11,500
ISAE	40 Faculty 450 Student	\$30,000		\$8,000		\$38,000
UVRI	15 Senior staff	\$4,500		\$4,000		\$8,500
Rakai	20 Senior staff	\$2,500		\$4,000		\$6,500
MOH**	300	\$10,000		\$4,000		\$14,000
Total	920	\$69,500	\$0	\$28,000	\$0	\$97,500

* Faculty includes faculty and their supporting staff, secretaries, IT specialists, etc.

** The MOH will obtain the majority of the necessary functions outside of this proposal.

*** Hubs, servers, cable, and radio transceivers

Table 4 justification

Computer cost is the cost per machine in Uganda to install, support, train to use the machine for one year. Support includes network connections, disk defragmentation, and standard application installation. Training includes formal and informal training of staff and the computer user. Printer and software costs are included in computer costs. Network systems include setup, connections, and ISP fees for the radio links.

The overall startup costs are \$369,600 and the yearly recurring costs to maintain and use the system are \$ 97,500.

Evaluation

There are a number of ways to evaluate this project. They are:

1. Functional level efficiency and effectiveness of IT use;
2. Impact on health communication;
3. Impact on disease incidence and prevalence.

The functional level of IT use will measure items such as speed of email and web availability, access to local datasets, institutional web site pages and hits. Impact on health communication can be measured by the number of email flowing into and out of each institution, the use of exterior web sites, the number of libraries that can be accessed by Ugandan researchers, and the hypothesized increase in the number and quality of reports and papers that will be generated by improved web access. The number and quality of reports would be a temporal observational study whereby pre-DHIS and post-DHIS publication efforts are compared.

The most interesting evaluation will be that which measures the impact of a DHIS on the health of a population. The way the DHIS project is structured provides a natural experiment whereby some health districts in Uganda will not benefit from the DHIS until later than others. Measures such as infant and maternal mortality could be used as

outcome variables and multivariate methods used to adjust for the numerous factors which go into calculating such measures on a regional basis.

References

1. JE Frazer in America's National Interests in Multilateral Engagement: A Bipartisan Dialogue
Princeton N. Lyman and Michael H.C. McDowell, Co-Directors A report on a Project of the Overseas Development Council. Washington DC September 2000 http://www.odc.org/conference/final_report/final_report.htm
2. JD Sachs in America's National Interests in Multilateral Engagement: A Bipartisan Dialogue
Princeton N. Lyman and Michael H.C. McDowell, Co-Directors A report on a Project of the Overseas Development Council. Washington DC September 2000 http://www.odc.org/conference/final_report/final_report.htm

Appendix 1 Needs Assessments Meetings and Consultations 1997 to 2000

There have been a number of projects, meetings and consultations with the objective of identifying and addressing specific needs for the HIS in Uganda these are shown below.

1997

- ? Johns Hopkins University School of Public Health (JHSPH) signs a Memorandum of Agreement with Makerere University to provide technical assistance and CD rom based public health courses for students of public health, statistics, and demography.
- ? The Mellon Foundation provides funds to support the development of the CD rom courses.

1998

- ? JHSPH (Mr. Kambic) reviews computing systems at Makerere and Rakai HIV project
- ? The Gates Foundation through JHSPH provides \$14K dollars to upgrade computer systems at Makerere

1999

- ? Mellon Foundation through George Mason University (International Center for Applied Studies in Information Technology (ICASIT <http://www.icasit.org/>) provides \$10k dollars to upgrade networks and Web access at the IPH
- ? The MOH plans to develop a Web site, and reviews Geographical Information Systems (GIS) for health data mapping

2000

- ? January - The MOH assesses their Infectious Disease Surveillance Systems for future planning and integration into an East Africa network
- ? January - IPH hosts a computer and network planning meeting in Kampala with experts from twelve agencies with an interest in HIS in Uganda
- ? June - Mr. Kambic reviews computer systems at Makerere, IPH, and other Ugandan sites
- ? Summer - Key personnel of the MOH (Drs. Mukooyo and Talisuna) visit SPH for information technology consultation

Specifications and current IT architecture at participating sites

There are a number of initiatives currently under way in Uganda to combat the infectious and communicable diseases which plague Uganda's people. Often these efforts are confined to local districts and health care centers far from the University and the MOH. Other such efforts in neighboring countries are also underway. Telecommunications, computers, and computer linking can provide health leaders in Uganda with the means to rapidly access the latest information in preventive medicine, and to monitor the progress of current conditions and potential areas where other outbreaks may occur. In this section of the proposal, we outline the details of what currently exists at sites specific to the DHIS and the infrastructure needs of the site to become a full participant in the DHIS.

The IPH is the training ground for public health professionals in Uganda. It is the center from which students go out to local health districts to practice public health and disease control under the guidance of the local MOH health officers, IPH, along with MOH, is also the place where current disease prevention specialists evaluate and develop the programs to reduce disease and increase health. It is central to the development of a DHIS in Uganda.

The current computing situation at IPH is as follows: 26 faculty and staff all with computers but only 14 attached to the network with desktop email and Internet access. There are 50 students with about 25 owning their personal computers (usually laptops). There are eight student computers in the student computer lab with two printers in the lab. Four laboratory computers are on the IPH local area network (LAN) and the IPH LAN is attached to the internet by a wireless connection to Uganda OnLine.

The RCQHC is located on the medical campus of Makerere. The Center is funded by USAID and is in a completely renovated complex with the latest in equipment and a beautiful training room for 20 participants. The Center is organizationally attached to the IPH. There are 15 PCs networked at the RCQHC. Ten will be for the faculty and staff and five for student use in the airy, well-lit training classroom. The computers are currently networked and use a radio link to Afsat a local ISP.

The ISAE is on the Arts and Sciences campus of Makerere. ISAE trained experts are crucial to public health information systems. The Gates Grant has provided about \$14,000 to ISAE for the development of a distance learning laboratory. The room is secure, newly painted, and air conditioned with offices for the head of IT. It however contains only four computers, two purchased by Gates, Dell Optiplex G1s, and two others. There is another computer laboratory at ISAE which is overcrowded.

The Ministry of Health (MOH) is in a new MOH building which is quite large and impressive. It is in a valley about one kilometer from the Milago Medical campus of Makerere housing the IPH and perhaps two kilometers from the University on the other side of the valley. The MOH has a room designated to become the IT center which will house the hardware and staff responsible for IT functions. The current MOH information system consists of paper reports. It was implemented in 1994 and is based upon a series of reports which begin at the local health center and are passed upwards eventually to arrive at the MOH. There have been several evaluations of this system and the conclusions are the same, reports are not completed in a timely manner, and there is little feedback to the district and local level. There are a number of reasons for this: lack of trained personnel, lack of time as there is a large amount of detail to be completed. There also may be emphasis on particular diseases or conditions that are the focus of NGO agencies. Furthermore the private health provides are not obligated to participate in the system.

The Rakai project Entebbe office computing resources are as follows: there are eleven professionals with five PCs, one secretary without a PC, and eleven data entry and lab personnel with eight PCs. Five of the current PCs are Pentium and have sound capability but only one has Web access. The Rakai Entebbe office would require a LAN system similar to the current simplified system at IPH. The system would connect to the IPH through the HF radio link discussed above, and be provided with access to data, the web, and email. SPH courses on CD could be used locally. A similar LAN and connectivity arrangement could be installed at the Rakai project office in the Rakai district where there are several stand-alone PCs.

This proposal would be remiss if it did not mention Uganda Online. Mr. Charles Musisi, Director of Uganda OnLine and internationally recognized computing and networking expert is a member of a prestigious seven member committee of the Internet Consortium for Assigned Names and Numbers (ICANN www.icann.org/nomcom/), three of whom are professors at US academic institutions and one each from Asia, Africa, and Latin America. Mr. Musisi is also a Board Member of AfriNIC -- The African Regional Internet Registry (www.afriNIC.org) and co founder of the Africa Netowrk Operator's Group --AfNOG(www.afnog.org). Uganda OnLine is a private company, a computer and telecommunications "solution provider." This means that they consult with their clients on best and cost effective approaches to computer and network usage. They can provide a range of services from consultation to full Internet connectivity with associated computer training.

Uganda Online will assist the development of IT infrastructure supporting the DHIS. For example, Mr. Musisi was willing to consider having IPH computer support staff attached to his company one day a week for on the job training, as long as there is no cost to be borne by Uganda OnLine. It is possible for Uganda OnLine to monitor Internet usage of the IPH to check for spurious usage. This becomes important when such usage interferes with the DHIS goals and objectives noted above.

Uganda Online will provide consultation for the development of computing and connectivity at the IPH, ISAE, and Rakai Project. Mr. Musisi would provide specifications and costs for internal hardware, software, and personnel training as well as plans and costs for Internet connectivity, acting as Senior Project IT consultant in Uganda.

The current network connectivity at IPH provides a proven scalable architecture which can used as a model for

connectivity and network access for other institutes participating in this proposal. Uganda Online has, with the funds from Mellon Foundation through George Mason University and ICASIT, provided the current connectivity at IPH. The existing architecture is straightforward. Network computers use Genius ethernet cards and 10BaseT cable to a hub and a Linux server (Pentium, 128 ram, 8 gig disk). There is a bridge between the server and a high frequency (HF) radio relay station on the roof of the IPH. The radio relay station provides a secure encrypted link to the Internet server at Uganda OnLine. The encrypted link means the digital radio signals cannot be read by anyone without the encryption keys and prevents those who might intercept the radio signals from understanding them. Download times were tested on the computers at 9:00 am 12:00 PM and 3:00 PM on three sites, two in the USA (average download time 36 and 18 seconds) and one in Uganda (time = 16 seconds). These times were adequate for student and faculty use. This setup provides a desktop link to the Internet for 12 of 23 (50%) of the professional staff. The students have access to the web through the eight computers in the student computer lab.

Appendix 2

To provide more functionality, security, and internal and external access, we propose additional servers all protected by a firewall to prevent unauthorized access (hacking). The additional servers and other hardware will distribute functions and provide rapid reliable network functioning. The functions the hardware will provide are:

- ? Hub providing connectivity for PCs and servers behind the firewall (Genius 10BaseT 10/100)
- ? Web server hosting the IPH web site, distance courses, and data (Pentium 500, 128 Ram, 20 Gig disk, Jazz Backup).
- ? Email server providing POP3 mail functionality for Eudora and Netscape mail, and DNS service (hardware as above).
- ? Access server which will provide dial-in services for access from home and provide firewall protection for the IPH site (Cisco Access Router with a minimum of 20 modems scalable). The router controls Internet access.
- ? An HF radio bridge to allow connectivity to both the health districts and to local agencies participating in the network. For example IPH and ISAE could use one HF radio bridge.
- ? A leased line radio to the Internet Service Provider (ISP, Uganda Online) similar to that which currently exists.

Computers and critical functions at IPH sit behind the firewall. All external access to IPH and from IPH is outside the firewall. These external access point include IPH users working at home who will dial in, IPH users at the district who will use the HF radio gateway to access IPH, users at ISAE who will use the HF radio gateway to access IPH, and the internet and World Wide Web both inside of Uganda and outside of Uganda.

To summarize, for secure and reliable internet connectivity each institution needs one or more hubs, at least two internet servers, an HF radio bridge, and a leased radio line to the ISP or five pieces of hardware and firmware each with its associated software. Depending on the size of the institution, its projected data usage and associated traffic, an institution may need more servers. Figure 2 shows a schematic map of Digital Health Information System. Here we see the component institutions and how they will communicate with each other and with the outside world by passing information over the network using local area networks (LANS) that are cabled as well as wireless and a wide area network (WAN) that is wireless based.

IPH	Has a current network and Web connectivity but requires additional internal cabling and servers to increase access and functionality.
RCQHC	Has connectivity but could use an additional server and some additional development software.
ISAE	Has no network and has aging computers. It needs to have a full network, data storage, and Web access for its faculty and students. Some of the software on their current computers should be upgraded and the software needs show that addition.
UVRI	Is in Entebbe and is a part of the Rakai project. They currently have only modem access to the internet and no internal networking. The Rakai project is in the Rakai district along the southwestern edge of lake Victoria about 100 miles from Kampala. The project office there has no internal networking and no access to the internet.

MOH

Plans to provide funds for its own network and connectivity, but the key components of the DHIS is the resource and information center of the MOH. In addition the MOH would benefit from some additional computing power and functionality. This proposal provides for a computer user laboratory that would give access to public health and medical staff from the unconnected districts, when they come to the MOH offices in the capital.

Fig. 1 Planned computer network for
Institute of Public Health

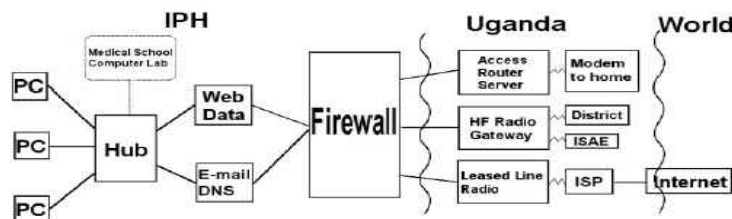


Figure 2: A schematic map of Digital Health Information System.

